



South Eastern Europe SWG RRD
Regional Rural Development Standing Working Group

EU4GREEN

CLIMATE CHANGE ADAPTATION IN AGRICULTURE – STATUS AND PROSPECTS IN WESTERN BALKAN ECONOMIES



VOLUME II: ECONOMIES' REPORTS







With funding from

Funded by the European Union

Austrian Development Cooperation

umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

CLIMATE CHANGE ADAPTATION IN AGRICULTURE – STATUS AND PROSPECTS IN WESTERN BALKAN ECONOMIES

VOLUME II: ECONOMIES' REPORTS

EU 4 Green:
Support the implementation of the Green Agenda for the Western Balkans

IPA/2021/429-949

Version 1; December 2024

Responsible EU Member State Consortium project leaders:
Fabian Kracmar & Laura Hohoff

Thematic Coordinators:
Andreas Bartel, Barbara Färber-Hallama, Bettina Schwarzl

DISCLAIMER:
The project implemented by Umweltbundesamt Austria, is funded by the European Union and the Austrian Development Cooperation. The content of this publication is the sole responsibility of the Umweltbundesamt GmbH. The views expressed herein can in no way be taken to reflect the official opinion of the European Union, the Austrian Government or the Governments of the Western Balkans. This document, any reference to Western Balkan beneficiaries and any map included herein are without prejudice to the status of, or sovereignty over, any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area. The designation of Kosovo* is without prejudice to any positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo* declaration of independence.

Imprint:
Owner and Editor:
Umweltbundesamt GmbH
Spittelauer Lände 5, 1090 Vienna, Austria

December 2024

Study Editor

Martinovska Stojcheska, Aleksandra

Authors

Volume I - Regional Coordinators and Regional Sections Editors:

Martinovska Stojcheska, Aleksandra (Economic and socio-economic aspects)

Mukaetov, Dusko (Soil)

Tanaskovikj, Vjekoslav (Water resources)

Chukaliev, Ordan (Crop production)

Andonov, Sreten (Livestock farming)

Volume II - Economies reports authors:

Economic and socio-economic aspects: Zhllima, Edvin (Albania); Vasko, Željko (Bosnia and Herzegovina); Miftari, Iliriana (Kosovo*); Spahić, Mirsad (Montenegro); Martinovska Stojcheska, Aleksandra (North Macedonia); Kovačević, Vlado (Serbia)

Soil: Zdruli, Pandi (Albania); Čivić, Hamdija (Bosnia and Herzegovina); Sharku, Afrim (Kosovo*); Knežević, Mirko (Montenegro); Mukaetov, Dusko (North Macedonia); Vidojević, Dragana (Serbia)

Water resources: Zdruli, Pandi (Albania); Marković, Mihajlo (Bosnia and Herzegovina); Nishori, Avdullah (Kosovo*); Knežević, Mirko (Montenegro); Tanaskovikj, Vjekoslav (North Macedonia); Stričević, Ružica (Serbia)

Crop production: Kullaj, Endrit (Albania); Čadro, Sabrija (Bosnia and Herzegovina); Kuci, Ylber (Kosovo*); Jovović, Zoran (Montenegro); Chukaliev, Ordan (North Macedonia); Vuković Vimić, Ana (Serbia)

Livestock farming: Dobi, Petrit (Albania); Rogić, Biljana (Bosnia and Herzegovina); Imeri, Bajram (Kosovo*); Marković, Božidarka (Montenegro); Andonov, Sreten (North Macedonia); Bogdanović, Vladan (Serbia)

Project coordination and implementation (SWG):

Ilić, Boban



Vaclav Volrab/shutterstock.com

Contents

ADAPTATION TO CLIMATE CHANGE IN AGRICULTURE – STATUS, GAPS AND RECOMMENDATIONS IN WESTERN BALKAN Economies		**7**
Introduction		**7**
Objectives		**9**
Methods, data and structure of the study		**9**
1.	**Adaptation to climate change in agriculture – status, gaps and recommendations in Albania**	**13**
1.1.	Status of economic, socio-economic and agricultural sector related to climate change	**13**
1.2.	Status of soils linked to climate change in agriculture	**23**
1.3.	Status of water resources and their importance for agricultural production	**33**
1.4.	Crop production analysis linked to climate change in agriculture	**44**
1.5.	Livestock farming analysis linked to climate change in agriculture	**51**
1.6.	Conclusions and recommendations on climate change adaptation in agriculture in Albania	**58**
1.7.	References	**62**
2.	**Adaptation to climate change in agriculture – status, gaps and recommendations in Bosnia and Herzegovina**	**69**
2.1.	Status of economic, socio-economic and agricultural sector related to climate change	**69**
2.2.	Status of soils linked to climate change in agriculture	**80**
2.3.	Status of water resources linked to climate change in agriculture	**90**
2.4.	Crop production analysis linked to climate change in agriculture	**102**
2.5.	Animal production analysis linked to climate change in agriculture	**112**
2.6.	References	**118**
3.	**Adaptation to climate change in agriculture – status, gaps and recommendations in Kosovo***	**127**
3.1.	Status of economic, socio-economic and agricultural sector related to climate change	**127**
3.2.	Status of soils linked to climate change in agriculture	**133**
3.3.	Status of water resources and their importance for agricultural production	**143**
3.4.	Crop production analysis linked to climate change in agriculture	**152**
3.5.	Livestock farming analysis linked to climate change in agriculture	**159**
3.5.	References	**168**
4.	**Adaptation to climate change in agriculture – status, gaps and recommendations in Montenegro**	**173**
4.1.	Status of economic, socio-economic and agricultural sector related to climate change	**173**
4.2.	Status of soils linked to climate change in agriculture	**184**
4.3.	Status of water resources linked to climate change in agriculture	**191**
4.4.	Crop production analysis linked to climate change in agriculture	**199**
4.5.	Livestock farming analysis linked to climate change in agriculture	**206**
4.6.	References	**216**

5.	**Adaptation to climate change in agriculture – status, gaps and recommendations in North Macedonia**	**221**
5.1.	Status of economic, socio-economic and agricultural sector related to climate change	**221**
5.2.	Status of soils linked to climate change in agriculture	**229**
5.3.	Status of water resources and their importance for agricultural production	**237**
5.4.	Crop production analysis linked to climate change in agriculture	**244**
5.5.	Livestock farming analysis linked to climate change in agriculture	**250**
5.6.	Legislative and strategic framework and institutional setup related to climate change adaptation in agriculture in North Macedonia	**253**
5.7.	Data availability and quality for analysis of climate change adaptation in agriculture in North Macedonia	**260**
5.8.	Conclusions and recommendations on climate change adaptation in agriculture in North Macedonia	**262**
5.9.	References	**266**
6.	Adaptation to climate change in agriculture – status, gaps and recommendations in Serbia	**271**
6.1.	Status of economic, socio-economic and agricultural sector related to climate change	**271**
6.2.	Status of soils linked to climate change in agriculture	**282**
6.3.	Status of water resources and their importance for agricultural production	**290**
6.4.	Crops production analysis linked to climate change in agriculture	**300**
6.5.	Livestock farming analysis linked to climate change in agriculture	**306**
6.6.	References	**313**
ANNEXES		**317**
Annex 1. Albania climate change adaptation in agriculture – additional materials		**319**
Annex 2. Bosnia and Herzegovina climate change adaptation in agriculture – additional materials		**333**
Annex 3. Kosovo* climate change adaptation in agriculture – additional materials		**341**
Annex 4. Montenegro climate change adaptation in agriculture – additional materials		**355**
Annex 5. North Macedonia climate change adaptation in agriculture – additional materials		**369**
Annex 6. Serbia climate change adaptation in agriculture – additional materials		**387**
List of acronyms		**403**

ADAPTATION TO CLIMATE CHANGE IN AGRICULTURE – STATUS, GAPS AND RECOMMENDATIONS IN WESTERN BALKAN ECONOMIES

Introduction

Climate change affects agriculture in numerous ways. Changes in temperature and precipitation as well as weather and climate extremes are already influencing crop yields and livestock productivity in Europe and globally. Weather and climate conditions also affect the availability of water needed for irrigation, livestock watering practices, processing agricultural products, and transport and storage conditions. Climate change is projected to reduce crop productivity in parts of southern Europe and to improve the conditions for growing crops in northern Europe. Although northern regions may experience longer growing seasons and more suitable crop conditions in the future, the number of extreme events negatively affecting agriculture in Europe is projected to increase.

The Western Balkans is one of the regions in Europe most heavily affected by the impact of climate change and this trend is projected to continue. Climate change already poses significant challenges to agriculture in the region, affecting crop yields, production resources, water availability, animal health and overall food security. The region is highly vulnerable to the effects of climate change, experiencing deviations in temperature, precipitation patterns, and increased frequency of extreme weather events, which impact agricultural productivity. Rural areas are significantly impacted by climate change. The economy faces a number of risks as a result of these climate change triggered hazards, including decreased public safety, loss of life and livelihoods, increased mortality and morbidity, impaired ecosystem functioning, extinction of species, water scarcity causing irrigation deficits and decreased energy security (Alhftan et al., 2015).

An essential element of a comprehensive response to climate change is adaptation. While mitigation efforts concentrate on limiting global warming by lowering or preventing the emission of greenhouse gases, adaptation is the process of making the necessary adjustments and preparations for the inevitable effects that are currently occurring or anticipated to occur as a result of past and present emissions that trigger changes in climatic conditions. Some effects of climate change are already unavoidable because of historical emissions, despite the increasing global commitment to mitigate them. Adapting to these changes is crucial to minimize the negative consequences for communities, ecosystems, and economies.

Adaptation is closely interconnected with the vulnerability concept in the context of climate change. Vulnerability refers to the degree to which a system (such as a community, ecosystem, or economy) is susceptible to the adverse impacts of climate change, while adaptation involves the actions taken to reduce this vulnerability and enhance resilience. Vulnerability encompasses a variety of elements including sensitivity or susceptibility to harm and lack of ability to deal with hazards and stress, and hence adapt. Vulnerability is a function of biophysical and social indicators, where exposure and sensitivity together constitute the potential impact, while adaptive capacity is the core ability towards successful adaptation, reflecting the potential of the system to cope with the climate change effects (Füssel and Klein, 2017). Stronger adaptive capacity moderates the potential impact of exposure and sensitivity, and hence reduces vulnerability.

The Agenda 2030 with its 17 Sustainable Development Goals (SDGs) along with the European Green Deal and its 9 Policy Areas, are the key strategic frameworks for the transformation of Europe into a climate-neutral continent in the future decades. The climate action is also at the core of EU reformed Common Agricultural Policy (CAP). Towards the Green Deal objectives, the Sofia Declaration on the Green Agenda for the Western Balkans was adopted in 2020 as the growth strategy for the region that aims to tackle the challenges of climate change and green transition and assist the Western Balkan economies to align environmental regulations with the European *acquis*. The Green Agenda for the WB is based on the European Green Deal and the related Economic and Investment Plan for the Western Balkans. The issue of climate change in agriculture is increasingly addressed in relevant policy documents in the economies. Translating strategic objectives into practice, however, remains a challenge.

Recognizing the need for imminent action, the Regional Rural Development Standing Working Group (SWG) initiated the setting up of a **Regional Expert Advisory Working Group on Climate Change Adaptation in Agriculture**. The Regional Expert Advisory Working Groups are a permanent part of the SWG structure. They include relevant national, regional and international experts, as well as representatives of relevant authorities, who analyze specific agricultural and rural development policy issues and provide national and regional policy recommendations. The Regional Expert Advisory Working Group on Climate Change Adaptation in Agriculture is composed of different profiles of experts from the region of the Western Balkans and will contribute to enabling evidence-based policy making in the area of climate change adaptation of the agricultural sector in the Western Balkans. This study is the first joint effort of the group, setting the grounds for further actions towards addressing the relevant issues for better and more successful climate change adaptation of agriculture in the region.

The production of the study was supported bu the EU4Green Project. The EU4Green Project implemented by Umweltbundesamt- Environment Agency Austria and financed by the European Commission (EC) with a contribution from the Austrian Development Agency (ADA), has its general objective to support the Western Balkans in the implementation of the Green Agenda, thus in the development and transformation towards sustainability and reaching climate neutrality by 2050. Accordingly, EU4Green is a very broad initiative building on the combined expertise and cooperation within the thematic areas Circular Economy, Depollution Water, Depollution Air, Depollution Soil, Biodiversity, Agriculture, Communication, Education, CSO engagement and Green Finance. The work package “Sustainable Agriculture” is dedicated to support i.a. the implementation of Action 50 of the Green Agenda Action Plan “Support investments in renewable energy production and technologies as well as GHG emission reductions and adaptation to climate change measures in agriculture”. Within this work package, EU4Green supported the compilation of this study as an information pool and as a basis for a strategical development of adaptation activities in agriculture. This assessment of the status of each economy facilitates the further development of actions and supports the establishment of climate change adaptation plans on national and regional level.

Objectives

This study aims to provide an overview of the **status of adaptation to climate change in agriculture in Western Balkan economies, with focus on the main developments in the socio-economic context, natural resources (soil and water), crop and livestock sector on economy and regional level**. Furthermore, it focuses on the following objectives:

- Providing a summary of existing analyses and assessments related to climate change in agriculture in the economies.
- Providing a summary of institutional responsibilities, strategic and operational frameworks linked to climate change in agriculture in the economies.
- Identifying the main gaps between actually implemented adaptation and goals set by policy, reflecting resource limitations and competing priorities.
- Identifying data availability, accessibility and quality, and data gaps related to analysis of climate change in agriculture.
- Identifying trends, practices and responses to climate change effects in the economies.
- Providing conclusions and recommendations of the status of adaptation to climate change in agriculture in the Western Balkan economies.

The economies reports also provide background for a regional comparative analysis (Volume I) of the climate change adaptation and impact status in the Western Balkan economies.

Methods, data and structure of the study

The analysis of climate change impact and adaptive capacities of the agricultural sector and rural development has been conducted through literature review of existing formal policy documents, strategic and programming documents, legislative acts, climate change reports to UNFCCC, research studies, expert papers, etc.

The statistical and meteorological data for certain sections of the study mostly originate from the available national statistical offices and hydrometeorological authorities, as well as from available and accessible international sources. Data gaps are supplemented where possible with input from key players in governmental and expert structures.

The study is structured in six chapters, each addressing the adaptation to climate change in agriculture and its status, gaps and recommendations in each of the respective six Western Balkan economies (Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia and Serbia). Within each economy chapter, there are five main sections that address different angles of climate change adaptation in agriculture in the economies context: (1) status of the economic, socio-economic and agricultural sector situation related to climate change; (2) status of soils linked to climate change in agriculture; (3) status of water resources linked to climate change in agriculture; (4) crop production analysis linked to climate change in agriculture; and (5) livestock farming analysis linked to climate change in agriculture.

This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

The sections on the **economic, socio-economic and overall agricultural sector situation linked to climate change in agriculture** cover the following main points: macro-economic background, key agricultural sector level indicators, land use features and trends, brief agricultural sector overview, farm structure key indicators and context in terms of adaptive capacities.

The sections on the **status of soils linked to climate change in agriculture** include: brief estimation of the exposure and sensitivity of soils to climate change and its influence on the overall soil health; overview of the producers' adaptive capacities relevant for sustainable use of soils; outline of the existing gaps and challenges to meet the newly adopted EU strategic and legal documents on soil and adaptation; summary of sustainable measures and best practices already applied for protection of agricultural land; and an overview of the already adopted mechanisms and opportunities for effective adoption of adaptation measures for soil health protection.

The sections on the **status of water resources linked to climate change in agriculture** address the following: analysis of water resources in the respective economy and their importance for agricultural production; brief analysis of irrigation status in the economy; drought risk assessment and crop water requirements; overview of the farmers' existing adaptive practices for proper water use under climate change; summary of national strategies and adaptation plans for water use in agriculture, including reports, R&D, projects and communications of the international climate change adaptation framework (UNFCCC).

The sections on **crop production analysis linked to climate change in agriculture** include: analysis of meteorological data availability and accessibility; most common agrometeorological indices available and used in the economies context; analysis of phenological monitoring; existing crop models used for estimating crop response to the climate change; analysis of extreme weather events; information on the most important crops sensitive to climate change, vulnerable regions and their combination; information on practices used by farmers to protect their crops from damages caused by weather variability; climate change adaptation measures and practices already tested/promoted or established in national documents related to climate change and agriculture; brief analysis of current infrastructure and systems for preventing the negative effects of weather extremes on crop production.

The sections on **livestock farming analysis linked to climate change** in agriculture cover the following: analysis of meteorological data availability and accessibility; analysis of extreme weather events; heat stress risk assessment for ruminants, pigs and poultry; overview of farmers' existing adaptive practices for mitigating the impacts of climate change.

Also, attention is given to the **legislative framework and institutional setup** linked to agriculture and effective adaptation to climate change, strategic policy objectives, instruments and measures. The existing **data availability and quality**, data constraints and data gaps are highlighted, followed by **concluding remarks with key recommendations and priorities**.

Given the complex knowledge and profile needed to cover the different aspects of adaptation of agriculture to climate change, a **multidisciplinary group of experts** prepared the respective sections in each economy chapter.



Adaptation to climate change in agriculture – status, gaps and recommendations in Albania

Nataliia Dvukhimenna/shutterstock.com

1. Adaptation to climate change in agriculture – status, gaps and recommendations in Albania

Edvin Zhllima[2], Pandi Zdruli[3], Endrit Kullaj[4], Petrit Dobi[5]

1.1. Status of economic, socio-economic and agricultural sector related to climate change

Albania stands out as one of the most influenced economies in WB when it comes to the changing climate patterns. Over the past 15 years, noticeable changes in weather patterns have unfolded, marked by a heightened occurrence of extreme events such as floods, droughts and heatwaves. Almost annually, regions like Shkodra, Tirana, Vlora and Fier bear the brunt of devastating floods, posing significant threats to Albania's economy, ecosystems, and the well-being of its people. Khan et al. (2019) projected that without mitigation policies, a persistent annual increase in global temperatures of 0.04°C (based on RCP 8.5) would lead to a reduction of GDP per capita in Albania of more than 9 percent. The IMF estimated that the additional annual costs for climate-resilient infrastructure in Albania would amount to about 1.1 percent of GDP.

Despite the stark projections of Albania's susceptibility to adverse climate change effects, there is a noticeable absence of evidence pertaining to these impacts on the socio-economic landscape. The primary aim of this section is to provide a concise overview of the critical socio-economic facets intertwined with the impact, vulnerability, and adaptation measures in the agricultural sector and rural development of the economy. It delves into a summarized portrayal of institutional responsibilities, strategic and operational frameworks associated with climate change within the agricultural domain, and relevant agricultural policies designed to address climate change challenges.

This section draws on a comprehensive review of existing analyses and assessments related to climate change in agriculture, along with the utilization of available secondary data sources. Consequently, it underscores the existing availability and quality of data, as well as the noticeable gaps that hinder a comprehensive analysis of the socioeconomic dimensions of climate change effects. The analysis discerns the primary gaps between the adaptation measures currently in place and the objectives set forth by the current status quo analysis. These identified gaps prominently revolve around resource limitations and the presence of competing priorities.

1.1.1. Economy macroeconomic background

Over the last few decades, Albania's GDP has exhibited significant cumulative growth, surpassing 70% in the period 2017-2022 when compared to the 2005-2010 period, reaching a level of 14 billion EUR. Even during the post-pandemic period, the annual real GDP growth has continued to rise by more than 5%. Due to the simultaneous growth in GDP and a reduction in population size, the GDP per

2 Agricultural economics expert, Agricultural University of Tirana, Faculty of Economy and Agribusiness (ezhllima@ubt.edu.al)
3 Soil and water expert, CIHEAM Bari (pandi@iamb.it)
4 Crop expert, Agricultural University of Tirana, Faculty of Agriculture and Environment (ekullaj@ubt.edu.al)
5 Livestock expert, Rural Association Support Programme Director (dobipetrit@gmail.com)

capita has reached nearly 5,000 EUR on average for the period 2017-2022, representing an 83.8% increase compared to the 2005-2010 period.

From a production perspective, this economic growth has been driven by the expansion of activities within the service sector, though there have been fluctuations in the construction and industry sectors. On the aggregate demand side, economic growth was primarily underpinned by the expansion of private consumption leading up to the onset of the pandemic. The growing level of consumption and the increasing trade openness has been accompanied with an increasing trade deficit (exceeding 20% of the GDP during the period 2018-2022). The unemployment rate has shown a consistent decline over the years, averaging 12% during the period from 2017 to 2022. However, in contrast, the inflation rate has experienced a slight increase over the past two years, largely attributed to the market turbulence resulting from the Russian aggression in Ukraine.

Table 1.1 Key macroeconomic indicators

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
GDP (at current prices)	mill. EUR	7,976	9,904	14,095	124.2	142.3	176.7
Value added (at current prices)	mill. EUR	6,928	8,643	11,887	124.8	137.5	171.6
GDP per capita	EUR	2,698	3,426	4,959	127.0	144.7	183.8
External trade balance	mill. EUR	-2,177	-2,232	-3,032	102.5	135.9	139.3
Unemployment rate	%	13	15	12	115.2	77.3	89.0
Food, beverages and tobacco in household expenditures	%	38	40	44	105.7	111.2	117.5

Source: Albania StatDatabase (2022)
Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

Despite the improved accessibility of the labour market, living conditions indicators in Albania do not reveal signs of improvement in the last five years. Notably, the share of household expenditures allocated to food, beverages, and tobacco has kept performing above 40%. Furthermore, the at-risk-of-poverty rate remains above 20%, indicating that a significant portion of the population still faces economic vulnerability. However, income inequality, as estimated by the GINI coefficient, has remained relatively modest and has fluctuated around 33%, suggesting that while poverty rates persist, income distribution is somewhat equitable (as shown in Table 1.2).

Table 1.2. Living conditions and inequality

Indicator	2017	2018	2019	2020	2021
Share of food, beverages and tobacco in total household expenditures	43.1	43	43	47	45
At-risk-of-poverty rate	23.7	23.4	23.0	21.8	22.0
Inequality income distribution (Gini coefficient)	36.8	35.4	34.3	33.2	33.0

Source: Albania StatDatabase (2022)*)*

The agricultural sector has seen a similar rise in line with GDP growth over the past few years, averaging 2.5 billion EUR on average for the period 2017-2022. Although agriculture's contribution to the economy's Gross Value Added (GVA) has remained stable at around 21%, employment in this sector has declined by 20 percentage points compared to the 2005-2010 period (as shown in Table 1.3). This decrease in employment can be attributed to migration and increased productivity in agriculture as well as other sectors.

The competitiveness of several agri-food sectors, such as greenhouse vegetables, medicinal and aromatic plants (MAPs), and fisheries, has significantly boosted the overall agri-food trade value, increasing it fivefold compared to the 2005-2010 period. This growth rate surpasses that of other sectors, as evidenced by the rise in the share of agri-food exports relative to total exports, which have increased from 7% to 12% over the past five years. Additionally, increased production has enhanced self-sufficiency in certain sectors, leading to a consistent share of agri-food imports relative to total imports, which remains at 17%.

Table 1.3. Key indicators for the agricultural sector

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
GVA of agriculture (at current prices)	mill. EUR	1395	1,920	2,517	137.6	131.1	180.4
Share in AgGVA in all activities	%	20	22	21	109.8	94.4	103.6
Employed in agriculture	000	520	481	448	92.6	93.1	86.2
Share in total employment	%	56	49	37	87.3	74.4	64.9
Export of agri-food products	mill. EUR	56	122	313	218.2	257.0	560.9
Share in export of all products	%	7	7	12	100.6	163.2	164.2
Import of agri-food products	mill. EUR	515	681	957	132.1	140.5	185.7
Share in import of all products	%	17	18	17	101.4	95.8	97.2
Trade balance in agri-food products	mill. EUR	-459	-559	-644	121.7	115.1	140.1

Source: Albania StatDatabase (2022)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

1.1.2. Background of the agriculture sector

Updated data on farm numbers and structures are unavailable, but based on 2012 data, it was estimated that there were approximately 350,000 farms in Albania (INSTAT, 2013). On average, each farm utilized an agricultural area of 1.9 hectares or 12 ha of arable land (usually divided in plots with an average size of 0.26 hectares). Data indicates that approximately 45% of all farms fall within the 0-1 hectare category and another 41% of farms are in the 1.1-2 hectare range, while only 14% of farms have a surface area exceeding 2 hectares. No updated data exist to understand farm categories and size, especially considering continued emigration.

Since 2011, there has been a notable shift, as the urban population has surpassed the rural population, marking a significant demographic transformation compared to the early 1990s. This shift has triggered population migration and aging, which are now factors that demand consideration in rural areas. Migration from rural areas has introduced challenges regarding the continuity of agricultural activities. A recent study focusing on the fruit and vegetable sector highlights that individuals who exhibit a stronger inclination to migrate tend to be more uncertain about remaining in this sector. However, those who choose to stay are more inclined to invest in the sector where they are active (Xhoxhi et al, 2023).

While the decision to migrate is primarily influenced by pull factors (Tema et al, 2023), rural areas are experiencing push factors due to the decline in education and healthcare services resulting from the de-concentration reforms. Additionally, there has been an overall reduction in social capital. The

Albanian Demographic Health Survey of 2018 identified significant gaps in educational attainment between urban and rural populations, with median years of school completed at 14.4 and 7.5, respectively (INSTAT, 2018). Furthermore, the Net Attendance Ratio for secondary education in rural areas is 8 percentage points lower, with slightly larger disparities among males.

Access to healthcare services is also limited in rural areas compared to urban areas. Although there are no official data provided regarding health services due to the absence of rural classification, some surveys, such as the Albanian Demographic Health Survey, reveal that the health situation is more precarious in rural areas. Women in rural areas are more likely to report at least one problem in accessing healthcare (45%) compared to women in urban areas (26%) (INSTAT, 2018).

Arable land accounts for 54% of the total agricultural land area (as shown in Figure 1.1). The majority of this land is dedicated to growing forage and cereals, primarily for animal feed. Over the past two decades, there has been a notable increase in the proportion of perennial crops, growing from 79,000 hectares to 87,000 hectares, primarily due to the expansion of orchard cultivation (as indicated in Table 1.4).

Table 1.4. Agricultural land use and agricultural holdings

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
Total agricultural land	000 ha	1150	1,187	1,173	103.2	98.8	102.0
- Arable land	000 ha	591	618	635	104.6	102.8	107.5
(of which fallow and uncultivated land)	000 ha	175	206	186	118.0	90.1	106.3
- Land under permanent crops	000 ha	101	79	87	78.3	110.3	86.4
(of which orchards)	000 ha	/	/	21	/	/	/
(of which vineyards)	000 ha	8	10	11	129.1	105.7	136.4
- Permanent grassland	000 ha	458	489	458	106.8	93.5	99.9

Source: Albania StatDatabase (2022)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

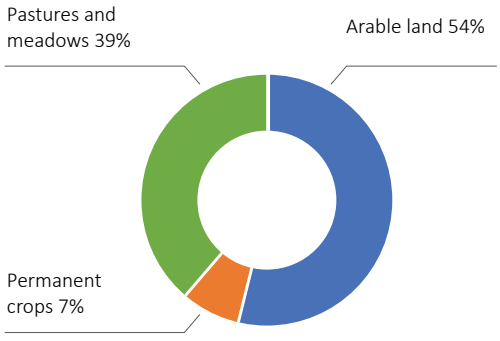


Figure 1.1. Agricultural land use (average 2017-2022)

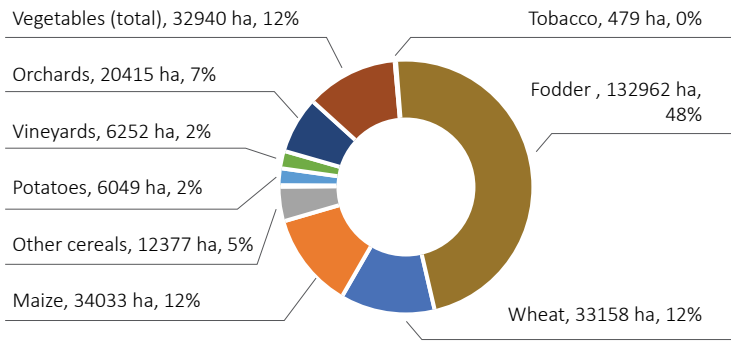


Figure 1.2. Area under major crops (average 2017-2022, in hectares)

Source: Albania StatDatabase (2022)

Crop production in Albania is mainly composed by forage and cereals (respectively 48% and 24% of crop area). The vegetable sector, although having a less important share in terms of area coverage (12% of the total area), is a large contributor in cash incomes. The sector continues to experience a highly positive trend in terms of production, especially greenhouse production, as a result of the shift to more intensive production. Positive trends are reported also in terms of production quantities for potato, but not as dynamic as in the case of vegetables.

Production of fruit trees overall, as composed mainly by orchards, citruses, grapes and olives, continues to increase in Albania. Production is boosted by a gradual increase of the planted area as well as improved production yields. The production of orchards and citruses has been growing from year to year, unlike grape and olives production, which have recently been experiencing slight decreases after a period of years with almost the same amounts of production.

Livestock farming is a very important activity for income generation for the majority of farms in rural Albania, considering that 86% of farms pursue livestock activity (Gjeci *et al.*, 2018). Trends in terms of size reveal that beekeeping and poultry are positively performing, while decreasing (negative) trends are revealed for small ruminants and cattle, accompanied ,by early signs of consolidation (Table 1.5).

Table 1.5. Number of livestock heads

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
Cattle	000	566	497	393	87.9	78.9	69.4
(of which dairy cows)	000	386	356	306	92.4	85.9	79.4
Pigs	000	155	166	187	107.2	112.3	120.4
(of which breeding sows)	000	14	12	12	87.8	103.0	90.4
Sheep and goats	000	2657	2,737	2,490	103.0	91.0	93.7
(of which breeding ewes/goats)	000	1977	2,063	1,693	104.3	82.1	85.6
Poultry	000	7436	9,015	7,397	121.2	82.0	99.5
Beehives	000	183	259	349	141.6	134.8	190.9

Source: Albania StatDatabase (2022)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

1.1.3. Legislative framework, institutional setup and policy support

Policy framework. Albania ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, Kyoto Protocol in 2005 and signed the Paris Protocol in 2016. The Albanian Government efforts and expected actions on climate change are reflected at the Intended National Determined Contributions to the global efforts for GHG emission reduction (DCM No. 762 of 16.09.2015). The National Integrated Energy and Climate strategy was formulated in 2017, as an engagement of the Republic of Albania at the Ministerial Meeting of the Energy Community. In 2019, the National Strategy on Climate Change (NSCC) and its two annexes, the National Action Plan on Mitigation (NAPM) and the National Adaptation Plan (NAP) were adopted. The NAP strategical goals are to reduce damages from floods, enhance agricultural resilience against floods and, and secure drinking water quality. The timeline for achieving these goals is defined as 20 years (until 2035).

In 2023, the National Disaster Risk Reduction Strategy and its Action Plan, the National Risk Assessment Document, and the ongoing preparation of the National Civil Emergency Plan have been

developed through a broad consultation process (ABKONS, 2022). Ultimately, the National Plan for Civil Emergency 2023-2030 was drafted (April 2023).

The legislative framework in Albania has been recently updated in order to strengthen the overall legal base for the mitigation and adaptation to climate change as well as to cope with climate changed hazards. In 2019, the Law on Climate Change (DCM no. 499, date 17 July 2019) was prepared. The legal base was extended by the adoption of the Law no. 45/2019 on Civil Protection, approved on 18 July 2019 and the Decision of the Council of Ministers no. 747, dated 20 November 2019 on the organization and functioning of the National Agency of Civil Defence.

There is a logical interlink between actions taken for addressing climate change and the overall policy framework in Albania. Climate change is an important component in the Strategy on Development and European Integration (NSDEI) 2021-2027 and clear activities are defined for coping with climate change in the National Plan for European Integration 2022 (SASPAC, 2023). In Addition, SARDF 2021-2027 provides special focus on activities related to climate change in Topic 1.4.

Table 1.6. Main strategic and legal documents

Document	Relevance of strategic objectives	Relevance of foreseen measures	Responsible institution(s)
Strategy on Development and European Integration (NSDEI)	High relevance	Low relevance	CM
National Plan on European Integration 2022	Low relevance	Low relevance	CM
National Strategy on Climate Change (NSCC)	Very high relevance	Very high relevance	MTE
National Action Plan on Mitigation (NAPM)	Very high relevance	Very high relevance	MTE
National Adaptation Plan (NAP)	Very high relevance	Very high relevance	MTE
National Integrated Energy and Climate Strategy	High relevance	High relevance	MIE
National Strategy on Risk Reduction and Civil Emergency 2023-20230 (ABKONS, 2022), Decision no. 94, date 22 February 2023	Very high relevance	Very high relevance	MoD
National Plan for Civil Emergency 2023-20230 (draft April 2023)	Very high relevance	Very high relevance	MoD
Strategy on Agriculture, Rural Development and Forestry (SARDF 2021-2027)	High relevance	Low relevance	MARD
IPARD Programme (2021-2027)	High relevance	High relevance	MARD
National Adaptation Planning (NAP) to Climate Change in Albania	Very high relevance	Very high relevance	MTE
Smart Specialization Strategy	High relevance	High relevance	MTE
Forestry Policy Document	Low relevance	Low relevance	MARD

Source: Own compilation.

Institutional framework. Similar to the legal base, the institutional base for addressing issues of climate change is also fragmented. Relevant institutional and legal components of green economy are implemented by several institutions functioning. Ministry of Tourism and Environment is strategically leading umbrella policies. MTE is the institution that drafts the national policies on climate change and coordinates the integration of climate change issues in agriculture, tourism, health, energy, transport, forestry, and water sectoral policies, etc. MTE has been appointed as the Designated National Authority (DNA) in the framework of the obligations under the UNFCCC and the Kyoto Protocol. Ministry of Agriculture and Rural Development is the one responsible for land use. In addition, the Ministry of Energy and Infrastructure is dealing with energy issues. Besides MTE, MARD and MEI, the

Ministry of Health and Social Protection and the Ministry of Foreign Affairs and European Integration are responsible.

Due to the complex character of the policy on climate change, all policies and measures are being formulated and implemented in close cooperation with several line ministries represented in the Inter-Ministerial Working Group on Climate Change, which coordinates all institutions involved in climate change processes and facilitates the integration of climate change into relevant new and existing policies, programmes, and activities.

At local level, the mayor is responsible for planning and responding to civil emergencies in the respective municipality. Local government units are yet not able to promote green economy due to limited budgetary and institutional capacities and high dependence from central government budgetary support. Last but not least, due to limited awareness of the business community and the farming community on green economy, there are weak potentials for organizing bottom-up initiatives soon.

Budgetary support. Currently, the level of commitment of the central government/public administration to climate change adaptation is high due to the continuing pressure for alignment with EU CAP 2030, as well as motivation to fulfil requirements from the Agenda 2030. However, the main challenge regarding the current strategic frameworks of which Albania is part, namely the Green Agenda for the Western Balkans (RCC, 2022), is the gap between policy formulation and policy implementation. For instance, the medium-term priorities of SARDF 2021-2027 and action plan which is part of SARDF are not clearly reflected in the Agriculture and Rural Development Programme Fund (ARDPF) priorities (more focus on competitiveness). But resources for addressing climate change adaptation are not yet foreseen in the Agriculture and Rural Development Programme Fund and in the Instrument of Pre-Accession in Agriculture and Rural Development (IPARD).

During the period 2018-2022 the overall budgetary support for agriculture in Albania increased notably. In 2022, support allocated to agriculture reached 3.2 % of GVA, or a respective overall value of 85 million EUR . Despite the rapidly increasing trend, this support represents a limited contribution to ensure the agriculture sector's response to climate change and to fulfil the demand for community development and social capital in rural areas. Albania does not earmark financial resources to green economy although there were some green like interventions in the past[6]. Through IPARD II support, during the period 2014-2020, minor components of green economy projects were applied, such as the establishment of photovoltaic panels, animal treatment systems and investments for energy efficiency. At IPARD III, the potentials to apply greener approaches are related also with the potentials for introducing new financing measures relevant to climate change adaption and mitigation measures (Measure 1, 3 and 7, 9 as well as measure on advisory services are expected to be activated at the beginning of 2024).

Policy and regulatory development in other sectors such as energy, infrastructure and tourism are creating a stimulating environment for carrying out climate change interventions (for instance, photovoltaic investments in agriculture and rural development are expected to develop more in the future, with the legal improvements; new changes in the Law on Forests might enable activities of carbon footprint accumulation). The current legal framework, including national regulations and national strategic documents and action plans, provide conditions but not stimuli for climate change mitigation and adaptation measures in the economy. However, considering that related budgetary instruments are not yet active, it is expected that in short term the level of financing in climate change adaptation remains mainly based on donor assistance.

6 Measure for the plantation of native seedlings in the vegetable sector was promoted but scarcely used. During the period 2019-2021 the measure for planting medicinal and aromatic plants was also supported (which contributes to excessive utilisation of wild MAPs in remote areas). Measures related to conversion into organic agriculture as well as support for Global G.A.P. certification were established during 2020. New measures are introduced with the ARDPF 2022, related to the support of farming digitalization but with no disbursement.

National financing in environmental protection is related to the MoTE budget. A budgetary review of WFD (2022)[7] found that the total MoTE budget from 2019 to 2022 had fluctuations and in financial terms in the year 2022 was 1% lower compared to 2019. The share of the budget for environmental protection in the overall budget occupies on average 0.21% (varying from 0.23% in 2019 to 0.18% in 2022[8]).

At the local level, municipalities are legally obligated to allocate at least 4% of their budget funds to address climate change hazard shock. As specified in the Law on Civil Protection, the object of this financial allocation is disaster risk reduction and ensuring adequate civil protection. According to a recent study (Janin et al, 2020), only 62% of municipalities have allocated funds for the management of disasters (as required by law) from their own annual budget.

1.1.4. Capacity to support climate change adaptation and mitigation to socioeconomic groups

Similar to Bosnia and Herzegovina and Serbia, Albania has a somewhat middle level of adaptive capacity (ENVSEC, 2012). Further concerns are raised on the adaptive capacity of vulnerable social groups (Tzvetkov et al, 2015). The National Strategy on Climate Change (NSCC) and its two annexes, the National Action Plan on Mitigation (NAPM) and the National Adaptation Plan (NAP) as well as the National Integrated Energy and Climate strategy (by DCM 466, date 3.07.2019) have no clear interventions.

At the national level, in order to respond to climate change hazards, a system of civil protection has been established. The central institutions and structures for civil defence are: a) the Assembly; b) the Council of Ministers; c) the Interministerial Committee of Civil Emergencies; d) the Civil Protection Committee (CPC) and the office responsible for the situation; e) the minister responsible for civil protection; f) ministries and central institutions; g) the National Agency for Civil Protection (NACP); h) technical advisory commissions, as required; i) the centres of civil defence at prefecture-level (QMCQ).

Services for early warning are provided by the National Meteorological and Hydrological Service (NMHS), which is headed by the Institute of Geosciences (IGEO). IGEO is the national scientific research centre in Albania, in the fields of regional and applied geology, seismology, meteorology, hydrology and the environment. It is part of the of the Polytechnic University of Tirana (PUT).

At the local level, the municipal police, fire and rescue teams are the operative forces. Although the formal systems for meteorology, civil protection and emergency response are well detailed on paper, in practice institutional and system capacities are weak. Albania is the only economy in Europe that does not have a proper 24/7 NMHS (WMO, 2020). Similarly, at the local level, community structures to support civil protection efforts have been established in less than half (49%) of municipalities.

7 https://www.wfd.org/sites/default/files/2022-09/EN_Green-Budgeting-in-Albania_Final.pdf

8 A disaggregated analysis of the budget found that the budget for the environmental protection programme increased (66% higher) while the budget for the forest administration programme decreased (42% lower due to lower share of donor funding), and the budget in the forests sector was reduced due to the finalization of the Environmental Services Project. According to AGT-DSA (2021), public investments in the forestry sector during 2019 recorded below 200,000 EUR per year.

1.1.5. Literature review on climate change adaptation capacity

The literature on the capacity of the Albanian system to adapt to climate change is very limited. Like other Mediterranean economies, Albania faces significant challenges due to climate change, as highlighted in various studies (Baettig et al., 2007; REC, 2011; Sutton et al., 2013). The economy ranks at the top among European nations in terms of exposure and vulnerability to natural disasters and extreme weather events (NAP Global Network, 2019). While the existing literature on the impact of climate change is limited, there has been a recent increase in efforts to collect data. Pojani et al. (2013) collected evidence and perspectives from the Albanian population on climate change, with limited focus on agriculture. Rama (2016) examined farmers' adaptability in terms of water management and crop planning, finding that many adaptation strategies adopted by farmers were not directly linked to climate or environmental change but still contributed positively to adaptation efforts.

A study carried in the frame of the Fourth National Communication to UNFCC, conducted by Zhllima (2021) indicate that men are better informed and have greater access to knowledge on crop cultivation techniques, pest management, and water management compared to women. However, men are less informed and prepared when it comes to adaptation measures related to livestock management. The study revealed that women's adaptation capacity is limited, and additional actions are needed to enhance their role in coping with climate change. The primary reasons cited by respondents for the difference in adaptation capabilities include access to information, availability of services and equipment, and relationships with suppliers and service providers.

1.1.6. Data availability for monitoring climate change impact on the socio-economic situation

Monitoring capacities are still limited. There are few surveys carried out and frequently access is still limited. No thorough surveys are carried out for analyzing the costs and challenges created by climate change. Prior to 2020, existing evidence on vulnerabilities, as presented in the First, Second, and Third National Communications, mostly focused on various socio-economic sectors, with only a few surveys conducted by UNDP and UNWOMEN. The most recent evidence was collected during the preparation of the Fourth National Communication (NC4) and the First Biennial Update Report (BUR1) in 2023 (UNDP, 2023). The report examined the impact of climate change by considering the agriculture activities and using gender lenses.

Administrative data are weakly oriented toward climate change. In general, sensitive indicators in the environmental sector are underdeveloped. Data on socioeconomic surveys do not use questions for capturing vulnerabilities to climate change. Household surveys, electricity consumption, income and living conditions, and household budget surveys lack questions on adaptation. Efforts are made to evaluate the effects of climate change by using gender data but except for a few surveys there is no systematic data collection process. INSTAT, the main source of official statistics, has expanded the number of indicators related to gender and provides separate sections and publications on gender equality, such as Men and Women in Albania, but collects very limited information on issues related to capabilities.

The Ministry of Tourism and Environment (MoTE) has undertaken capacity-building initiatives in monitoring the environment, natural resources, and using IPCC software and greenhouse gas inventory, among other initiatives. Additionally, the National Agency for Civil Protection (NACP) provides reports on natural disasters at the central level.

In the Ministry of Agriculture and Rural Development (MARD), statistical data availability in Albania has remained stagnant since 2014. Data on farm structure, farm population, agricultural economic

accounts, and prices are still lacking. Farm survey data are primarily used for internal purposes, such as calculating national accounts, by INSTAT. A market information system is absent, and the Farm Accountancy Data Network (FADN) has not been established.

The Ministry of Health and Social Protection (MoHSP) has introduced new data collection requirements based on Order No. 428 (2016), on Approval of the Strategy Document on Sexual and Reproductive Health in the Event of Crisis and Humanitarian Emergency. No information is available with regards to the type of indicators and accessibility.

At the local level, data availability is limited. The Civil Emergency Plan for Municipalities contains minimal data, primarily the gender ratio of the population. According to a study by Janin et al. (2020), approximately 53% of municipalities have commenced data collection related to natural hazards within their areas. Only 75% of municipalities have established a database of the costs associated with damage caused by natural disasters. Additionally, fewer than half of the municipalities maintain a database of local private entities and civil society organizations (CSOs) that can be mobilized to provide support to affected communities and populations during civil emergencies.

1.2. Status of soils linked to climate change in agriculture

1.2.1. Brief estimation of exposure and sensitivity of soils to climate change and its influence on overall soil health

The Republic of Albania is in the Balkan Peninsula, located between 39^0 38' and 42^0 39' N latitude, and 19^0 16' and 21^0 40' E longitude. The north and northeast part of the economy borders Kosovo* and the Republic of North Macedonia, in the south with Greece, and in the west are the Adriatic and Ionian Seas. Total surface area of the economy is 28,748 square km, and of this area, only 16.2% is less than 100 m above sea level. Albania is a very mountainous economy, with many varied landscapes including bare rock and large extension of shrubs and forested areas. Agriculture is well distributed within the economy, but it is most intensive in the western coastal lowland. The total agricultural land area is about 696,000 hectares. Because of the differences in climate, natural vegetation, elevation, slope, and parent rocks, soils are highly diverse.

Due to its geographic position, Albania is in two diverse climate zones. The western lowland coastal areas are affected by Mediterranean climate, while in the remaining areas the climate is more typically continental. There are at least four main subdivisions that include the Mediterranean flat zone, the Mediterranean hilly zone, the Mediterranean sub-mountainous zone, and the Mediterranean mountainous zone.

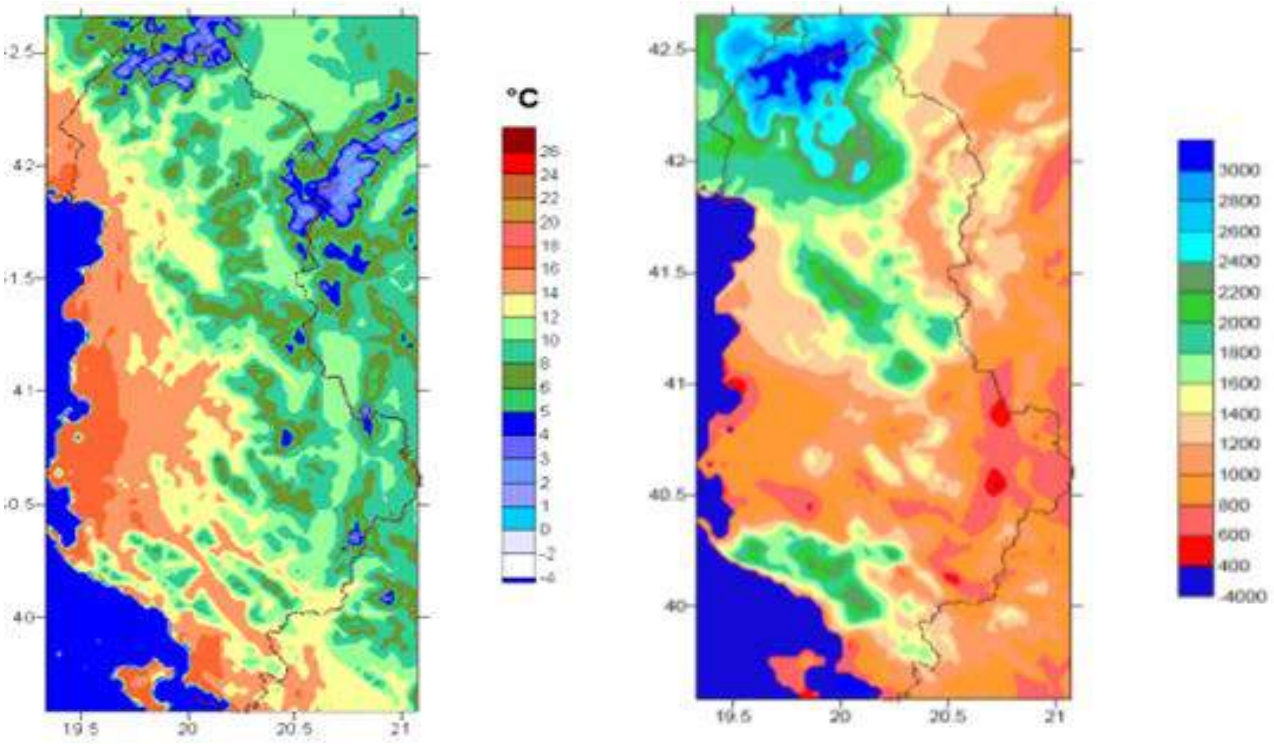
The flat zone which is mostly located in the coastal area, has relatively dry and hot summers with mean temperature of 26^0C and mean humidity of 60% in July and August. Winters are cool and wet with mean temperatures in December and January between 11.8^0C and 9.8^0C. Average annual rainfall of this zone is between 900-1,400 mm and more than 80% occurs during the rainy season from October to March. The central and northern part of the coastal area is wetter, especially in Shkodër where rainfall measures about 2,000 mm per year. A wide range of crops such as, cereals, vegetables, forage, fruits, and olives can be grown in this area. In terms of climate change, this area is experiencing drought and floods, especially the area of Shkodër that has been flooded continuously over the last decade.

The hilly area stretching from north to south and located on the eastern side of the coastal zone is divided into three parts: northern, central, and southern sub-zones. Hills reach an altitude of 300 to 500 m a.s.l. and have similar climate characteristics with the flat zone. Mainly fruits, grapes, and olives are cultivated there, but the yields are low because of lack of irrigation and advanced management technologies. **Droughts are more relevant for this area, while intensive rainfall accelerates erosion intensity.**

The sub-mountainous zone is comprised of highland plains in the South (for instance the plain of Korça) and small river valleys in Peshkopi, Kukës, Tropojë and Pukë. The altitude is about 800 m a.s.l. and mean temperatures 3-4^0C lower than the coastal plain with frequent frost. The plain of Korça has been a historically important agricultural area for Albania. **Nevertheless, it suffers mostly of water scarcity and climate change is making the situation worse.**

The mountainous zone, which covers all lands above 800 m a.s.l., has a continental climate. Annual precipitation is 1,000-1,800 mm, while in the Northern Albanian Alps exceeds 2,000 mm. Maximum summer temperatures are always below 25^0C, while minimum temperatures can be as low as -20^0C. This is an area covered mostly by forests and natural pastures. **The most common phenomenon of**

climate change for this area is the drastic reduction of snowfall that is associated with the reduction of water resources, even though overall this process is minor compared to other neighbouring economies and Albania has still no shortage of water resources (Zdruli and Cukaliev, 2017).



Map 1.1. Distribution of average air temperature (left) and average annual rainfall (right)

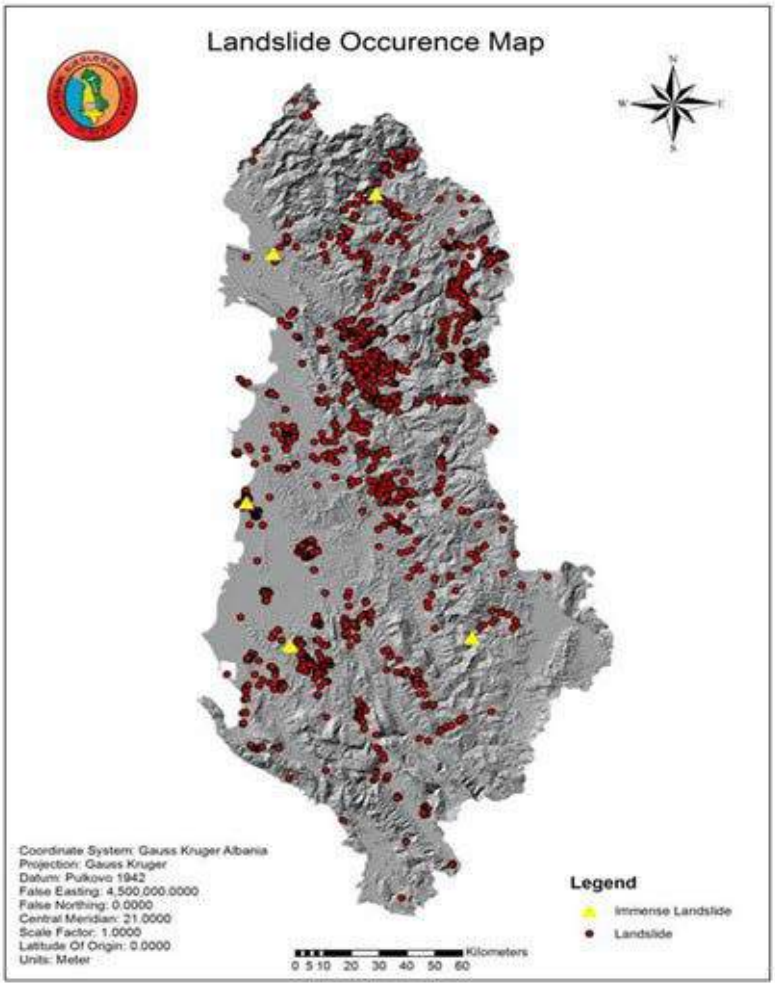
Source: Bruci, 2008

1.2.2. Short description of climate related events and soil degradation

Landslides are widespread in Albania and more than 9% of the economy's territory is prone to slope instability. Human activity is responsible for causing about 80% of historical landslides. The Albanian Geological Survey has developed the National Landslide Database which is the most comprehensive source of information on landslides in the economy. Landslide inventory map (Map 1.2) shows the current database with over 3,021 records of landslide events.

The largest landslides that have occurred in the recent years are: the landslide of Moglice (1977, Korça area) triggered by heavy rainfall, that destroyed more than 50 houses; in Gjirokastra city (2008) a destabilization due to man-made construction occurred and the landslide killed 3 people and 1 building was destroyed; in 2009 in Synej (Kavaja area) landslides triggered by heavy rainfall damaged 8 houses, roads and other civil infrastructures; in 2013 in Ngracie area, landslides triggered by heavy rainfall destroyed 13 houses, roads and other civil infrastructures (Jaupaj et al., 2015).

It is expected that landslides may increase mostly in the hilly and mountainous areas accelerated by the increased frequency of extreme rainfall events as it has happened for instance in Blinisht, Reps in Lezhe.



Map 1.2. Landslide inventory map



Picture 1.1. Landslides in Blinisht, Lezhe

Source: Top channel TV

The most affected districts are (in decreasing order): Mirdite (45 events), Mat (42 events), Librazhd (42 events), Kukes (40 events), Puke (40 events). The municipalities with the highest number of landslides are Rreshen-Mirdite district (19), Baz-Mat district (14) and Gjegjan-Puke district (11). More than 50% of municipalities have experienced at least one landslide in the last 20 years, while more than 59% for all recorded years.

Forest fires and droughts have been an ever-increasing problem in Albania with often catastrophic consequences. For instance, in 2021 hundreds of hectares of forests, shrubs and olives were burned to the ground. Many of them were deliberate, even though higher temperatures above 40°C also had an impact. These are important warnings that **climate change will aggravate the situation**. Climate change effects have increased the number and the intensity of fires in Albania. During 2006–2007 there were 352 major fires that burned throughout Albania's parks and forests, destroying entire ecosystems and pastures. In some areas tens of kilometres were left without seeing a single tree unburned – the fires also devastated entire forests. The fires can be attributed to higher temperatures in summer, **prolonged droughts**, and earlier melting of snow on the mountain caps. Since 2007, there have always been summer fires with devastating consequences, such as the one in 2022 that heavily damaged the Karaburun peninsula vegetation cover.



Picture 1.2. Burned forest in the area of Puke

Source: Emre Tazegul/AP/picture alliance

Floods, coastal erosion and erosive river flows, along with flash flooding in coastal regions are also common and will increase due to climate change. By 2030, it is predicted that approximately 32 percent of coastal areas will experience regular flooding, and large amounts of arable lands may be lost due to inundation and increased salinity[9].

Climate change in Albania shows the intrusion of sub-tropical climate further to the north, leaving coastal and southern areas very hot and dry during the summer season which is expected to have prolonged duration from near future to the end of the century.

9 Third National Communication of the Republic of Albania under the United Nations Framework Convention on Climate Change, June 2016

Another big problem that will be **aggravated due to climate change is desertification**. Zdruli and Lushaj (2000) and Zdruli et al., (2016) link deforestation with overgrazing, soil pollution, re-salinization, acidification, water logging, flooding, urbanization, soil sealing, nutrient mining, loss of soil fertility and accelerated soil erosion as perhaps the most alarming environmental problems in Albania.

Other climatic extreme events include also hail that creates extensive damage in various areas around the economy.

1.2.3. Overview of producers' adaptive capacities relevant for sustainable use of soils

The farming system in Albania is very diverse and in a process of profound transformation. While most of the farms are small, often with land less than 1 ha, on few occasions, a process of consolidation and creation of larger farms is ongoing. Sustainable land management techniques such as reduced tillage, no till, contour tillage, or strip cultivation are implemented in limited areas and farmers are not aware of them. In some cases, due to increasing costs of fuel, they have reduced tillage operations not for the sake of soil health status but for economic reasons. Another aspect that has become rather widespread is the cultivation of olives throughout hilly areas. They are designed in a good manner also considering the protection of soils from erosion. Overall erosion control measures are implemented in rare occasions (see Figure 5) and apparently this is not a priority for the majority of farmers.



Picture 1.3. Contour terraces in Mallakaster cultivated with olives

Fertilizer use has seen a drastic reduction after the war in Ukraine due to higher prices. It is unfortunate that in most cases fertilizers are used without any advice from extension services and mostly in an amateur manner. This has created problems of soil and water contamination, especially in greenhouses. Fertigation is used only in very sporadic cases in a few modern greenhouses and where pressurized irrigation systems have been established. It is worth mentioning that the Agricultural Technology Transfer Centre located in Fushë-Krujë has established a good relationship with many farmers around the economy and it is offering its services in support of soil fertility and nutrient management. Precision agriculture is not practiced anywhere in Albania. It was the intention of the Agricultural University of Tirana to establish a modern precision agriculture farm at their experimental site in Tirana but this project has been put on hold for the time being. If this becomes a reality in the future, it should be supported by intensive soil fertility testing as well as detailed meteorological data that are largely missing or hard to access throughout Albania.

Albania has had good experience in saline soil management in the past 30 years owing to efforts invested by the Soil Science Institute of Tirana. At that time experimental and scientific research has been conducted in 4 state farms located in Rremas Lushnjë, Spitalle Durres, Hoxhare Fier and Akerni Vlorë. After the political changes in the 1990s this experience was lost, and the area of salinity expanded further.

1.2.4. Outline of existing gaps and challenges to meet newly adopted EU strategic and legal documents on soil and adaptation

The most important piece of legislation related to soil management and land protection is the Law on Land Protection No. 9244, approved by the Albanian Parliament in 2004. However, the Law has been overall weakly implemented, especially in the first years after its approval. The situation has slightly improved lately, particularly in terms of restrictions to housing expansion into agricultural land in rural areas. However, infrastructure development continues to consume parts of fertile agricultural soils, especially in highly intense economic zones between Tirana, Durres, Fier, Vlorë, Kruje, Lezhe, Shkodër and in the vicinity of large cities.

Within the Law on Land Protection No. 9244 there are several regulations that determine the principles of soil management, soil fertility monitoring and appropriate agrotechnological measures to increase soil fertility. Rehabilitation of land that had been damaged by harmful impact of climate and human factors is also considered a priority. Nevertheless, the implementation of the Law and its regulations is still weak and soil protection needs further attention.

The Strategy for Agriculture, Rural Development and Fisheries 2021–2027 (SARDF 2021–2027) drafted by the Ministry of Agriculture in the frame of the GIZ-SRD Project "Support to MARD in the elaboration of the SARDF 2021-2027" and implemented by GFA Consulting Group, Hamburg, Germany notes that *no agricultural practices promoting soil conservation were identified at policy level in Albania* . The SARDF 2021–2027 raises several issues related to legal connections between rural development and soil management. They include the promotion of organic farming as a practice that also promotes soil quality, the Water Framework and Nitrate Directives even though Albania has no legal obligations regarding their implementation.

The approval from the EC of the Mission Soil Deal for Europe should have ramifications also for the non-EU member states such as Albania. This becomes even more imperative in the context of the EU Green Deal for the Western Balkans and Sofia Declaration that was inspired by the ambitious targets of the EU Green Deal. Based on this context, soil legislation in Albania is yet to be drafted and finalized in terms of maintaining and improving soil health.

The SARDF 2021–2027 raised concerns that *good agricultural practices are not systematically promoted in Albania*, and weak manure management is cause for soil and water contamination. Nitrates Directive has not yet been transposed. Consequently, there is no Code of Good Agricultural Practices and no Action Programme for the prevention and reduction of the nitrates pollution caused by agriculture. Therefore, continuing (IPARD) investments without imposing mandatory manure management may lead to a considerable increase in nitrates pollution and ammonia emissions. Furthermore, Albania did not report data on ammonia emissions from agriculture or reported uncorrelated data (such as agricultural soils – as mentioned in the Report for stage 3 in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings Directive for Albania, 2017)[10].

10 https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2017_s3/albania_s3_reviewreport-2017.pdf

Albania is committed by the Sofia Declaration on Green Agenda for the Western Balkans to increase administrative capacities implementing environmental obligations on monitoring, promoting, and enforcing compliance on EU biodiversity priorities that also include soils. This will be done by consolidating the advisory system for delivering information, advisory and training focusing on environmental conditionalities that are part of the Common Agriculture Policy (CAP). This will ensure that agriculture-related environmental baseline indicators can be developed**.** Unfortunately, Albania lacks most of these basic indicators. For example, the use of pesticides and veterinary medicines, definition of agricultural areas with high natural value, water quality and soil erosion by water are important indicators that must be developed. They are part of baseline indicators that should be made available for EU acquis alignment as well as for evidence-based policy decisions. To accomplish these targets, the development and implementation of the Land Parcel Identification System (LPIS) would be very useful. The LPIS should be combined in a GIS platform with the soil information system under development by the QTTB Fushë-Krujë to provide comprehensive information on soil quality and the cadastral system.

The SARDF 2021–2027 has put forward a set of actions that are relevant for soil management. They also include the use of IPARD III and national funds for co-financing afforestation of land vulnerable to soil erosion, which should be a priority. Furthermore, in the case of larger and more intensive farms, adopting modern agricultural practices with a focus on water conservation and soil protection should be implemented. In addition, there is need to support sustainable agricultural management practices, such as no-till, strip-till (especially on slopes), crop rotations with forage-legume crops, forest and woodland planting (including agro-forest belts and woody landscape features) especially in flat areas. Investments in new technologies, training, and advisory activities according to specific demands must be encouraged since currently they are weakly implemented. Higher efficiency in the use of fertilizers will require not only machinery, but also soil tests and training. Furthermore, while certain efficiency would be gained through the sustainable use of pesticides and improving nitrogen use efficiency, implementing environmental and especially climate change standards would be necessary.

1.2.5. Outline of sustainable measures and best management practices already applied for protection of agricultural land

Regarding natural soil constraints, Albania has about 25,000 ha of saline and sodic soils, 60,000 ha alkaline soils mostly in the western coastal area and acid (or low pH) soils on about 90,000 ha, largely distributed in the northeastern part of the economy. In addition, there are also magnesial (serpentine or smonitsa) soils on about 20,000 ha and heavy clay soils covering 60,000 ha (Zdruli, 2005; Zdruli et al., 2002) spread throughout the economy. Due to these constraints, **climate change is expected to have a major impact on saline soils that are expected to increase as well as on the reduction of soil organic matter, specifically soil organic carbon that could be reduced due to an increase in temperatures and acceleration of the mineralization process.**

All other soil constraints will not be affected.

Sustainable land management was a concept widely used during the period of agricultural collectivization in Albania. Anti-erosive channels and salinity management for instance were ordinary practices in areas affected by both erosion and salinity buildup. With the fall of the Communist regime in the 1990s and the process of privatization of agricultural land, and extreme land fragmentation created a type of chaotic agricultural system that still today suffers the consequences. In fact, for many farmers sustainable soil management is not a top priority when compared with production, yields and income. Issue is that the consequences of this process will be much higher in the medium term when

soil quality deteriorates and evidently the production will suffer. There are several examples of this, for instance in greenhouses higher accumulation of nitrates and salts deriving from excess use of chemical fertilizers has created soils that quickly lose their fertility level and productivity.

On the positive side, a very good example of best soil management in saline soils comes from a private company called Agro-Iliria that is cultivating pomegranates and goji berries on 100 ha of saline soils of Rremas in Lushnjë. Due to the success of this practice, the company has the intention to expand this cultivation to another 500 ha in the same area. The practices implemented include the creation of rectangular soil beds 30 cm high, mixed with organic manure to create a suitable substrate for the rooting system.

Furthermore, a well-designed fertigation system is in place to provide water and nutrients to the plants, while the drainage system is well maintained throughout the year, especially during the rainy season to accelerate the process of salt leaching. In summer, there is always the risk that salts could accumulate on the surface of the soil, but the rectangular beds reduce that risk. This is also supported by the rooting system of pomegranates and goji berries that does not penetrate deep saline soil layers; instead, it is mostly concentrated inside the rectangular beds.

Biodegradable plastic is used to cover the topsoil layer and conserve soil moisture. Finally, the careful selection of crop varieties is another part of the success. They are salt tolerant and, in the meantime, have a good market value not only for the oligo-mineral properties but also for the beauty of the fruits.

The success of Agro-Iliria Group is now consolidated, and the company has signed contracts with several supermarket chains in Europe and is already exporting large quantities of its products in the United Kingdom and other European economies.



Picture 1.4. The expansion of pomegranates on the Agro-Iliria farm



Picture 1.5. Employees of Agro-Iliria at work (left), goji berries (right)

1.2.6. Overview of the already adopted mechanisms and opportunities for effective adoption and adaptation measures for soil health protection

Agro-ecological principles are largely unknown in Albania and implemented only in sporadic cases. But the traditional way of farming mostly in hilly and mountain regions (Figure 8) indicates that even without being aware of such practices, many farmers already implement them. For instance, cultivation of vegetables with minimum use of chemical fertilizers is also typical due to their higher prices. Regarding fertilizer use, the main concern remains with the way they are used.

Most of the farmers do not perform chemical analyses for their soils and the use of fertilizers is mostly empirical. This creates problems of contamination in several areas. Furthermore, the efficiency of their use is very low, and therefore training activities are needed. In that context, it is very important that specialised centres like the Agricultural Technology Transfer Centre of Fushë-Krujë (ATTC Fushë-Krujë) must engage in a campaign to encourage farmers to conduct soil analyses. Moreover, it is strongly recommended that these analyses are either made at no cost to the farmers, or strongly subsidised.



Picture 1.6. Typical farming system of mountain regions showing a combination of forests, pastures and small agricultural parcels

1.2.7. Analysis of the current institutional and legal setup for effective adaptation of soils to climate change

The Ministry of Agriculture and Rural Development is the only governmental institution in charge of adaptation measures for sustainable agricultural and rural development in Albania. The Ministry collaborates also with the Ministry of Environment on issues related to soil management, as well as on estimating erosion control measures. The Ministry of Environment has financed in the past projects that have contributed to the assessment of soil erosion risk in the economy. After opening of the negotiations with the EU, both these ministerial institutions have been coordinating the work towards the completion of various chapters required for EU membership. The same is also true for the UN conventions Albania has signed.

Adoption capacities of Albanian institutions towards the implementation of sustainable land management practices are improving. There is an extensive network of agricultural technology transfer centres spread throughout the economy (i.e. Fushë-Krujë, Vlorë, Shkodër, Lushnjë, Korçe) that oversee transferring of advanced technologies to farmers. In addition, there are also extension services that do the same. It is worth mentioning that there is also a network of private consultants that own input facilities (pesticides and fertilizers), therefore they also provide technical support. Finally, the Agricultural University of Tirana too is expanding its activities towards providing support to farmers.

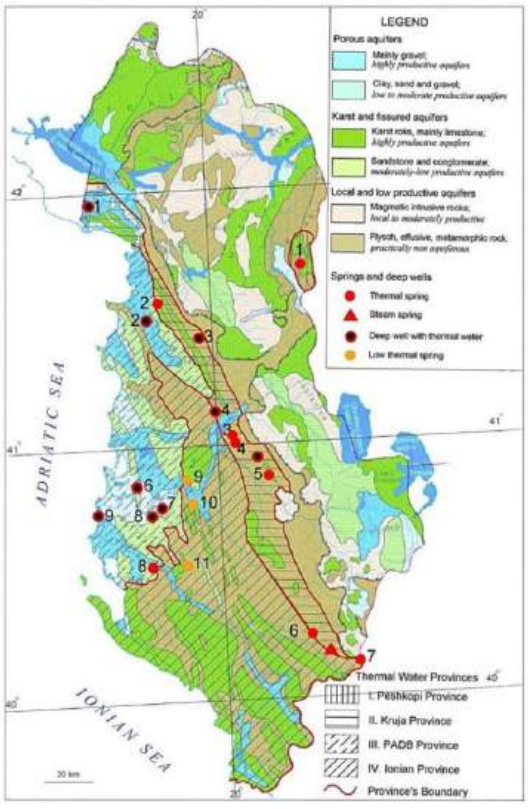
1.2.8. Existing soil data availability and quality: data constraints and data gaps

The national focal point for field soil survey, data collection, validation and GIS processing of soil information is the Agricultural Technology Transfer Centre (ATTC) based in Fushë-Krujë, 10 km north of Tirana. This institution is under the Ministry of Agriculture. The digital GIS database established by QTTB provides information on more than 400,000 ha of agricultural land and contains a set of soil characteristics, including exchangeable sodium per cent (ESP), electrical conductivity (EC), cation exchange capacity (CEC), topsoil fertility (pH, soil organic matter- SOM, available P, exchangeable Ca, K, Mg and Na), topsoil and subsoil structure, slope, flood risk, soil depth, topsoil stoniness, topsoil and subsoil texture, natural drainage, total available water, and erosion risk. The QTTB is equipped with a laboratory for soil, water, plant analyses and provides analytical services for farmers and/or clients. The Agriculture University of Tirana also has a very well equipped laboratory and provides services to farmers and other land users.

1.3. Status of water resources and their importance for agricultural production

1.3.1. Analysis of water resources in the economy and their importance for agricultural production

Albania is blessed with abundant water resources originating from numerous rivers, lakes, groundwater resources and coastal waters. The total water per capita is equivalent to 8,600 cubic meters per year. The mean annual discharge of all rivers is about 1,300 m³/s. This corresponds to a specific discharge 29 l/s/km², which is one of the highest in Europe. The total annual flow rate is 39,22 billion m^3/year (86% of the flow rate occurs between October and May) of which 95% is discharged into the Adriatic Sea and 5% into the Ionian Sea, despite a very limited amount is discharged also into the Black Sea (only 1.7% of Albanian's territory is part of the Danube basin). Underground aquifers contribute 23% of the annual total flow of water (Selenica, 2000, Selenica, 2009).



The climate in Albania is typically Mediterranean, marked by hot and dry summers and cold and wet winters. Average annual temperatures are variable, ranging from 7°C in mountainous zones to 15°C in lower western plains. The climate varies from one region to another with great contrasts in temperature, precipitation, solar lighting, and air humidity. The total mean annual precipitation over Albania is about 1,485 mm per year and declines from west (1,000 mm) to east and from north (up 3,000 mm per year) to south (600 mm). Precipitation levels follow a clear annual pattern, with the maximum in winter (70% October – March) and the minimum in summer (July and August). Albania is also rich in thermal waters (Map 1.3).

Map 1.3. Thermal waters of Albania

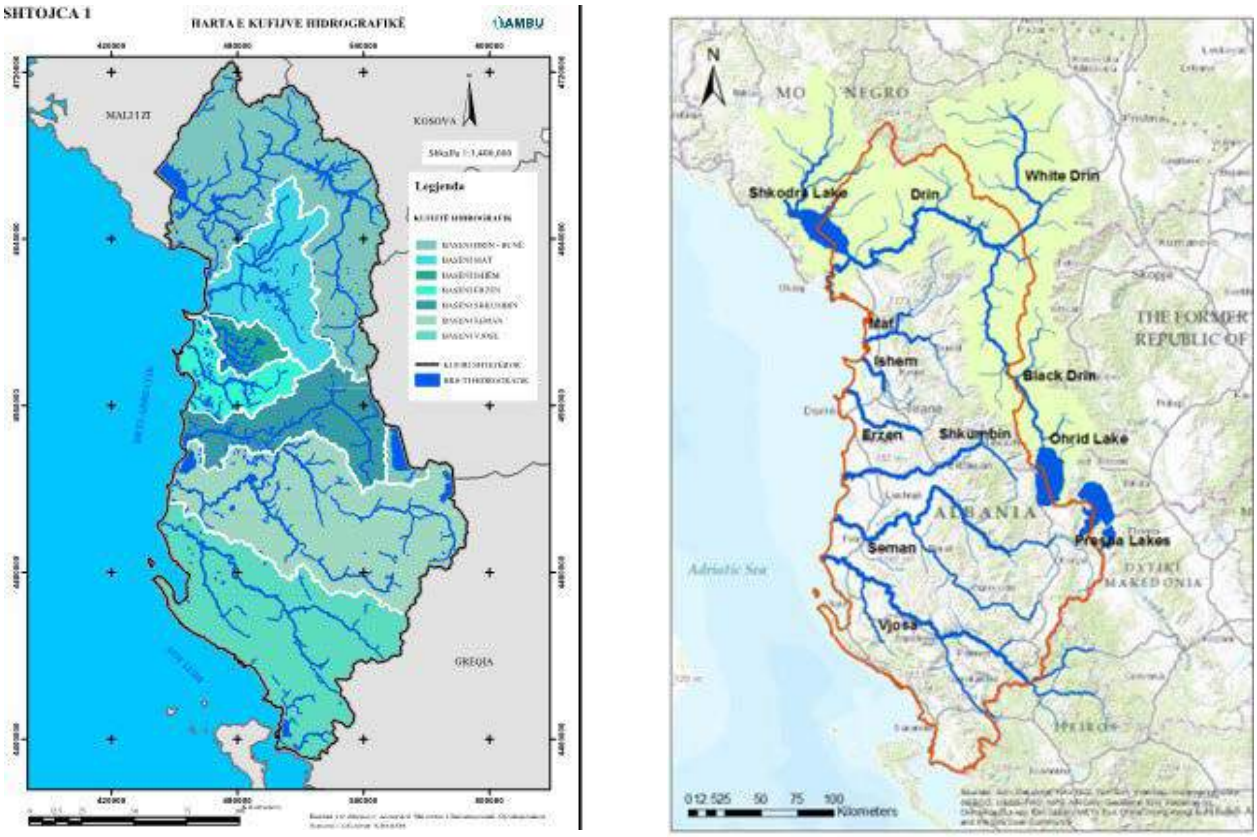
[Map of thermal water provinces of Albania and main thermal water springs and deep boreholes. Thermal water provinces: I-Peshkopia Province; II-Kruja Province; III-PAD Basin province; IV-South Ionian Province. Thermal springs: 1-Peshkopi, 2-Mamurras, 3-Elbasan (Llixha), 4-Hidraj, 5-Holta, 6-Përmet, 7-Leskovik, 8-Selenicë. Deep wells: 1-Dajç-2, 2-Ishmi-1b, 3-Shupal, 4-Kozan-8, 5-Galigat-2, 6-Ardenica-3, 7-Marinza-547, 8-Verbas-2, 9-Seman-3. Low thermal springs: 1-Karbunara, 2-Ura Vajgurore, 3-Kapaj. (based on IHM of Europe, Albania; sc. 1:1.5., EFTIMI, 2010]

Albania has six river basins described as Drin-Bune, Mat, Ishem-Erzen, Shkumbin, Seman and Vjose. (Map 1.4). Sixty-six percent of the areas of these basins is located within Albania and one third is in Montenegro, North Macedonia, Kosovo*, and Greece. This amount of water is essential for the reservoirs to store adequate amounts for irrigation during the summer growing season. Groundwater provides 80% of potable water used by the population.

In terms of water resources management, the economy is divided into seven[11] River Basin Councils with respective main office locations, as follows:

11 DCM No. 697, date 30 October 2019 on territorial and hydrographic defined boundaries of the river basins in the Republic of Albania and centre and composition of each River Basin Council.

- Drin-Buna Water Basin, located in Shkodra
- Mat Water Basin, based in Lezha
- Ishëm Water Basin, located in Durrës
- Erzen Water Basin, located in Tirana
- Shkumbin Water Basin, located in Elbasan
- Seman Water Basin, based in Fier
- Vjosa Water Basin, based in Vlora



Map 1.4. The hydrographic borders and transboundary river basins of Albania

[Left: hydrographic borders of the main river basins. Right: transboundary river basins. Source: AMBU based on the DCM No.697, date 30 October 2019 on territorial and hydrographic defined boundaries of the river basins in the Republic of Albania and the composition of each River Basin Council]

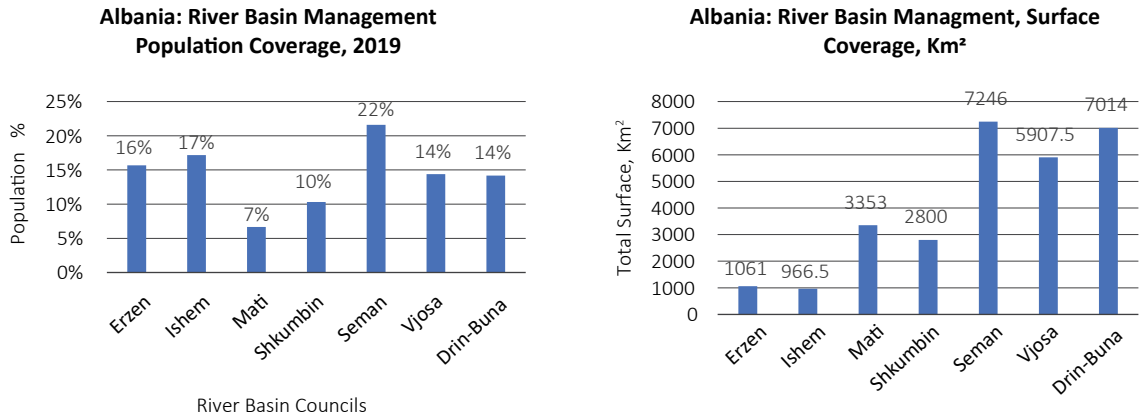


Figure 1.3. Population distribution and river basin surface area of major rivers of Albania

Source: Gjinali, Report of the Institutional Framework of Water Resource Administration and Management in Albania, April 2020

The largest population concentration is in the river basins of Erzen and Ishem (33%) that cover the densely populated areas of Tirana, Durres and Kruje. While the largest surface area is in the river basins of Seman and Drin-Buna (Figure 1.3). Much of the data is available at the River Basin Councils. They bring together numerous administrative units. Nevertheless, there is the need to update information on a regular basis.

The largest user of water resources is currently the energy sector with 14 billion m^3 of water whereby hydropower plants produce around 83% of the annual total electrical power generated in the economy. Irrigation uses approximately only 1 billion m^3 of water per year.

1.3.2. Brief analysis of the irrigation status in the economy

Agriculture plays a very important role in Albania. In 2021, it provided 50% of employment and almost 18% of Gross Domestic Product (GDP). Although there are abundant water resources and an annual average rainfall of 1,485 mm, agriculture is dependent on irrigation. Irrigated agriculture has a direct impact on increasing sustainable agricultural production, but water resources in Albania are predicted to decline by 14% due to climate change (Chenoweth *et al.,* 2011). Greater competition for water resources coupled with low level of technologies in use, weak organization of farmers, land fragmentation and low level of know-how will exacerbate the problems of farming systems and rural communities.

Agriculture is in a period of transition towards a more efficient system that produces more food, income, better livelihoods and ecosystem services with less water and other inputs compel not only the eco-innovative solutions leading to water conservation and savings in irrigation, but also to approaches such as the participatory irrigation management (PIM). Albania has attempted to decentralize the management of irrigation schemes to water user associations (WUAs), giving them decision-making powers and the responsibility to manage the irrigation system (Sallaku *et al.,* 2009). But the process has been associated with shortages and malfunction and water use efficiency remains problematic.

The agriculture system remains scattered over thousands of small farms, despite some small recent trends towards consolidation. Most Albania's farms (84 %) combine crop and livestock farming, with the rest having only crops. The main crops grown are forages (51%), wheat (18%), maize (13%) and vegetables (10%). Except for wheat all other crops are irrigated but the main method of irrigation applied in the economy is surface irrigation, where the furrow method dominates. This is an obsolete method that uses large amounts of water and water use efficiency is very low. On national scale, approximately 360,000 ha are equipped for irrigation, mainly belonging to the western lowland area. But less than 210,000 ha (30% of the total agriculture land) or less than 60% of the equipped area are irrigated. This is far less than the area that was irrigated until the 1990s. Practices are generally designed for seasonal irrigation with water quantities varying between 2,000 and 7,000 m^3 per hectare.

Albania has an estimated number of 626 reservoirs that provide 55.4% of irrigation water followed by rivers and lakes (44.3%) and groundwater only 0.3%. However, the capacity of storage in reservoirs has declined by 45% due to silt deposits. Many of them are in despair and in need of rehabilitation. Data from a World Bank funded project indicated that rehabilitating 410 dams would cost approximately $103 million USD. Since only about 20% of annual average rainfall occurs during the summer months, irrigation is indispensable while drainage and flood protection become necessary during the winter months.

At economy scale, the total length of irrigation channel network is 25,000 km, with 2,000 km of primary irrigation channels, 6,200 km of secondary irrigation channels, and 16,800 km of tertiary irrigation channels. The system of irrigation by open channels through gravitational irrigation has been designed with total water use efficiency from the source to the plant at about 70%, but practically this efficiency varies within 30% to 60%, which is quite low, and indicates large amounts of water lost. Irrigation has a direct impact on yield increase as shown by Figure 1.4 below.

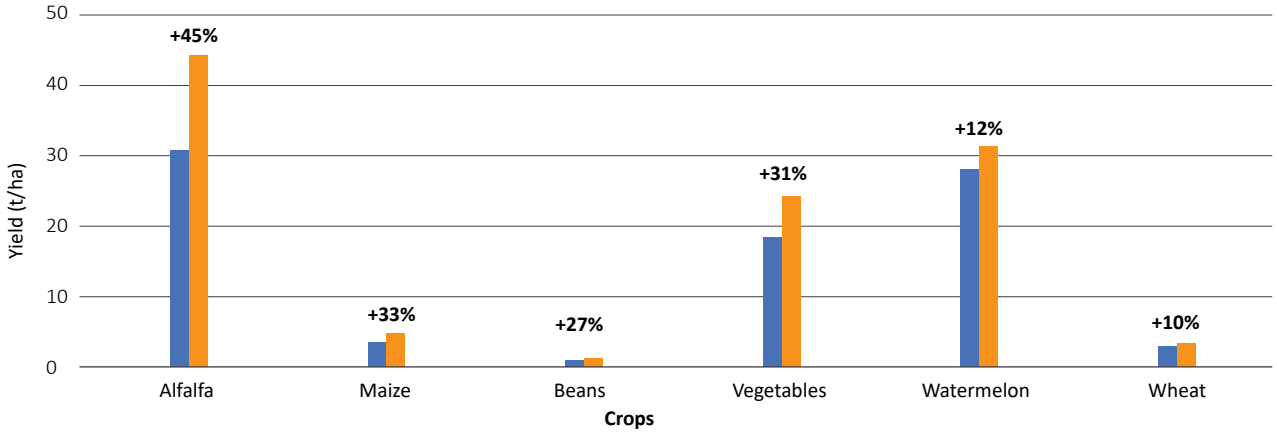


Figure 1.4. Impact of irrigation on crop yields

(blue – yields without irrigation, orange – impact of irrigation markedly shown)

The estimated total cost of rehabilitation and modernization of irrigation, drainage and flood protection infrastructure is about 557 million USD. The highest priorities are desilting of main and secondary irrigation and drainage canals, rehabilitation of 14 drainage pumping stations (hydrovors) in the western region, improving the capacities of all 27 hydrovors around the economy and equipping them with solar panels for energy production, conducting feasibility studies, and rehabilitation of irrigation, drainage and flood protection infrastructure. However, none of these investments will be cost-effective unless adequate maintenance and proper operations are ensured by effective institutions and management practices. This underscores the priority that needs to be placed on institutional reforms and capacity building.

The exploitation and utilization of water for irrigation and the ongoing trend of their increased use requires periodic evaluations of the utility and efficiency of water use. This will not be possible without developing effective methodologies and systems for assessing and improving the performance of irrigated agriculture.



Picture 1.7. Maintenance and cleaning of drainage canals in the region of Korçe

The performance of any irrigation system is the degree to which it achieves the desired objectives, i.e. productive and effective irrigation and drainage systems by providing relevant feedback to management at all levels (field, farm, irrigation sector, watershed). At each specific scale, agronomic and engineering aspects of irrigation management are compared by means of water demand and supply aiming at a balance of resources (Todorovic *et al.,* 2003). While in the past the improvement in irrigation performance was concentrated in hardware components (such as irrigation structures), with greater competition for other uses (industry, domestic, etc.) the need for improvement of software components, namely water use for agricultural practices, is steadily increasing. Albania has an urgent need to modernize its irrigation system and increase the efficiency of water use as described at Table 1.7 below.

Table 1.7. Summary of irrigation situation in Albania using the SWOT approach based on a World Bank funded project in the economy

Strengths	Weaknesses
Government is committed to invest in system rehabilitation and modernization Government commitment to strengthen the operational and management system(O&M) Deteriorated irrigation systems can be returned to their original capacity through investments in repairs, rehabilitation and maintenance	Small and fragmented farms make irrigation systems difficult to manage Experience with participatory irrigation management in Albania has been relatively unsuccessful and not sustained There has been a lack of commitment, support, accountability, and social cohesion among water users Water Users Organizations were unable to collect sufficient fees for O&M services Insufficient investment in routine maintenance and rehabilitation of irrigation systems Extensive damage and theft of pumps, electrical panels, and mechanical parts of pump stations for irrigation systems
Opportunities	**Threats**
Farmers and government support for the development of irrigated agriculture There are still sufficient water sources to restore the irrigated area to approximately 300,000 ha. Municipalities can provide essential support for irrigation service provision for secondary canals and financial management The Water Administration Directorate will provide management and support services to all stakeholders Cost-benefit and feasibility assessments for rehabilitation are positive overall	There is possibility in the future that inadequate maintenance of irrigation systems and rapid deterioration could make rehabilitation not yield the sustainable productivity needed Frequent rehabilitation will be unaffordable to the Government and could make Albania become too indebted to international financial institutions 45% of reservoir designed storage capacity is now filled up with silt

The Government considers rehabilitation and modernization of irrigation systems to be a high and urgent priority. In the short term, it intends to mobilize funds from the state budget to enable the

rehabilitation of irrigation systems serving 90,000 ha. Out of the 210,000 ha of existing irrigation systems, 90,000 ha need rehabilitation and 120,000 ha need improved maintenance. Furthermore, agricultural and agri-business support is needed in all irrigated areas. On 7 July 2023, the Government decided to take additional measures and invest 64 million EUR for the improvement and modernization of irrigation on 23,000 ha and 10,000 ha of drainage system in the economy. Part of this investment will be used for other activities.

Following the collapse of the Communist regime and state farms, Participatory Irrigation Management (PIM) programmes were initiated in Albania with financial support from the World Bank (under IBRD Loan No.1211-AL) with the objectives of restoring highly deteriorated irrigation systems. The projects included four components, system rehabilitation, institutional development and capacity building, policy support, and project implementation support. The summary of the output of these projects is presented in Table 1.8.

Table 1.8. MARD irrigation rehabilitation projects for the period 1994–2019

		Projects (phases)		
		I	II	III
Fund	Mill. $	45.62	42.49	39.32
Rehabilitated irrigation infrastructure	Ha	100,149	52,000	36,000
Rehabilitated drainage infrastructure	Ha	109,968	92,000	34,500
Rehabilitated dams for irrigation	No.	3	25	33
Assessed and monitored dams for safety	No.	26	25	195
WUA set up and assisted	No.	212	144	107
FWUA set up and assisted	No.	15	9	
Irrigated surfaces transferred to WUA/FWUA	Ha	90,063	83,000	110,331

Source: Albanian Ministry of Agriculture and Rural Development (MARD)

The overall achievements of project objectives were considered as satisfactory, where, alongside the rehabilitation of numerous schemes with irrigation service area of 188.149 hectares, substantial increase in agricultural production at farm level was achieved. Project impacts (based on a sample of about 700 farms) indicated satisfactory impact on yields, thus increasing farming productivity and farming income by up to 85% and reducing rural poverty, and thereby the sustainability of irrigation and drainage management. Moreover, the projects made substantial achievements in the provision of farm equipment (e.g. excavators and dredgers) for the maintenance of large irrigation and drainage canals as well as provided technical assistance and training for WUAs through a demonstration programme for improved on-farm water management.

1.3.3. Drought and flood risk assessment and crop water requirement

Under the IPCC A1B emissions scenario, it is predicted that Albania will be exposed to an average temperature increase of 2°C in summer and in winter, with an 8% decline in annual precipitation for the period 2030-2049 compared to the years 1980-1999 (World Bank, 2021). The decline in rainfall is likely to be higher in the summer season, followed by autumn and winter. In summer, precipitation is predicted to fall from 5.6 to 8.0% by 2025 and 9.1 to 20.0% by 2050, while rainfall in winter will be relatively stable with precipitation to decrease from 0 to 1.6% by the year 2025 and 0 to 1.8% by 2050. Sea level is also predicted to increase by 20-24 cm by 2050 and 48-61 cm by 2100 (World Bank, 2021). These projections will induce enormous pressures on farming systems and rural communities, not only in agricultural production, but also for animal health, food, farming, and livestock related

infrastructure. Consequently, if adaptation options are implemented, risks related to climate change and food security could be minimized altogether.

It is predicted that the temperature increase would also affect drought that is defined as a period when an area experiences reduced rainfall that results in much less soil moisture, or even groundwater. The end effect is cropping failure and food insecurity. Droughts can last for weeks, months, years or even for decades and the longer they last the greater their damages would be. The most severe impact they have on the local population is the lack of water, both for drinking and irrigation.

Another form are the flash droughts or dry spells with a surprisingly rapid onset due to climate change with a devastating impact. They are increasing quickly especially over Europe and in Albania, even though detailed data are missing. A study of Kerpaçi and Abullahu, 2021 found out great disparities between northern and southern regions of Albania in terms of rainfall distribution and consistently those affected mostly by drought. They include the coastal plans and the valley of Korça in the southeast of the economy. Overall, the northern area, especially Shkodër, is characterized by larger amounts of rainfall.

Floods are also a very big problem for Albania. The percentage of communes that experienced at least one flood is about 54% of all communes. There has been a general increasing trend in the last 20 years. At least one flood occurred every year in the economy with an average of nearly 23 events per year. Though mortality has decreased in the last 20 years, floods are continuing to cause deaths at an average rate of more than one person per year with a maximum of 9 persons killed in 1995. The statistics for the last 20 years show an average mortality of 0.05 per event, with a maximum of 5 deaths per event.

Floods and flash floods have high impacts on buildings: nearly 40 houses per year have been destroyed by floods in the last 20 years and 1,200 houses were damaged. Floods and flash floods also have a big impact in the agricultural sector, causing damage to on average more than 7,000 hectares of land every year, with a maximum of more than 40,000 hectares. The average hectares damaged per event are around 300 ha, with a maximum of 20,000 ha for a single commune in a single event (World Bank, 2021). The average economic losses per year are estimated to be around 370 mill. LEK (3.2 mill. $), with a maximum of 4 billion LEK (35.2 mill. $) in 2010. More than 17% of the communes in Albania have registered economic losses in the last 20 years.

The Albanian monitoring network consists of more than 125 meteorological stations located all over the economy with a long observed period, 175 hydrometric stations and experimental stations, especially in the Lushnja region with an observed period of about 10 years. Evapotranspiration evaluation is based on the observed period 1961-1990. National topographical maps of 1:25,000 scale were used to evaluate the morphometric characteristics.

Potential Evapotranspiration values vary from 890–1,080mm in the lowlands, 850 mm in the hilly areas and 800–850 mm in the mountain areas. Real evapotranspiration values for the lowlands are about 700 mm, 650 mm for the hilly areas and 500–540 mm for the mountain areas. The Pluviometric Deficit in Albania varies from about 200 mm in the coastal area to 2,500–3,000 mm in the mountains (Bardhi et al., 2012).

As a result of the specific physic-geographical conditions of the Albanian territory, the principal natural factors that influence evapotranspiration processes are a) climate regime and b) morphometric conditions of the territory. To this end, the Albanian territory is classified into three areas> I – field areas situated in the western Lowlands in Lushnjë, Durres; II – hilly areas Peshkopi, Burrel and III – mountainous areas Korçe, Erseke (Figure 4).

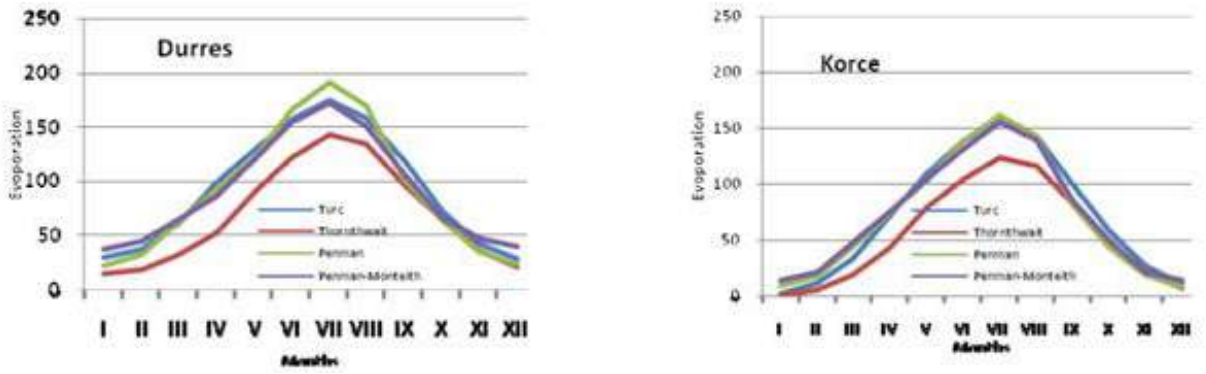


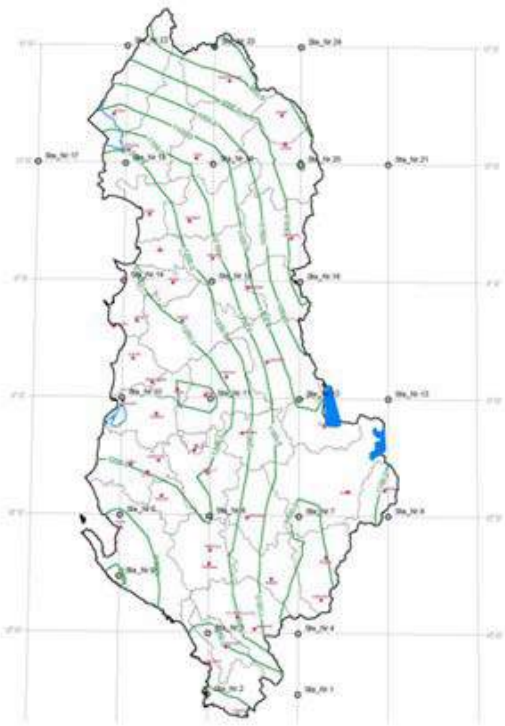
Figure 1.5. Evapotranspiration data for Durres and Korçe

The principal results of the evapotranspiration evaluation of the Albanian territory (Laska Merkoçi, et al., 2010) are summarized as follows:

- Annual evapotranspiration distribution is generally characterized by a typical Mediterranean nature.
- The scheme of classification and division into homogenous sectors is based on the evaluation and determination of the natural factors participating in the evapotranspiration process.
- Region is accepted as the smallest taxonomic unit.

The map below shows the annual reference evapotranspiration outcomes for Albania.

Albania's climate follows the economy's topography, with temperatures and precipitation varying by altitude and distance from the sea. Most of the economy's rainfall occurs between November and March, with lower amounts during the June to September growing season. Analysis of data from the World Bank Group's Climate Change Knowledge Portal (CCKP) provides historical information for the period 1901–2020. Mean annual temperature for Albania is 11.6°C and average monthly temperatures ranging between 21°C (July–August) and 1°C (December–January) and mean annual precipitation is 1,019.8 mm, with steady rainfall occurring throughout the year.



Map 1.5. Annual Reference Evapotranspiration isolines (ETo) layers per station (mm/year)

Data show that Albania has experienced an increase in mean annual temperature of 1°C since the 1960s. Temperature increases have been observed to be higher in the summer months. Heat waves across the eastern Mediterranean are expected to increase in intensity, duration, and frequency, possibly by as much as six-to-eight times per year (USAID, 2016). As Albania has continued to develop, rapid urbanization and population increases have also been observed to experience increasing Urban Heat Island (UHI) impacts during summer seasons and high-heat days. Key urban and economic zones, such as Tirana, are coming under increasing pressure from UHI and related heat-stress experienced (Republic of Albania, 2016).

Table 1.9. Summary of main climatic data for Albania for the period 1991-2020

Climate variables	1991-2020
Mean annual temperature (^{0}C)	11.6^{0}C
Mean annual precipitation (mm)	1,019.8 mm
Mean maximum annual temperature (^{0}C)	16.7^{0}C
Mean minimum annual temperature (^{0}C)	6.5^{0}C

1.3.4. Overview of farmers' existing adaptive practices for proper water use under climate change

Albanian farmers are aware of the benefits of irrigation. Improvements have been made in intensive horticulture cultivation with the introduction of drip irrigated pressurized systems. Other such improvements are available in almost all greenhouses that have expanded enormously over the last years. Many of them also implement fertigation methods. On the other side, field crops such as maize and forages are still being irrigated by furrow gravitational methods where, obviously, the efficiency is low. Overall, farmers are not aware of the risks deriving from climate change and therefore additional awareness activities are needed.

1.3.5. Summary of national strategies and adaptation plans for water use in agriculture

Regarding the use of water resources, the National Water Council (NWC) is the central decision-making authority that determines national policy on water resources. NWC has a Technical Secretariat as its executive authority. The main law pertaining to water resources is the Law no. 8093 of 21 March 1996 on Water Reserves, as amended by the Decision of the Council of Ministers no. 273 of 7 May 2004, and approved as the National Water Strategy. The ministries responsible for the management of water resources in their respective sectors are the Ministry of Agriculture and Rural Development, Ministry of Environment, and other relevant ministries. Under the authority of these institutions, there are several agencies and institutions using, exploiting, and monitoring various water resources. At the local level, six river basin authorities, covering the entire territory of the economy divided into six water collection basins, are operating. Meeting the needs of various users for water to the effect of economic and social development on one side, and environmental protection on the other, makes integrated water resource management increasingly indispensable.

Albania has improved its water sector both in terms of legal and regulatory frameworks. The Government has approved the National Strategy on Integrated Water Resource Management (2018–2027) in February 2018. The National Strategy is built on five strategic objectives, which include sustainable use of water resources, attainment of good water quality in all water resources by the year 2027, disaster risk reduction and management of drought and floods, increase of sound scientific knowledge on water and climate issues, and application of inclusive and sustainable water management practices that yield equitable profits to all involved stakeholders. The challenges the economy must face regarding water quality are exacerbated by a growing demand for water resources in some parts of the economy where inland waters are the scarcest. The capacity of public water companies to manage essential services in delivering drinking water and wastewater treatment remains low. Management plans for Drin-Buna and Semani River Basins were approved by the National Water Council in February 2020. Lack of investment in flood protection, irrigation and drainage infrastructure has exacerbated the damage and losses from heavy rainfall; this was especially pronounced in 2014, 2015, and 2016 floods (World Bank, 2021).

Albania approved its National Strategy on Irrigation, Drainage and Action Plan 2019–2031, which

identifies the primary strengths, weaknesses, opportunities and threats to irrigation, drainage, dams and reservoirs, and flood protection across the economy. This strategy supports the optimization of investments in irrigation, drainage and flood protection in order to expand and increase sustainability of all irrigation systems, in order to meet the needs for drainage, and to protect the Albanian people and their property from flooding.

1.3.6. Overview of the political and institutional setup, and legislative framework for adaptation activities relevant to the water sector

The water sector is organized as a two-tier system, with national government being responsible for sector strategies and policy development, and basin institutions for the integrated services of water resources provision. Therefore, this section provides a summary of the institutional framework that is currently in force to administrate, manage and regulate water resources in Albania. The institutions are:

The National Water Council (NWC) is the central decision-making authority in the field of water resource administration in the Republic of Albania (DCM 590, date 18.0.2017). The National Water Council (NWC) is the main inter-institutional body chaired by the Prime Minister of Albania, Deputy Prime Minister and six line ministers such as:

- Minister of Tourism and Environment
- Minister of Agriculture and Rural Development
- Minister of Infrastructure and Energy
- Minister of Finance and Economy
- Minister of Interior,
- Minister of Health and Social Protection

The Water Resources Management Agency[12] is the executive authority of NWC recently established in the Prime Minister's Office, responsible for the development and implementation of policies and strategies related to integrated water resources in Albania, ensuring effective functioning and monitoring of the entire integrated water system in the economy. River Basin Management Offices are under the Water Resources Management Agency. The agency also plays the role of Technical Secretariat for the National Water Council.

River Basin Councils (RBC) are set up under the DCM No. 697, dated 30October 2019 on the approval of territorial and hydrographic boundaries of river basins in the Republic of Albania and the composition of their councils, while four River Basin Management Offices (4)[13] were set up under the National Agency of Water Resources Management. The Head of the RBC is the Prefect of the region where the centre of the river basin is located. The Secretary of the RBC is the Head of the River Basin Management Office.

In general, each River Basin Council is composed of:

- Municipality representative, appoint by respective Mayor
- Regional central government offices, such as the Regional Environmental Agency (Ministry of Environment), Directory for Protected Areas (Ministry of Environment), Local Health Care Units (LHCU, Ministry of Health) and Irrigation and Drainage Directorate (Ministry of Agriculture).
- Interested groups from different service fields

The governmental structure in charge of water management in Albania is illustrated in Figure 1.7.

12 DCM No. 221, dated 26 April 2018 on the Organization and Functioning of the Water Resources Management Agency
13 Prime Minister Order, dated. 1 October 2018 on the Water Resource Management Agency Structure Approval

1.3.7. Data availability and quality, data constraints and data gaps

Much of the data related to the water sector are based at the Ministry of Agriculture. But the website of the Ministry provides very limited information on water issues. As of 6 July 2023, there are only three laws dating back to 2016 and 2017 regarding water legislation. Some data are also available at the Agricultural Technology Transfer Centre in Fushë-Krujë. Unfortunately, the Institute of Statistics do not provide data on water, neither for irrigation nor drainage.

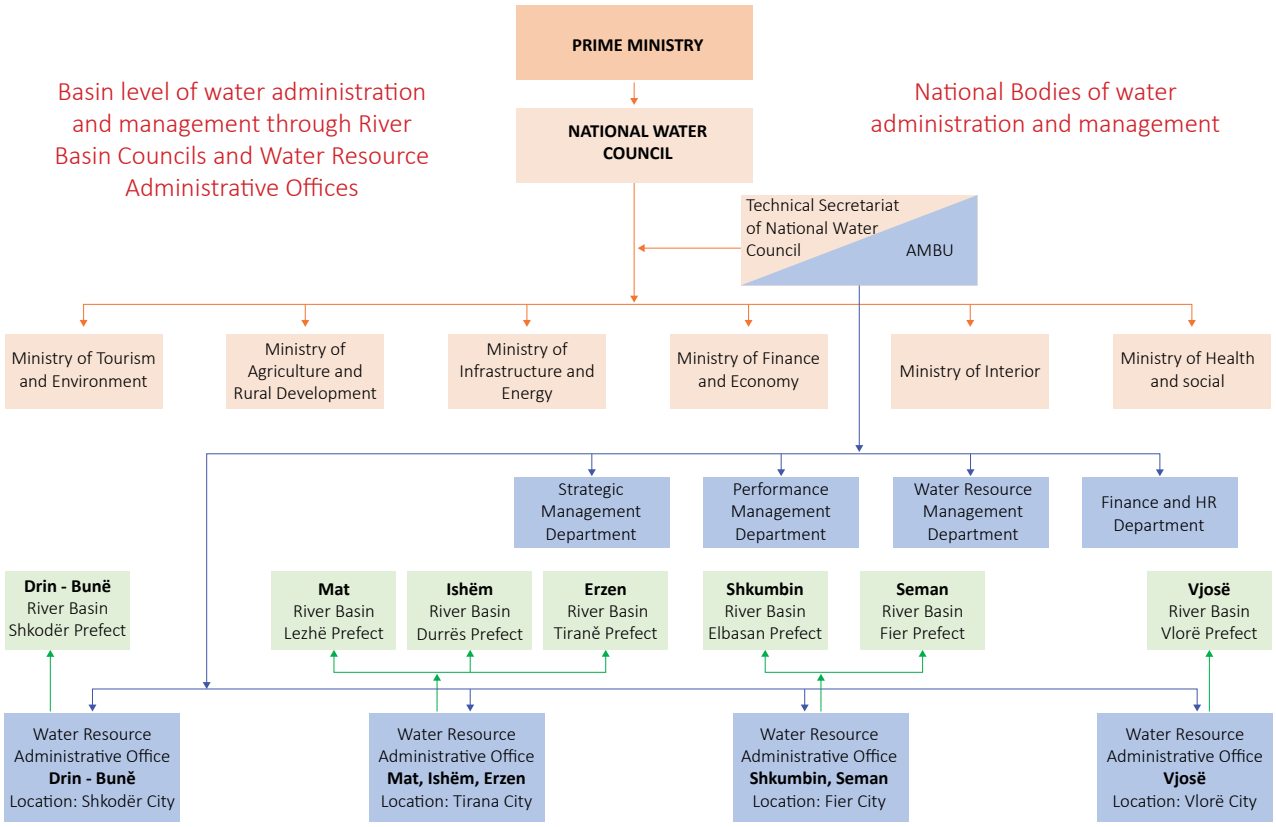


Figure 1.6. Governmental structure in charge of water management in Albania

1.4. Crop production analysis linked to climate change in agriculture

1.4.1. Analyses of the meteorological data availability and accessibility

Meteorological data is the essence of climate change analyses. The meteorological network in Albania is owned by the Institute of Geosciences (IGEO), a national scientific research centre in the field of regional and applied geology, seismology, meteorology, hydrology, and the environment. The Institute of Geosciences, monitors and evaluates natural hazards such as earthquakes, storms, avalanches, floods, droughts, fires, active tectonics, massive mass movements, soil erosion, etc., with the aim of risk reduction.

IGEO owns and uses the national data archive of meteorology, both analogue and digital formats, to accomplish operational and strategical support towards civil protection structures, as well as to support scientific research and academic activities. The institute is responsible for generating, updating, modernizing, and securing the national data archive. In this regard, it should play a key role in providing data for climate change studies.

Meteorological monitoring in Albania is carried out through surveys with manual and automatic meteorological stations. The activity in the field of meteorological monitoring in Albania started with the first observations at the meteorological station in Durrës in 1868 but the hydro-meteorological service was created in 1949. Since that time, the distribution of manual meteorological stations has come to a wider spread on the territory, improving according to the standards of the World Meteorological Organization (WMO).



Map 1.6. National network of meterological stations

The map shows the spatial resolution but information on the temporal resolution for each station or for the entire network was not made available by IGEO. Data from manual stations are measured in a classic way, every day, in the constant presence of an observer. Nowadays, manual meteorological stations are divided into three categories of stations, pluviometric, meteorological, and climatic. Pluviometric stations measure a set of elements such as rainfall height, snow, hail, or other elements such as frost, dew, fog, cloudiness, etc. Meteorological stations have a wider range of elements, including temperatures, precipitation, wind direction, wind speed, etc. As for the climate stations, they measure the complete set of climate elements, including sunshine, atmospheric pressure, air humidity, surface and deep soil temperatures, etc. All the units of measurement follow the WMO standards (see Annex 1.4).

Automatic meteorological stations have their own categorization according to the typology of the meteorological station. These can be pluviometric, thermometric and pluviometric, or with a wider range of elements and measurements with fairly short time intervals. These stations work by archiving measured data or by broadcasting in real time through various computer programmes and providing more complete meteorological monitoring, increasing opportunities for more in-depth scientific research to be closer to the social and economic needs of the economy. Data from these stations are

required for analyses of more complex indicators and for advanced crop modelling and estimating crop response to changing weather.

IGEO publishes a monthly climatic bulletin (72 bulletins so far but only 2 bulletins published for 2023) which aims to provide scientific information on the meteorological situation for each month as well as in the climatic context, to provide estimates and tendencies on climate change in Albania. The bulletin contains:

A synoptic assessment and some key features from the meteorological point of view that characterize the analysed month

Meteorological data which, after being checked, digitized, verified and processed according to the scientific technical standards of WMO mainly for air temperature, atmospheric precipitation, etc. is reflected in the form of charts, maps, etc., in order to give an estimate and clear idea of the time and space distribution for the economy

Comparison with the rate values referring to the period 1961-1990 or other periods of time to enable the conclusion to be made on how the various climatic elements are moving in the perspective of climate change for Albania (surface air temperature anomaly; mean air temperatures and their anomalies)

Based on the information and scientific climate assessment products from the world's most recognized scientific professional centres, provides estimates for the medium- and long-term forecast of the expected situations for the coming months following the date of each bulletin broadcast

Two short sections on agrometeorology and climate change (see next section)

The last columns of this bulletin relate to the coverage of various information related to scientific achievements in the field of meteorology or the climate in particular, not only in Albania, special events such as the World Meteorological Day, results of scientific research or different subjects realized by students under the scientific leadership of the department

Although IGEO is a research institute under the Polytechnic University of Tirana (PUT), meteorological datasets covering historical and current periods are not available even for research purposes. This has impacted or hindered several authors or institutions (i.e. World Bank) to use such datasets for studies or reports on climate change, assessment of crop response in the future, and for designing and testing adaptation practices. Some authors who have published some climate change scenarios have used datasets from WorldClim or other sources.

Other meteorological stations have been financed by various donors but after the end of the project they have failed to provide meteorological data due to lack of maintenance.

1.4.2. Analysis of the most common agrometeorological indices available and used in the national context

For a couple of decades, an agrometeorological bulletin was published to help public or private agricultural advisors or farmers understand better the weather and its effects on crop production. Such publication was discontinued and instead a short section about agrometeorology was included in the monthly climate bulletin referred to above. In this section they report indices like NDVI for the vegetation, Standardized Precipitation Index (SPI) for drought, the sum of active temperature above 10°C threshold and evaporation, beginning and end of growing season (vegetation period). However, the presentation is rather illustrative, for one region, is not presented in every bulletin and there are no tables or annexes with raw data to be used by researchers. More importantly, these are not related

to main crops. As a result, farmers rely solely on privately funded or neighbouring economy sources for meteorological information.

No datasets are provided online for these indices. Other indices like growing degree days or chilling units for main crops, etc. are not reported. Some researchers from IGEO have published some papers on chilling units for the area of Korça, important for the production of apples.

1.4.3. Analysis of phenological monitoring

Phenological monitoring offers crucial insights into the observed alterations in crop growth patterns and the appearance and duration of various phenological stages. Elevated temperatures and accelerated temperature accumulation have the potential to trigger earlier initiation of growth, premature flowering, abbreviated growth phases, and a reduced period for biomass accumulation, among other effects. Analysing historical records provides a comprehensive view of how crops have responded to annual weather variations and aids in anticipating their future behaviour. This data is invaluable for making informed decisions regarding agricultural practices in the face of changing climate conditions. By closely tracking these phenological shifts, we can better adapt and optimize our approaches to crop management and cultivation strategies.

It is reported that there are 13 phenological stations but there is no official information on the indices measured. There is no systematic phenological information from other sources. The only phenological information that could be retrieved was from USDA's Foreign Agricultural Service and only for the beginning and end of the growing season of winter wheat and maize.

1.4.4. Analyses of crop models used for estimating crop response to climate change

Crop modelling can provide valuable data on crop response to changing weather, as well as to changing agricultural practices. Moreover, crop models can provide numerical outputs on predicted crop yield in the future and provide data for other (farm models, economic models and cost-benefit analyses) that can estimate expected damages and gains caused by climate change and adaptation measures.

The use of modelling in agriculture is minor, only limited to research, i.e. AquaCrop, CropWat, CropSyst, etc. Other models have been used for erosion, water dynamics in the soil, evapotranspiration, etc. Other researchers from agrarian economics have used models for research but listing them goes far from the scope of this chapter as they are not related to climate change.

Several reports and papers have shown estimates or scenarios on climate change in Albania and potential effects on agriculture or several crops or the potential for introducing new subtropical or tropical species.

1.4.5. Analysis of extreme weather events

There is high confidence that extreme weather events such as drought, floods, late spring frost, hail, fires, etc. will become more frequent and more severe in the future. IGEO has long-term systematic monitoring and records of extreme weather events, at least since the 1950s (see Annex 1.4). In recent years, there have been some studies especially related to floods by analysing rainfall data. However, in general, they do not provide information regarding effects on agriculture. Other studies have pointed out an increase in days with excessive heat or night heat events. The Ministry of Agriculture and Rural Development keeps records about damages in agriculture caused by floods, late frosts, hails, and storms.

1.4.6. Information on the most important crops sensitive to climate change, vulnerable regions and their combination

There are no specific studies to assess the sensitivity of crops to climate change in Albania mainly because reliable fine-scale time series for yield data are difficult to access. Few studies or reports have analysed climate change in the last 20 years and future climate scenarios impacting a few main crops.

The most important crops in terms of cultivated surface are maize, winter wheat, alfalfa, tomato, watermelon, dried onion, apple, grapevine and olive. Annex 1.4 provides an overview of climate change on these crops.

Agriculture is one of the most climate-sensitive of all economic sectors. Albania is one of the many economies where the majority of the rural population depends on agriculture, directly or indirectly, for their livelihood. The risks associated with climate change pose an immediate and fundamental problem in the economy. In this case, we will make references to areas prone to floods, drought, day or night heat, late frosts or hail and climate scenarios. Average temperature during the growing season of most plants will likely remain the highest in lowland and coastal areas of Albania. The main crops affected will be vegetables, especially in protected culture which constitute the most intensive sub-sector of Albanian agriculture. Such products are using marketing windows which are now shifting due to climate change. Moreover, radiation and excessive heat may damage the quality of the products. Other affected crops in lowlands are grapevine, olive and cereals (see Annex 1.4 for the effects of climate change on these crops).

Temperature increase will be substantially higher following topographic gradients. According to climate models, we should experience an increase in the number of day heat events in the future. Heat events will also likely become more severe, i.e. they will affect larger parts of the region at once. They will tend to become frequent in spring and autumn. Night heat events will also become more frequent and more severe with future climate warming. In contrast to day heat, night heat events will largely occur only during July and August, and not during spring or autumn.

Precipitation during the growing season is expected to be higher only in the Shkodra region which is an area prone to floods (see Annex 1.4). These will affect mainly crops like maize, grapevine and field vegetables. For the rest of the territory, the amount of precipitation will decrease with future climate warming. Heavy precipitation events are characterized by daily amounts of precipitation above 20 mm. Such events can happen all year round and seem not become more frequent or more severe with future climate warming. However, there is a slight increase in the amount of more severe events during the months from April to September, particularly in the mountainous terrain and where heaviest precipitation events occurred during the historical baseline period. As expected, increases will become more restricted to the months December to February, and will become less likely during November and March.

The northeastern and southeastern parts with a colder climate and much favourable for the cultivation of apples and sweet cherries are affected almost every year by hail and every two or three years by late frosts causing a drastic reduction in production. Warming can also reduce the number of chilling hours causing irregular fruit bearing for temperate fruits like apples and pears in particular.

1.4.7. Information on practices used by farmers to protect their crops from damages caused by weather variability (hot weather, drought, excessive water, hail, intensive sun, etc.)

Albanian farmers have already identified several climate stressors of concern, including temperature stress, water quality, drainage, and extreme weather events. Frequently farmers autonomously adapt their practices to the weather variability and they have experienced how to react to changing weather. However, besides reports of such practices during interviews, there are no consistent records of such autonomous adaptation practices. For instance, during heat waves, hot, dry winds lasting as little as two to three days can be a major risk, and affect both the quality and quantity of production. One farmer explained that he tries to cover his watermelons in hay to reduce sun and heat damage.

Droughts are also a primary concern. Because the irrigation and drainage infrastructure are often non-functional, farmers have very limited capacity to adapt to droughts.

Climate change is also associated with rising sea levels by adding coastal flooding, resulting in land losses and increased groundwater salinity. This will affect one of the most productive and intensive agricultural areas, coastal lowlands. Farmers are trying to substitute groundwater sources with water coming from reservoirs or springs.

1.4.8. Information on climate change adaptation measures and practices already tested/ promoted in the economy or established in national documents related to climate change and agriculture

The main reference for adaptation measures to climate change is the joint study by the World Bank and the Government of Albania, titled *Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change – Impact Assessment and Adaptation Options*. The study identifies and prioritizes options for climate change adaptation in the agricultural sector, both at national and agroecological zone level. At the national level, the most important measure is *to increase the access of farmers to technology and information, both generally and for adapting to climate change*. Achieving this goal will necessitate engaging in capacity-building initiatives to enhance both research and extension services. These efforts will be crucial in promoting superior agronomic practices directly on farms. This entails not only wider adoption of demonstration plots but also ensuring farmers have access to comprehensive information regarding the availability and optimal management of high-yielding crop varieties. Additionally, it is imperative to implement strategies aimed at sustaining yields in the face of more frequent instances of extreme water stress, a trend anticipated with ongoing climate change. It is worth emphasizing that allocating resources towards extension services yields a notably high benefit-to-cost ratio.

The next adaptation measure is *to improve dissemination of hydrometeorological information to farmers*. It is imperative to allocate sufficient funding and direct the IGEO efforts towards effectively communicating climatological information to farmers. In the short run, there is a pressing need for enhanced capacities and a more farmer-centric institutional approach to facilitate improved decision making at the farm level. Looking ahead to the medium term, these enhancements will also play a pivotal role in informing sound policy decisions in Albania.

Another adaptation measure is to *improve information collection and dissemination on soil types, drainage potential, and crop suitability*. The Agricultural Technology Transfer Centre (ATTC) in Fushë-Krujë, and other ATTCs operating across Albania, should strengthen their evaluation of soil data. This data should be more closely aligned with both national policy endeavours and localized farmer education initiatives. Notably, ATTC is on the verge of releasing assessments regarding the suitability of crops, which will serve to inform national policies and directly benefit farmers. This step will synergize

with others aimed at enhancing drainage infrastructure. Additionally, employing crop modelling in conjunction with detailed soil information on a spatial scale has the potential to be a potent tool for effectively directing investments in infrastructure.

An additional adaptation measure at the national level is to *encourage private sector involvement to most efficiently adapt to climate change*. The economic analysis underscores a compelling incentive within the private sector, as the gains from implementing measures to enhance the climate resilience of Albanian agriculture far outweigh the associated costs. Therefore, it is imperative for the national government to concentrate on establishing policies that facilitate effective private sector involvement in adaptation efforts. This could involve activities like evaluating seed and livestock varieties for their suitability to Albania's climate, terrain, and soil conditions, and subsequently offering recommendations for the most suitable options. However, the actual provision of these varieties could be left to the private sector.

1.4.9. Information on measures from the national agricultural policy and the national systems for support to agriculture, which can relate to climate change adaptation

Climate change is referred to in the vision of the Strategy on Agriculture, Rural Development and Fisheries (SARDF) 2021–2027, *enable an efficient, innovative and viable agri-food and fisheries sector in Albania in a position to better withstand national and international market pressures and respond to the challenges of climate change and sustainable natural resource management, while improving the quality of life of rural residents and increasing the attractiveness of rural areas*. One of the four general objectives is strengthening sustainable management of natural resources and climate actions. The specific objective is contributing to climate change mitigation and adaptation, as well as renewable energy. The SARDF objectives with their specific interventions contribute to the achievement of SDG 13 of the UN Agenda 2030. Another major international commitment to which the SARDF is directly linked is UNFCCC.

The National Plan for Climatic Change Mitigation promotes to conserve and increase the content of carbon in arable lands, encourages sustainable agricultural practices, introduction and protection of agroforestry practices and green infrastructures in agricultural areas and encourages the use of agricultural waste. All the practices of increasing of organic matter in the soil would increase the resilience to climate change. This includes the use of biochar, which helps to achieve mitigation goals and at the same time provides adaptation benefits.

The Monitoring of the Action Plan 2019-2021 and the National Strategy on Climate Change 2020-2030 envisages a specific programme to support new agricultural technologies, or seed variety adaptation to climate change and draft river basin management plans.

The Fourth National Communication of Albania on Climate Change (2022) foresees to improve energy efficiency in agriculture (tractors, irrigation, biomass), improve manure management systems and implement agro-forestry practices on agricultural land.

The revised Nationally Determined Contributions 2021 urges the increase of greenhouses, tunnels and hail protection systems, promoting plant breeding programmes, which focus on the development of new cultivars adapted to climate change (drought and cold resistant), application of crop rotation practices in the flatland areas of the economy, as well as planting perennial crops in hilly and mountainous areas.

The Albania's First Biennial Update Report 2021 sets targets related to the increase in the number of certified organic farms and farmers benefitting from irrigation infrastructure (for the complete list of actions see Annex 1.4).

1.4.10. Brief analysis of the current infrastructure and systems for preventing and mitigating the negative effects of weather extremes on crop production

A good part of large plains used for agriculture are located at sea level, in areas prone to floods. As it has been reported in Annex 1.4, there have been some floods affecting more than 10,000 ha. Before 1990, there have been high investments in drainage systems. Changes in land ownership, lack of maintenance and cleaning of drainage canals has resulted in increased damages from floods. After the flood of 2010, there have been several investments planned to mitigate the negative effects of floods. Some donors have supported the infrastructure of IGEO to monitor the weather in the upper Drini basin in order to forecast heavy rains which would flood the area mentioned above.

Hail events have also intensified and with increased frequency in the last decade. In the past, this phenomenon was quite rare and would not justify the investment in hail nets for apple and cherry orchards (the most important fruit trees). Currently, an increasing number of fruit growers are installing hail nets. Until such investments cover the areas under risk, crop insurance could be considered.

Frosts are also a frequent phenomenon but there are no early warning systems, or systems for regular monitoring and forecasting at the regional or national level, with the exception of a few private service providers that apply crop scouting in very small zones.

The current agricultural extension service is not oriented toward ameliorating risks from climate. Although the service aims at covering the entire economy, it has little or no capacity to advise on adapting agricultural systems to climate risks. Agricultural research capabilities are expanding but have few connections to extension. The Agricultural Technology Transfer Centres, or ATTCs, conduct research and demonstrations on farms with a division of responsibilities by crop. However, these centres have yet to focus on climate change as a major risk to agricultural production, and are not as effectively coordinated with the extension service or the Agricultural University of Tirana as they could be.

Many farms are small (average size of 1.3 hectares) and have limited resources for adaptation investments. Agricultural markets are limited too.

1.4.11. Existing data availability and quality

The ability to collect, generate, and provide meteorological data to farmers is very low. IGEO is the only institution in Albania responsible for observation, processing, including quality control and maintaining/processing climate data. Although there is an official meteorological network with a good coverage of the territory, meteorological data are not freely available or at least on request for research purposes or policy. IGEO has not made such datasets available to the World Bank for preparing studies on the impact of climate change on agriculture and adaptation strategies. IGEO records data, but their quality cannot be assessed as long as these datasets are not available. Due to increasing demands for high quality climate-related data, there is a need to strengthen the capacities of IGEO, in particular for the maintenance of monitoring stations and data processing. There is also need for general support, additional staff, funding, and technical equipment.

Regarding crop yield data, these are available at NUTS-3 level. For the main crops, there are historical data since the 1930s. However, there are no long-term studies or observations that would enable to link climate change with yields.

1.5. Livestock farming analysis linked to climate change in agriculture

1.5.1. Livestock farming and climate change

Albania registers 298,000 cattle of which 261,000 cows, 1,373,000 sheep of which 1,085,000 lambing ewes, 722,000 goats of which 563,000 lambing goats, 137,000 pigs of which 12,000 sows, and 6,848,000 poultry. In Albania, cattle production primarily utilizes intensive and semi-intensive systems. Only a small portion of cattle, primarily in mountainous regions, are raised in pasture-based systems. Sheep and goat production predominantly employs pasture-based systems, with some incorporating transhumance practices. Pig production is concentrated in specific regions of Albania, where traditional small-scale, extensive pig farming practices prevail. Intensive pig production remains limited in scope. Poultry production for both egg and broiler meat is exclusively confined to intensive systems with controlled environments.

Climate change poses a significant threat to animal production and well-being. Extreme weather events, such as heat waves, storms, hailstorms, and floods, have increasingly disrupted livestock operations in recent years. These events directly impact animal health and productivity, and they also indirectly affect animal well-being by diminishing forage production and pasture quality.

1.5.2. Meteorological data availability and accessibility

The IGEO is the institution responsible for the collection, processing, and safeguarding of meteorological data. It holds the national meteorological data archive, encompassing both analogue and digital records. This comprehensive resource serves as the foundation for operational and strategic support to civil protection infrastructure, while also underpinning scientific research and academic endeavours. The institute shoulders the responsibility for generating, updating, modernizing, and safeguarding this invaluable national data archive. In light of its central role in meteorological data management, the IGEO is positioned to make a pivotal contribution to climate change studies.

Meteorological monitoring in Albania is carried out through surveys with manual and automatic meteorological stations. According to indirect information, the institute has a network of 120 meteorological stations that collect data. The stations collect data on a variety of meteorological parameters, including: temperature, pressure, humidity, wind speed and direction, precipitation, snow depth, solar radiation, etc.

The collected data are processed by the institution itself, but are not open to the public. The institute is not cooperative and ready to share data with other interested parties. The IGEO website says that there is a monthly bulletin for public use, but it cannot be found.

1.5.3. Extreme weather events

Albania is a economy that is highly vulnerable to extreme weather events, such as floods, droughts, heat waves, and storms. In recent years, the economy has experienced an increase in the frequency and intensity of these events, which is attributed to climate change.

A list of extreme events recorded during the last years is shown in the four tables attached as annexes to this report. The tables show the events of heavy rains, floods, extreme cold, and extreme heat that occurred in Albania during the last years

In addition to these specific events, Albania has also experienced a number of other extreme weather events in recent years, such as heavy snowfall, hailstorms, and tornadoes. The impacts of extreme weather events on livestock in Albania are significant.

1.5.4. Heat stress risk assessment for ruminants, pigs and poultry

The Albanian Institute of Meteorology, Hydrology and Seismology (IMH) (www.igeo.edu.al) calculates and publishes THI on a daily basis. However, the data are not accessible.

According to the collected information, there is no systematic monitoring of the effects of extreme weather events on livestock in Albania, but there are some initiatives underway to improve data collection and analysis in this area.

Search shows that there are no studies on the effects of climatic stress on livestock in Albania. Overall, there is a growing recognition of the need to improve data collection and analysis on the effects of extreme weather events to livestock in Albania. The initiatives that are currently underway will help to address this gap and provide valuable information for developing and supporting effective adaptation strategies for farmers and policymakers.

Although research on the presence of new diseases may be lacking, some outbreaks are believed to be linked to climate change, as the populations of transmitting vectors depend on climatic conditions. For instance, Crimean-Congo haemorrhagic fever (CCHF), a viral disease transmitted by ticks, poses a threat to humans, potentially causing severe illness and death. Efforts to mitigate harsh winters, associated with climate change, can increase the survival rates of CCHF-carrying tick larvae, elevating the risk of outbreaks. Conversely, colder periods can negatively impact tick populations, reducing the likelihood of CCHF outbreaks.

Another example is blue tongue disease, a non-contagious viral disease affecting ruminants and transmitted by biting midges. While it does not directly endanger public health or food safety, blue tongue disease can result in substantial financial losses due to decreased productivity and animal deaths. Currently, the disease is widespread in Albania.

1.5.5. Overview of farmer's' existing adaptive practices

With rising global temperatures, livestock farmers face the challenge of safeguarding their animals from extreme heat stress. Heat stress not only impacts animal welfare but also negatively affects productivity and reproductive performance. To address these concerns, farmers have implemented various strategies to mitigate heat stress and ensure the well-being of their livestock.

A crucial aspect of heat stress management is ensuring adequate water intake for animals. Farmers provide ample water throughout the day, particularly during the hottest hours. Water availability during all days is becoming a widespread practice even in the old type of stables. This increased water availability allows animals to maintain their body temperature through evaporative cooling.

During the hottest midday hours, farmers stable their animals to reduce their exposure to direct sunlight. Stables provide a cooler environment, shielding animals from intense heat and reducing their heat load.

Various measures have been implemented to improve air circulation and ventilation in existing stables, such as enlarging ventilation openings to enhance airflow, or trimming surrounding vegetation to promote natural ventilation.

In the construction of new stables, farmers prioritize natural ventilation designs. These designs incorporate features such as strategic placement of windows and doors to maximize airflow, use of open-sided or partially enclosed structures, orientation of the stable to capture prevailing winds.

An innovative approach adopted by some farmers is the installation of showers in their stables. These showers provide cows with a refreshing spray of water, allowing them to cool down and alleviate heat stress.

Some adaptive practices in small ruminants applying grazing systems have been identified. Shepherds graze their animals near water sources and water ponds. They have a long-standing experience of grazing management that is being used effectively to adapt flock movements to easily access water sources and use natural shade during the hot hours of the day. Dry summers, which bring early diminishment of water sources and ponds, require the adaptation of herd movement to places with access to water. Changes in the availability of water sources, as well as the reduction of the number of animals and consequently the decrease of pasture load has mainly led to undesirable alterations to the vegetation plant structure. Adaptation of movement and displacement of flocks is also done in the function of changes that the pasture vegetation is undergoing.

Outdoor broiler rearing systems rely on open environments to provide chickens with access to sunlight, fresh air, and exercise and sometimes some pasturing. However, this approach is only feasible during favourable seasons and when temperatures are moderate. When extreme heat or harsh weather conditions prevail, chickens are kept indoors to protect their health and well-being.

Farmers often manage heat stress by reducing the density of chickens in closed environments. This measure helps improve air circulation and reduce the risk of overheating. However, reducing stocking density also leads to increased costs per unit of production.

In conventional poultry farming for egg production, chicken is housed in controlled environments, with temperature and ventilation control systems that maintain a consistent microclimate, which ensures normal production, regardless of external weather conditions. As a result, extreme temperatures primarily affect production costs indirectly, through factors such as increased energy consumption for heating or cooling poultry houses.

Pork production in Albania is limited, with traditional family-based systems predominating in certain regions. These systems lack sophisticated management practices and adaptive measures to cope with extreme weather conditions. Currently, there is no available data on the implementation of specific techniques or measures tailored to address extreme weather events.

1.5.6. Summary of national strategies and adaptation plans, reports, R&D, projects and communications to UNFCCC (adaptation)

The main document on climate change in Albania is the National Strategy on Climate Change (2016-2030) and Action Plan (NSCC), approved by the Albanian Government in July 2019. NSCC is a national policy with a cross-sectoral approach and has two annexes: the National Action Plan on Mitigation (NAPM) and the National Adaptation Plan (NAP). NSCC focuses on three main components of climate change in Albania: mitigation measures, adaptation measures and sustainable development.

The monitoring of NSCC 2020-2030 and the Action Plan 2019-2021 envisages a specific programme to support new agricultural technologies, or seed variety adaptation to climate change and drafting of river basin management plans. There is no specific reference to livestock.

The monitoring of the Action Plan 2019-2021 deals with livestock in Chapter 4, Assessment of Adaptation Measures in the Agriculture and Rural Development Sector in two priority actions: Priority Action 7, Irrigation, Drainage, and Flood Protection, where livestock is referred to indirectly as a consequence of floods, and Priority Action 9, Adaptation in the Agricultural Sector – Measure 4, Establishing Standardized Environments for Livestock, to Control the Vector-Borne Transmission of Diseases. What are the measures taken to reduce livestock morbidity due to parasites? Even though Measure 4 is related to livestock, there is a complete lack of data on interventions implemented within this Measure.

The National Adaptation Plan Framework (2020): This framework provides guidance on the development of a NAP in Albania. It includes a number of steps that need to be taken, such as:

- Conducting a vulnerability assessment
- Identify adaptation options
- Prioritize adaptation measures
- Develop an implementation plan

The reference to livestock is only in terms, but no concrete action is foreseen.

In addition to the NSCC, there are a number of other important documents related to climate change in Albania. These include:

- The Climate Change Law (2020), which sets out the legal framework for climate change action in the economy. The Law deals mainly with carbon and greenhouse gas emissions. There is no substantial part of it that deals with adaptation to climate change. Livestock is not mentioned at all.
- The National Greenhouse Gas Inventory Report, which provides information on the economy's greenhouse gas emissions. The GHG calculations from AFOLU sector are done by using the IPCC 2006 software (version 2.691), which integrates the previously separate guidance in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for Agriculture and Land Use, Land-Use Change and Forestry. This integration recognizes that the processes underlying greenhouse gas emissions and removals, as well as different forms of terrestrial carbon stocks, can occur across all types of land. It recognizes that land use changes can involve all types of land. This approach is intended to improve consistency and completeness in the estimation and reporting of greenhouse gas emissions and removals. The IPCC 2006 software integrates both, agriculture and FOLU in one sector.

The Albanian government has also submitted a number of reports to the UNFCCC on its climate change adaptation activities. These reports include:

- National Frameworks and Plans
- Albania Post-Disaster Needs Assessment (2020)
- National Strategy on Water Resources Integrated Management 2018–2027 (2018)
- Third National Communication on Climate Change (2016)
- National Strategy on Development and Integration (2013)
- Second National Communication to the UNFCCC (2016)
- Third National Communication to the UNFCCC (2021)
- Biennial Update Report (BUR) to the UNFCCC (2020)
- Fourth National Communication to the UNFCCC (2022). This report includes the impact of climate changes on livestock, which is explained below.

Expected impact of climate change on livestock. The potential climate change impacts on livestock include, among others: water availability, expected change in forage production yield, spread of pests and diseases, heat stress, existence of rare and/or local breeds, and expected changes in animal production.

Vulnerability assessment is conducted for main livestock categories. The maximum risk level is rated at-5 while the lack of impact is rated at zero.

Based on the analysis done above, it turns out that sheep and cattle will be more affected in lowland Agro-ecological Zones (AEZ) as heat stress, water availability, pests and diseases and forage production are very limiting factors and have a significant impact on this category. North and central mountain AEZ is expected to have the lowest level of impact as the impact of forage production is lower. Goats are expected to be affected mostly in lowland and intermediate AEZ as the stress from heat and lack of water will be more evident in these two areas. The least affected categories are expected to be pigs and chickens. The south highland AEZ is expected to be more affected by diseases as the vectors of their spread are affected by global warming in the south-north direction.

1.5.7. Policy and institutional setup and legislative framework for adaptation activities

The Ministry of Tourism and Environment (MoTE) is the lead government agency responsible for climate change adaptation in Albania. It is responsible for coordinating and implementing adaptation policies and measures, as well as for providing scientific and technical support.

The MoTE is supported by a number of other institutions, including:

- The Inter-Ministerial Working Group on Climate Change (iMWGCC), which is a permanent coordinating body for climate change issues (leadership and coordination)
- The Climate Change Unit (CCU), which is the national UNFCCC focal point and is responsible for fulfilling Albania's duties under the UNFCCC
- The State Environmental Inspectorate, which is responsible for identifying and responding to environmental issues, including climate change
- The National Environmental Agency, which is responsible for permitting, environmental impact assessment, and public information
- The Ministry of Industry, which is responsible for developing and implementing policies to reduce greenhouse gas emissions
- The Ministry of Agriculture, Rural Development and Water Administration, which is responsible for developing and implementing policies to adapt to the impacts of climate change in the agricultural sector
- The Ministry of Infrastructure and Transport, which is responsible for developing and implementing policies to adapt to the impacts of climate change in the infrastructure sector
- The Ministry of Urban Development and Tourism, which is responsible for developing and implementing policies to adapt to the impacts of climate change in the urban and tourism sectors

These institutions work together to ensure that Albania is prepared to adapt to the impacts of climate change. They collect data, develop policies, implement measures, and monitor progress.

Institute of Geosciences is a national scientific research centre in Albania in the field of regional and applied geology, seismology, meteorology, hydrology, and the environment.

The National Centre for Forecast and Monitoring of Natural Hazards (NCFMNH), a structure of the Institute of Geosciences (IGEO), aims to fulfil the operational tasks of monitoring, analysis and forecasting of hydro-meteorological phenomena and forest fires in the economy; informing authorities and the public in time in case of hydro-meteorological events and forest fires; data archiving and documenting extreme events; and supporting research activities of the Department of Hydrology and Meteorology.

According to the collected information, there is no systematic monitoring of the effects of extreme weather events to livestock in Albania. However, there are some initiatives that are underway to improve data collection and analysis in this area.

Investment and funding opportunities. Here are some specific examples of funding organizations that support adaptation activities in Albania:

- The Green Climate Fund (GCF) is the world's largest dedicated fund for climate change adaptation and mitigation. The GCF has approved several projects in Albania, including a project to develop the national climate change adaptation plan.

- The Global Environment Facility (GEF) is a multilateral fund that supports developing economies to address global environmental challenges, including climate change. The GEF has supported a number of projects in Albania, including a project to develop climate-resilient agricultural practices.

- The European Union (EU) is a major donor of climate finance to Albania. The EU has funded a number of adaptation projects in Albania, including a project to develop the climate adaptation strategy for the agriculture sector.

Another EU-funded programme is Improving National Early Warning System and Flood Prevention in Albania. The programme started on 01 January 2017 and ended on 01September 2021, with the overall objective of ensuring increased resilience to floods in Albania by strengthening the National Early Warning System and improving disaster prevention in line with EU good practices.

EU IPARD programme is a good opportunity to support adaptation to climate change through better tailoring measures and criteria for adaptation to climate change.

- The German Agency for International Cooperation (GIZ) is a government agency that provides development assistance to developing economies. GIZ has supported a number of adaptation projects in Albania, including a project to develop drought-resistant cropping systems.

- The United Nations Development Programme (UNDP) is a UN agency that supports developing economies to achieve sustainable development. The UNDP has supported a number of adaptation projects in Albania, including a project to develop climate-resilient early warning systems.

Insurance opportunities. Albania's low insurance penetration imposes considerable burden on public finances, with the budget being the only line of defence in case of extreme weather events and natural disasters. Non-life insurance penetration is low compared to peers. Despite an increase in recent years, the Albanian Financial Supervisory Authority (AFSA) estimates that only 3 percent of properties are covered against extreme weather events and natural disasters. On the other hand, disaster relief programmes are costly and take limited resources away from more productive investment, especially given Albania's high public debt and gross financing needs. With the assistance of the World Bank, the authorities are preparing to pass legislation that will make disaster insurance compulsory. (IMF 2022)

There are still areas of national environmental policy that are yet to be implemented effectively. Albania does not have an umbrella policy framework for environmental protection; the recent Environmental Impact Assessment Directive is not always fully enforced, and a national strategy for air quality is yet to be adopted. There is also a need to adopt a climate policy consistent with the EU 2030 framework.

1.5.8. Identification of gaps

Many materials and documents were used for this report. There are a number of documents covering national strategies, adaptation plans, reports, and projects, as well as communications for the UNFCCC. There are also many documents that describe the political, legislative and management levels, political institutional setup, and the legislative framework for adaptation activities. All these documents and materials were sufficient for completing the legal and policy frameworks. However, most of these documents deal with mitigation measures, and only a few of them deal with adaptation to climate change. References to livestock are very limited.

The situation is completely different with regards to meteorological data availability and accessibility. Even when meteorological data exist, they are not accessible to most interested actors. On the other hand, data on the impact of climate change on livestock are mostly missing or inaccurate.

Based on the collected information, here are some gaps in existing data availability and quality on climate change in Albania regarding livestock:

- There is a lack of data on the specific impacts of climate change on livestock farming in Albania, such as the effects of heat stress, drought and flooding on animal health and productivity.
- There is limited data on the adaptive practices that farmers use to cope with the impacts of climate change on their livestock. This information would be valuable for developing and supporting effective adaptation strategies.
- There is a need for more data on the costs and benefits of different adaptation practices, so that farmers can make informed decisions about how to adapt to climate change.
- There is a lack of data on the vulnerability of different livestock farming systems to climate change. This information would be essential for identifying the most vulnerable systems and developing targeted adaptation strategies.
- There is a lack of recognition among research institutions of the critical importance of prioritizing research on climate change impacts on the livestock sector and the efficacy of farmer-led adaptation practices.
- Extension services and Agricultural Technology Transfer Centres (ATTCs) demonstrate limited understanding of climate change impacts in the context of adaptation.

1.6. Conclusions and recommendations on climate change adaptation in agriculture in Albania

Analysis of climatic data by various independent studies for the last 20 years demonstrate higher temperatures, decreased and more variable precipitation, reduced river runoff, increased frequency and severity of extreme events, etc. Climate scenarios for the next decades predict an exacerbation of these phenomena, therefore adaptation is the only way out. Albania appears among the most sensitive European economies to climate change. Since agriculture accounts for about 20% of the GDP and almost half of total employment of both women and men (the highest in Europe), climate change effects on the agriculture sector might also impact the wellbeing of rural communities that depend on this sector. Global climate change will impact mostly smallholder farmers (more than 80% of farms in Albania can be considered small farms or smallholders). Their vulnerability to climate change comes from various socioeconomic, demographic, and policy trends limiting their capacity to adapt to change.

The Strategy on Agriculture, Rural Development and Fisheries (SARDF) 2021–2027 is more environmentally ambitious. As a result, environment, climate and biodiversity-related support measures are eligible to receive higher aid intensity. However, modern climate change adaptation measures including best practices for sustainable farming are currently almost non-existent in Albania and should be part of extension services and the agriculture knowledge and innovation system (AKIS). The impact of climate change is particularly pronounced in Albania, given the agriculture sector's substantial contribution to the national economy and its dominance by smallholder farmers. Understanding the implications of climate change and gathering insights from extension experts can enhance the management's ability to address climate-related risks (Roco et al., 2015).

In this context, building adaptive capacity is crucial for enhancing the resilience of farmers, especially in areas and sectors where financial resources are limited. Therefore, policymakers should consider various measures, including providing innovation grants for farms, introducing disaster recovery and crop failure insurance, offering information and early warning systems for natural disasters and epidemics, increasing capacities of women, youth and other vulnerable social groups for developing adaptive capacities, namely adaptation measures in agriculture, entrepreneurship skills for off-farm development, renewable energy and energy saving business activities, as well as agroforestry. The findings underscore the pressing need to prioritize climate change as an integral component of extension programmes for women and youth.

The quality of land and soil has widespread implications not only for agriculture but also for the productive capacity of the land, and the risk of soil and land degradation is likely to increase with climate change. Increases in temperature, changing precipitation patterns, floods and droughts directly influence the properties and processes in soils, which can lead to accelerated erosion, land degradation and desertification. When droughts which are forecasted to increase significantly during the summer periods throughout the Western Balkans (Alfthan et al 2015) are followed by periods of intense rain on steep, unstable terrain, the soil is not able to absorb rainfall, resulting in excessive run-off, landslides, and floods. Wildfires and overexploitation of resources can further contribute to desertification. Erosion in Albania affects more than 25 per cent of the economy, with the most critical areas being the northeast as well as Shkodra, Tropoja, Saranda and Gjirokastra. Soil loss via water erosion is a widespread phenomenon estimated to be 2-3 times higher than in other Mediterranean economies and 10 to 100 times greater than in many other European economies (Kovats, 2012). The typical Mediterranean climate is one of the most aggressive ones in terms of erosion (heavy rainfall

intensities, high rainfall amounts, drought as a permanent process, etc.). These processes, along with topographic and soil conditions (steep slopes, silty soils, low humus content) already classify more than 50% of the total land area in Albania as naturally erosive. This is amplified by anthropogenic impacts (illegal forest cutting, fires, cultivated steep slopes, up-down cultivations, bare soils after harvesting, overgrazing, absence of erosion protection measures) resulting in significant soil loss rates (Kovats, 2012). **It is a known fact that climate change will aggravate the situation mostly due to intense rainfall events that will be accompanied by floods and landslides.** Soil mineralization rates will increase, and this will be followed by additional release of CO_2. Saline areas may further increase due to accelerated rate of salt accumulation during hot summers.

In summary, the effects of climate change in the water sector are also detrimental to water. **Growing demand for water will increase the need for energy-intensive water pumping**, therefore **depleting groundwater resources**. Temperatures are expected to increase and rainfall to decrease, especially during the summer months. This will be followed by a decrease in yields and **higher competition for water. Snow cover will be drastically reduced** with severe consequences on water supplies, especially for irrigation. Albania will experience water stress by the 2050s and pronounced water stress by the 2090s, with most **severe drought experienced in the central and southern areas**.

In order to cope with climate change hazards, the following interventions should be promoted.

- **Harvesting rainwater.** Rainwater capture is particularly useful in regions with uneven rainfall distribution to build resilience to shocks and ensure supplies for dry periods. Techniques include rooftop capture for small-scale use and surface dams to slow down run-off, reduce soil erosion and increase aquifer recharge.
- **Adopting climate-smart agriculture.** Using conservation techniques to improve organic matter to increase soil moisture retention; drip irrigation; reducing post-harvest losses and food waste; and transforming waste into a source of nutrients or biofuels/biogas.
- **Reusing wastewater.** Unconventional water resources, such as regulated treated wastewater, can be used for irrigation, industrial and municipal purposes. Safely managed wastewater is an affordable and sustainable source of water, energy, nutrients, and other recoverable materials.
- **Harnessing groundwater.** In many places, groundwater is overused and polluted; in other places, it is of unknown quantity. Exploring, protecting, and sustainably using groundwater is central to adapting to climate change and meeting the needs of a growing population.

After a careful review of all the documents cited in this report, some key recommendations have been put forward for all stakeholders in relation to crop production.

Public awareness, knowledge and skills

- Strengthening public awareness, knowledge and skills of the agricultural administration, advisory structures and farmers on EU standards related to climate change mitigation and adaptation.
- Knowledge transfer networks for good environmental practices are extremely important. The production of training materials for climate change mitigation and adaptation, with the involvement of research institutes, universities, environmental NGOs and other civil society organisations, while the delivery of training involving farmer organisations in practical demonstration is ideal for the sustainability of networks.
- Support programmes to address knowledge limitation of farmers on climate change.

Demonstration of climate resilient agricultural systems

- On a pilot basis, adequate voluntary environment and climate-related measures that go beyond the legal requirements and best practices can be tested and scientifically verified in close coordination with academia, advisory services and the international community.
- Pilot eco-schemes aiming at the maintenance and improvement of the environment and climate change mitigation and adaption should be prepared and implemented, thus increasing the institutional capacity and raising awareness. All construction/rehabilitation and modernization costs, the costs for machinery, equipment and training should be covered by projects.
- Standards that aim to contribute to mitigation and adaptation to climate change, to tackle water challenges, protect the quality of soil and protect the quality of biodiversity through good practices only.
- Promotion of best practices, such as use of cover crops, no-tillage or minimum tillage, crop diversification and rotation, etc. Support farmers applying conservation or regenerative agriculture.
- Optimize agronomic practices and inputs: fertilizer application and soil moisture conservation; improve soil, water, and crop management; improve appropriate land use, and develop resource management strategies.

Investment in assets to mitigate the impact of climate change

- Address the lack of timely meteorological information needed to respond effectively and improve farmer access to hydrometeorological data
- Focus regional cooperation programmes on implementing reliable early warning and long-range weather forecast systems and provide efficient information dissemination
- Improve irrigation water infrastructure and application efficiency; rehabilitate irrigation infrastructure, including water storage infrastructure; broad-scale water regime planning
- Improve drainage infrastructure; implement floodplain management measures; increase understanding of water resource threats and groundwater risks to improve water use efficiency in agriculture and in urban zones
- Install hail nets in fruits trees or shadowing nets in vineyards in areas where harvesting is anticipated to be affected by climate change
- Improve crop varieties for resilience to climate change
- Risk management through insurance schemes

Albania has adopted legislation on climate change mitigation and adaptation regarding livestock. Despite the progress that has been made, there are still a number of challenges that need to be addressed in order to improve the legal framework especially including concrete measures for adaptation of livestock farming to climate change.

Another challenge is to raise awareness of administration and research institutions for prioritizing climate change in their activity, through increasing institutional capacities, better coordination between institutions, better funding of research on the effects of climate change on livestock farming and well-being, as well as to analyze impacts of adoption practices.

Overall, there is a need for more and better data on climate change and livestock in Albania. This information would be valuable for developing and supporting effective adaptation strategies for farmers and policymakers.

Effectively addressing climate change challenges in livestock farming necessitates prioritizing crucial scientific research. This research must comprehensively explore climate change impacts on livestock rearing aspects, including animal health, productivity and overall sustainability. Crucially, research

programmes should focus on evaluating data, identifying patterns and providing tailored adaptation recommendations for specific livestock farming systems and regions, selecting heat-tolerant breeds, etc.

Identifying and analyzing adaptive practices employed by farmers is vital for knowledge sharing. Understanding farmers' strategies to cope with changing climatic conditions helps researchers and policymakers identify and promote best practices across the livestock sector.

Effective research should be based on comprehensive data on climate change. To ensure a continuous flow of climate and livestock farming data, robust infrastructure for data collection is essential. This infrastructure should include, in addition to the existing network of weather stations, also sensors and monitoring systems for real-time data livestock indicators, upgrading data collection technologies, and improving analysis and forecasting capabilities.

Expanding the scope of agricultural statistics collection is essential for understanding livestock farming and its vulnerability to climate change comprehensively. This includes data on livestock population, production trends, feed availability, and pasture conditions.

Integrating climate change considerations into agricultural policy is paramount, particularly for the livestock sector. This entails embedding climate resilience measures into livestock development initiatives, offering financial incentives for adaptation practices, and fostering investments in adaptation measures and innovative solutions for animal production.

Implementing vital insurance schemes for livestock in the face of natural disasters is crucial for financial protection against extreme weather impacts. Designing accessible, affordable schemes tailored to unique risks is essential. Considering a national livestock insurance scheme in Albania could offer comprehensive risk management by pooling resources for accessible financial support post climate-related disasters.

Exploring options like regional or sectoral livestock insurance schemes holds potential for customized risk management solutions, addressing specific needs in various regions or production systems.

Note that while natural disaster insurance schemes can be complex and costly to administer, they serve as a valuable financial safety net for farmers and herders, aiding recovery from losses incurred during such events.

1.7. References

Albanian Parliament (2020). Law on Climate Change.

Alfthan, B.; Krilasevic, E.; Venturini, S.; Bajrovic, S.; Jurek, M.; Schoolmeester, T., Sandei, P.C., Egerer, H, and Kurvits, T. (2015). *Outlook on climate change adaptation in the Western Balkan mountains.* United Nations Environment Programme, GRIDArendal and Environmental Innovations Association. Vienna, Arendal and Sarajevo. www.grida.no

Bardhi, A., Laksa Merkoci, A., Dvorani, M. (2012). Estimating evapotranspiration and its components in Albania. Agriculture and Forestry. Vol. 58. Issue 4: 55-65, 2012, Podgorica.

Bruci E. (2008). *Ndryshueshmëria dhe Tendencat e Klimës në Shqipëri*. Universiteti Politeknik – Instituti për Energjinë, Ujin dhe Mjedisin, Tiranë. (In Albanian)

Chenoweth, J., Hadjinicolaou, P., Bruggeman, A., Lelieveld, J., Levin, Z., Lange, M.A., Xoplaki, E., Hadjikakou, M. (2011). Impact of climate change on the water resources of the eastern Mediterranean and Middle East region: Modelled 21st century changes and implications. https://doi.org/10.1029/2010WR010269

Energy Community (2021). Draft of the National Energy and Climate Plan of the Republic of Albania.

ENVSEC (2012). Climate Change in the West Balkans. [Online] Available at: https://climateadapt.eea.europa.eu/metadata/publications/climate-change-in-the-west-balkans/11278310 [Accessed on 15 July 2022].

European Commission, (2023). ERA5-Land hourly data from 1950 to present. https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land

FAO (2018). Comprehensive analysis of disaster risk reduction and management system for agriculture in Albania. Enhancement of Disaster Risk Reduction and Management (DRRM) capacities and mainstreaming Climate Change Adaptation (CCA) practices into the Agricultural Sector in the Western Balkans (TCP/RER/3504).

GEF (2016). The Third National Communication of Albania on Climate Change. Document produced by a project implemented by the Ministry of Tourism and Environment and the United Nations Development Programme (UNDP), with financial support of the Global Environment Facility (GEF).

GEF (2021). Albania's First Biennial Update Report.

GEF (2022). The Fourth National Communication of Albania on Climate Change. Document produced by a project implemented by the Ministry of Tourism and Environment and the United Nations Development Programme (UNDP), with financial support of the Global Environment Facility (GEF).

GIZ (2021). Strategy for Agriculture, Rural Development and Fisheries 2021 – 2027. GFA Consulting Group GmbH.

GIZ (2021). NDC Assist II Albania Strengthening the financing and implementation of National Determined Contributions (NDCs). In: https://www.giz.de/de/downloads/giz2022-en-albania-ndc-assist-II.pdf

GIZ and SWG, (2018). Country Report-Albania "Agrobiodiversity in Southeast Europe-Assessment and Policy Recommendations".

Government of Albania (2019). National Adaptation Planning (NAP) to Climate Change in Albania Framework for the Country Process.

Government of Albania (2019). Strategy of Climate Changes and Action Plans. https://data.chc.ucsb.edu/products/CHIRPS-2.0/global_daily/netcdf/p05/

Imami, D., Skreli, E., Kullaj, E. and P. Shohi (2020). Implications of climate changes for Mediterranean agriculture- the case of horticulture sector in Albania. 9th AIEAA Online Conference. Mediterranean agriculture facing climate change: Challenges and policies.

Imami, D., Skreli, E., Kullaj, E., Shoshi, P. (2019). Climate changes implications in the agriculture sector – the case of a Mediterranean country dominated by smallholdings. Agricultural sector development and policies in Western Balkans – challenges and prospective in the light of EU integration. 5.– 6.09.2019; Budapest, Hungary: Corvinus University of Budapest.

INSTAT (2018). Albania Demographic and Health Survey 2017-18. Tirana, Albania: Institute of Statistics, Institute of Public Health, and ICF.

INSTAT, (2022). Men and women in Albania 2021. In: http://www.instat.gov.al/media/8713/burra-dhe-gra.pdf

International Monetary Fund (IMF) (2022). Selected Issues, IMF Country Report No. 22/363, available at https://www.imf.org/en/Publications/CR/Issues/2022/12/09/Albania-Selected-Issues-526824

International Monetary Fund, (2022). Adapting To Climate Change.

International Monetary Fund (2020). Fiscal Monitor: Policies for the recovery. Washington.

Janin, G., Titka, M., Dodaj, D., and Xhaferri, F., (2020). Raporti i Sintezës për Funksionin e Mbrojtjes Civile në Nivel Vendor. In: https://www.shav.al/images/raporte_publikime/pdf/Raporti_i_sintezes_emergjencat_civile.pdf

Jaupaj, O, Kulici, H., Lamaj, M., Gjonaj, V., Deda, D. (2015). Landslide susceptibility of Kruja, using a heuristic approach. https://www.researchgate.net/publication/308404330_Landslide_susceptibility_of_Kruja_using_a_heuristic_approach

Kerpaci, A., Abdullahu, I. (2021). Determination of evapotranspiration in Albania. American Journal of Engineering Research. e-ISSN: 2320-0847 p-ISSN : 2320-0936, Volume-10, Issue-12, pp. 187-193.

Khan, M., K. Mohaddes, R. Ng, H. Pesaran, M. Raissi, and J.-C. (2019). Yang. Long-term macroeconomic effects of climate change: A regional analysis. No. w26167. National Bureau of Economic Research, 2019.

Kovats, A.S., Fulop, B., Honti, M. (2012). Detection of hot spots of soil erosion and reservoir siltation in ungauged Mediterranean catchments. Energy Procedia 18: 934-943.

KULLAJ, E. and F. THOMAJ (2013). Assessing climatic stress effects on apple (Malus domestica Borkh.) using various plant-based methods. The Journal of Ege University Faculty of Agriculture, Special Issue, Vol.1, ISSN 1018-8851.

KULLAJ, E., DOMI, H., SPAHIU, T. and F. THOMAJ (2014). Behaviour of apple cultivars under a high radiation and temperature regime of Western Plain in Albania. Acta Horticulturae 1038.

Laska Merkoci, A., Ndini Bogdani, M., Dvorani, M. (2010). Evapotranspiration and its evaluation in Albania. BALWOIS 2010- Ohrid, Republic of Macedonia- 25, 29 May 2010.

MARD, (2022). Rural Development Programme 2021-2027 Under Instrument for Pre-Accession Assistance (IPA).

Ministry of Foreign Affairs, (2022). National Plan for European Integration 2022 – 2024. In: https://integrimi-ne-be.punetejashtme.gov.al/wp-content/uploads/2022/02/NPEI_2022-2024_EN-.pdf

Ministry of Infrastructure, (2016). Plani i përgjithshëm kombëtar dokumenti i parë kombëtar për planifikimin e territorit 2015 – 2030. In: https://planifikimi.gov.al/index.php?eID=dumpFile&t=f&f=5154&token=da636af1a1a4ffe0d0973a5cfc7eedbca62f49cc

Ministry of Social Welfare and Youth (2016). National Strategy and Action Plan on Gender Equality 2016-2020. Available online at https://www.un.org.al/publications/national-strategy-and-action-plan-gender-equality-2016-2020

Ministry of Tourism and Environment, (2015). Document of Strategic Policies for the Protection of Biodiversity in Albania. In: https://www.cbd.int/doc/world/al/al-nbsap-v2-en.pdf

Ministry of Tourism and Environment, (2022). "The Fourth National Communication of Albania on Climate Change".

MoEF (2022). Economic Reform Programme 2023-2025. In: https://financa.gov.al/wp-content/uploads/2023/02/Economic-Reform-Programme-2023-2025.pdf

MoFE (2021). Medium-Term Budget Program, 2021-2023 Phase III Annex 4 Gender Responsive Budgeting, available at: https://www.financa.gov.al/wp-content/uploads/2021/03/Aneksi-2-BPGJ-PBA-2021-2023-Faza-III.docx

MoTE (2022). Albania's Fourth National Communication to UNFCCC. In: http://hdr.undp.org/en/economies/profiles/ALB202

Müller D., and M. Hofmann (2022). Impacts of climate change on agriculture and recommendations for adaptation measures in the Western Balkans. Funded by SWG, Leibniz Institute of Agricultural Development in Transition Economies (IAMO) and GFA.

Pojani, E., Grabova, P. & Kodhelaj, M. (2013). Climate change impacts: Public policies and perception in Albania. Albanian Journal of Agricultural Sciences, 12(4).

Rama, K. (2016). Too much but not enough: Issues of water management in Albania in light of climate change, Studies on the Agricultural and Food Sector in Transition Economies, Leibniz Institute of Agricultural Development in Transition Economies IAMO, Volume 84.

RCC (2021). Action Plan for the implementation of the Sofia declaration On the green agenda for the Western Balkans, 2021- 2030. Available at https://www.rcc.int/docs/596/action-plan-for-the-implementation-of-the-sofia-declaration-on-the-green-agenda-for-the-western-balkans-2021-2030.

REC Albania (2021). Monitoring of the Action Plan of the National Strategy on Climate Change, 2020-2030. Funded and copyright by Westminster Foundation for Democracy.

Regional Cooperation Council (2019) Study on climate change in the Western Balkans region.

Republic of Albania (2016). Third National Communication of the Republic of Albania under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/Albania%20NC3_13%20October%202016.pdf

Sallaku, F., Chachalis, D., Darawsheh, M.K., Tota, O., Huqi B., and Fortuzi, Sh. (2009). Improving participation and cooperation on water management: Experience from farmer-managed systems in Albania. Journal of Food, Agriculture & Environment Vol.7 (1): 252-255, 2009.

SASPAC (2022). Strategjia Kombëtare për Zhvillim dhe Integrim Europian 2030. In: https://konsultimipublik.gov.al/documents/RENJK_538_Draft-Strategjia-Kombetare-per-Zhvillim-dhe-Integrim-2021--2030-.pdf

Selenica A. (2000). Water resources of Albania. medhycos.mpl.ird.fr/en/project/who/pres/alb-pre.html

Selenica, A., (2009). Hidrologjia Inxhinierike. (In Albanian)

Shahu, E., Zhllima, E., (2023). Climate change and gender-based impact - The case of Albania, paper presented in IBANESS Congress Series-Plovdiv/Bulgaria April 08-09, 2023.

Sutton, W. R., Srivastava, J. P. & Neumann, J. E. (2013). Looking beyond the horizon: How climate change impacts and adaptation responses will reshape agriculture in Eastern Europe and Central Asia. World Bank Publications.

Sutton, W.R., Srivastava, J.P. and J.E. Neumann (2013). Looking Beyond the Horizon – How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia. World Bank.

Tema, A, Zhllima, E, Imami, D and Xhoxhi, O. (2023). Factors influencing migration from rural areas of Albania. Proceedings of 4th International Conference on Agriculture and Life Sciences, held in Tirana, 1-2 November 2023.

The Albanian Climate Change Law no. 155/2020. It was adopted by the Albanian Parliament on 26 November 2020 and entered into force on 1 January 2021.

The Global Facility for Disaster Reduction and Recovery (GFDRR). Summary report improving disaster risk and loss information in Albania. May 2022.

Tisseuil, C., Velo, E., Bino, S., Kadriaj, P., Mersini, K., Shukullari, A., ... & Gilbert, M. (2018). Forecasting the spatial and seasonal dynamic of Aedes albopictus oviposition activity in Albania and Balkan economies. PLoS Neglected Tropical Diseases, 12(2), e0006236.

Todorovic, M., Steduto, P. (2003). A GIS for irrigation management. Physics and Chemistry of the Earth Parts A/B/C. https://doi.org/10.1016/S1474-7065(03)00023-8

Tzvetkov, G., Spassov P., Petkov V., and Tagarev T. (2015). Albania: Capabilities, Organisations, Policies, and Legislation in crisis management and disaster response.

UN Women (2015). Gender Inequality and Floods Impacts in Albania, available on request.

UN Women (2016). National study on Economic Diversification for Women Living in Albanian Rural Areas. Retrieved from: https://www.un.org.al/sites/default/files/UNWomen-RuralStudy-EN-PRINT_0.PDF

UN Women (2021). UN Women in Action: Gender-responsive budgeting (GRB) at a glance in Albania. In: https://eca.unwomen.org/en/what-we-do/national-planning-and-budgeting/transformative-financing-for-gender-equality-in-the-western-balkans/albania

UNCFF (2021). Albania Revised NDC. In: https://unfccc.int/sites/default/files/2022-08/Albania%20Revised%20NDC.pdf

UNDP (2015). Gender Responsive National Communications Toolkit. Available online at: https://www.undp.org/content/undp/en/home/librarypage/womens-empowerment/gender-responsive-national-communications.html

UNDP (2016). Guidelines to mainstreaming gender in climate change adaptation and mitigation programmes and plans in Albania Draft Abstract, April 2016. Available online at: https://info.undp.org/docs/pdc/Documents/ALB/Guidelines%20to%20mainstreaming%20gender%20in%20climate%20change%20adaptation%20and%20mitigation%20programmes%20and%20plans%20in%20Albania.pdf

UNDP (2022). Albania's Revised NDC.

UNDP (2020). Assessment and Integration of Gender Vulnerability, Standards and its Access to Management and Conservation Actions in the Protected Areas in Albania. In: https://www.undp.org/sites/g/files/zskgke326/files/2022-11/Gender_PA_assessment.pdf

UNECCE (2022). Assessment of the Water-Energy-Food-Ecosystems Nexus in Albania. In: https://www.gwp.org/globalassets/global/gwp-med-files/list-of-programmes/see-nexus/final-reports/albania-nexus-assessment_final.pdf

UNEP (2015). Outlook on climate change adaptation in the Western Balkan mountains.

UNFCC (2022). Albanian Revised NDC. In: https://unfccc.int/sites/default/files/2022-08/Albania%20Revised%20NDC.pdf

UNFCCC (2015). Paris Agreement. Retrieved from: http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

USAID (2016). Climate Change Risk Profile – Albania. URL: https://www.climatelinks.org/sites/default/files/asset/document/2016%20CRM%20Fact%20Sheet%20-%20Albania%20%28003%29.pdf

WDF (2021). Climate change strategy in Albania 2020-2030. 2019-2021 Action Plan Monitoring. In: https://www.wfd.org/sites/default/files/2022-05/EN_Report_Monitoring%20of%20National%20Action%20Plan%20%281%29.pdf

WMO (2020). Albania. Albania Country. In: Albania | World Meteorological Organization (wmo.int)

World Bank (2013). "Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change"

World Bank (2021). Climate Risk Profile: Albania. World Bank Publications, The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA.

World Bank (2021). Climate risk country profile: Albania.

World Bank, (2021). Southeastern Europe Disaster Risk Mitigation and Adaptation Programme at a Glance. In: https://www.preventionweb.net/files/18135_seedrmapbrochure.pdf

World Bank (2022). "Improving disaster risk and loss information in Albania" Summary Report.

Xhoxhi, O., Skreli, E., Zhllima, E., Imami, D. (2023). From Pandemic to Warfare: Understanding the Complex Trajectory of External Shocks on Albania's Agricultural Sector, presented at the Conference fourth International Conference on Agriculture and Life Science (ICOALS IV 2023), held in Tirana, 1-2 November 2023.

Zdruli P. (2005). Soil Survey in Albania. In: Soil Resources of Europe, second edition. (Eds. R. Jones, B. Houskova, P. Bullock and L. Montanarella). Office for Official Publications of the European Communities. EUR 20559 EN.

Zdruli, P. and Cukaliev O. (Eds). (2017). Areas with Natural Constraints in the Southeast Europe: Assessment and Policy Recommendations published by the Regional Rural Development ***Standing Working Group*** (***SWG***) in South-Eastern Europe based in Skopje, Macedonia and funded by the German Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Zdruli, P., and Lushaj, Sh. (2000). Status of soil degradation in Albania. In: Soils in Central and Eastern European economies, in the New Independent States, in Central Asian economies and in Mongolia. Office for Official Publications of the European Communities. EUR 19732 EN.

Zdruli, P., Karydas, C., Dedaj, K., Salillari, I., Cela, F., Lushaj, Sh., Panagos, P. (2016). Spatiotemporal analysis of erosion risk per land cover category in Korçe region, Albania. Earth Science Informatics. DOI 10.1007/s12145-016-0269-z.

Zdruli, P., Sh. Lushaj, A. Pezzuto, D. Fanelli, O. D'Amico, O. Filomeno, S. De Santis, M. Todorovic, E. Nerilli, K. Dedaj, and B. Seferi. (2002). Preparing a georeferenced soil database for Albania at scale 1:250,000 using the European Soil Bureau Manual of Procedures 1.1. In: OPTIONS méditerranéennes (Zdruli, P., Steduto, P., and Kapur, S.) CIHEAM Paris, France.

Zhllima, E. (2021). Gender analyses of selected value chains, Report for GIZ SRD project.

Zhllima, E., (2021). An expert assessment of gender equality in climate change adaptation, A report for UNDP Albania in the preparation of the 4NC and 2BUR for UNFCC (provided upon request).

Zhllima, E., Imami, D., Nam, J., Shoshi, P., & Gjika, I. (2022). Awareness of Climate Change Impact and Adaptation in Agriculture–The Case of Albania. European Countryside, 14(4), 604-622.

Zhllima, E., Xhoxhi, O. & Imami, D. (2020). Feminization in Agriculture in a Transition Economy: Women's Role in Family Farms, Sociologia Ruralis, https://onlinelibrary.wiley.com/doi/abs/10.1111/soru.12332





Adaptation to climate change in agriculture – status, gaps and recommendations in Bosnia and Herzegovina

Timofeyev Alexander/shutterstock.com

2. Adaptation to climate change in agriculture – status, gaps and recommendations in Bosnia and Herzegovina

Željko Vaško[14], Hamdija Čivić[15], Mihajlo Marković[16], Sabrija Čadro[17], Biljana Rogić[18]

2.1. Status of economic, socio-economic and agricultural sector related to climate change

Agricultural land occupies about half of the total land area of Bosnia and Herzegovina and is important to the economy in social, environmental and economic terms. However, the sector is threatened in many ways. The Third Environmental Performance Review (EPR) of Bosnia and Herzegovina noted that agriculture was one of the main sources of methane and ammonia emissions in the economy, whilst also being the most sensitive sector to climate change. Indeed, the sector faces risks from droughts and water scarcity; as well as increased risk of fires; increasingly intense hailstorms; and increased wind speeds. The Third EPR noted that the economy had taken few measures to implement policies or measures on adapting the agricultural sector (UNECE, 2018).

2.1.1. Macro-economic aspects on the national economy level

Bosnia and Herzegovina's gross domestic product and gross value added are increasing, absolutely and per capita (Table 2.1). Rising prices influence more the absolute increase in GVA in recent years than the actual increase in production volume. The estimate of the B&H Agency of Statistics (2023) is that from 2013 to 2022 the number of inhabitants decreased by 97 thousand (2.74%), which is reflected in the increase in population density. There is pronounced internal migration between rural and urban areas, and in recent years there has been a significant increase in migration from the economy abroad (mostly Western Europe) mainly of younger workforce, of all educational levels. The latest wave of migration is particularly affecting agriculture, which has a growing problem to ensure the necessary workforce, especially seasonal. Exports and imports of goods are increasing, and the foreign trade deficit is also increasing. The total foreign trade deficit approached 4 billion EUR. In recent years, the coverage of imports of goods by their exports has been between 60% and 66%. There are no systematic and continuous data on poverty for B&H (UN database for B&H has only data on GINI index in B&H for 2011 being 33). According to Obradović et al. (2019), the share of individuals at risk of poverty in B&H in 2015 was 27% based on income. GDP per capita and the average salary are constantly growing, so it can be concluded that the living standard of the population is increasing.

14 Agricultural economics expert, University of Banja Luka, Faculty of Agriculture (zeljko.vasko@agro.unibl.org)
15 Soil expert, University of Sarajevo, Faculty of Agriculture and Food Science (h.civic@ppf.unsa.ba)
16 Water expert, University of Banja Luka, Faculty of Agriculture (mihajlo.markovic@agro.unibl.org)
17 Crop expert, University of Sarajevo, Faculty of Agriculture and Food Science (s.cadro@ppf.unsa.ba)
18 Livestock expert, University of Banja Luka, Faculty of Agriculture (biljana.rogic@agro.unibl.org)

Still, there is an uneven distribution of income among the population, about which there is no official data.

Table 2.1. Key macroeconomic indicators

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
GDP (at current prices)	mill. EUR	11,187	13,922	18,516	124.4	133.0	165.5
Value added (at current prices)	mill. EUR	9,102	11,435	15,595	125.6	136.4	171.3
GDP per capita	EUR	2,376	3,851	5,331	162.1	138.4	224.4
External trade balance	mill. EUR	-3,793	-3,631	-3,986	95.7	109.8	105.1
Unemployment rate	%	27	27	17	101.2	63.3	64.1
Food, beverages and tobacco in household expenditures	%	38	41	40	108.7	96.0	104.4

Source: Agency of Statistics of B&H (2022)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

2.1.2. Macro-economic aspects on the agricultural sector level

The gross value added of agriculture, forestry and fishery in B&H is increasing in absolute terms, while at the same time, its share in the total gross value added is decreasing. In 2022, the share of agriculture in total GVA fell below 6% for the first time (according to preliminary data, 5.8%). Recently, there has been no data on the contribution of the crop and livestock sub-sectors to the generation of GVA. While the total number of employees in the economy is increasing, the number of employees in the agriculture sector is decreasing. In 2022, the percentage of those working in agriculture, forestry and fishery (7.3%) for the first time approached the percentage of contribution of agriculture, forestry and fishery to the total GVA. Food price increases have had the greatest influence on the growth of agricultural GVA (measured by current prices) because food prices have been growing faster than consumer goods prices. Bosnia and Herzegovina is still highly dependent on food imports. Its food imports are covered by food exports by 25% and in recent years there has been a decreasing trend (Table 2.2). Food and beverages contribute to the total foreign trade deficit of B&H by about one-third.

Table 2.2. Key indicators for the agricultural sector

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
GVA of agriculture (at current prices)	mill. EUR	865	897	1,038	103.6	115.8	120.0
Share in AgGVA in all activities	%	10	8	7	81.7	85.5	69.9
Number of employed in agriculture	000	173	152	122	87.8	80.3	70.5
Share in total employment	%	20	19	13	91.6	70.2	64.3
Export of agri-food products	mill. EUR	195	375	491	192.3	130.9	251.6
Share in export of all products	%	7	8	7	128.5	88.1	113.2
Import of agri-food products	mill. EUR	1,152	1,433	1,744	124.4	121.7	151.4
Share in import of all products	%	17	18	16	103.6	92.0	95.3
Trade balance in agri-food products	mill. EUR	-957	-1,058	-1,252	110.6	118.4	130.9
Share of crops in total agricultural output	%	59	44	/	73.4	94.0	69.0
Share of livestock in total agricultural output	%	41	56	/	138.8	104.7	145.3

Source: Agency of Statistics of B&H (2022)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

2.1.3. Land use

Data on agricultural area structure, realized volume of production and average yields in plant production originated mainly from statistical sources. Since the statistical authorities in B&H shifted from the method of expert estimations to the method of farm structure survey (FSS) data collection, significant changes occurred in certain data related to agricultural land and its use. So, it is difficult to distinguish to what extent the observed changes are the result of real changes in the volume and structure of agricultural production, and to what extent are the result of a change in data collection methodology. For example, according to the new methodological approach, there will be four times less arable land in 2022 than in 2021 (previously it was reporting on cultivated land, and now on utilized agricultural area). As much as there were reservations earlier according to statistical data collected based on the estimation method, there are now reservations according to some new data collected by FSS. The bottom line is that it is difficult to make conclusions about multi-year trends of yields and other indicators by combining 'old' and 'new' data from the same source (statistical authorities). The ministries of agriculture in RS, FB&H and BD maintain farm registers, but since the registration of farms is voluntary, those registers do not contain data from which a complete picture of the state of the agricultural sector could be obtained. Collected multi-year data (mostly without data for 2022, due to drastic deviation) are summarized in Table 2.3.

Table 2.3. Agricultural land use and agricultural holdings

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
Total agricultural land	000 ha	2,156	2,177	1,925	101.0	88.4	89.3
- Arable land	000 ha	1,016	1,025	930	100.9	90.7	91.5
(of which fallow and uncultivated land)	000 ha	471	492	461	104.6	93.6	97.9
- Land under permanent crops	000 ha	103	108	106	104.6	98.9	103.4
(of which orchards)	000 ha	95	100	88	105.3	88.3	93.0
(of which vineyards)	000 ha	6	5	4	95.5	78.2	74.7
- Permanent grassland	000 ha	1,036	1,052	959	101.5	91.1	92.5
(of which meadows)	000 ha	443	452	450	102.0	99.4	101.4
(of which pastures)	000 ha	593	600	626	101.2	104.4	105.6
Utilized agricultural area (UAA)	000 ha	1,757	1,776	1,599	101.1	90.0	91.0
Number of agricultural holdings	000	/	363	/	/	/	/

Source: Agency of Statistics of B&H (2023)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

Based on multi-year data, 47% of agricultural land in Bosnia and Herzegovina is arable land, 5% is under permanent crops and 48% is meadows and pastures.

2.1.4. Brief agricultural sector overview

Agricultural land in B&H occupies about two million ha, about half of which is arable land. Previously, the viewpoint was that about half of arable land was not cultivated. There were a lot of rational reservations about such data, considering it overrated. The latest statistical data show that utilized agricultural areas are significantly smaller than previously reported cultivated areas. Such data is primarily the result of a change in statistic methodology. However, good connoisseurs of the situation agree that the areas of cultivated/used land are decreasing, primarily in areas with less favourable conditions for agricultural production. Arable land has moved to meadows, unused meadows have moved to pastures, and unused pastures have moved to bushes. In this way, agricultural land is lost in terms of size and quality. The structure of arable land utilization (Figure 1), shows cereal production as predominant (58%), and within it maize (36%) and wheat production (13%). Wheat production is partly favoured due to high incentives in the RS. The second most important crop on arable land is fodder plants (21%), which are mainly used for animal feed. Vegetables occupy an area of about 28 thousand ha (6%) with a dual structure of production. A larger number of rural households produce vegetables only for their own needs, with a low yield, and a smaller number of specialized farms produce vegetables for the market and achieve several times higher yields than small farmers. The situation is similar with fruit growing. Orchards occupy 23 thousand ha (5%). There are many extensive plantations that serve only their own needs. Contrary to this, there are modern fruit plantations managed according to high technological standards. These two types of vegetable and fruit production different when it comes to the effects of climate change. In extensive plantings, yield variations are smaller, and in intensive plantings large, so that high yield-oriented vegetables and fruit growers must undertake more extensive adaptation measures (irrigation and protection against frost and hail). Natural meadows and pastures are underutilized. There are fewer and fewer nomadic practices and more and more breading of ruminants in barns or keeping them in fenced pastures.

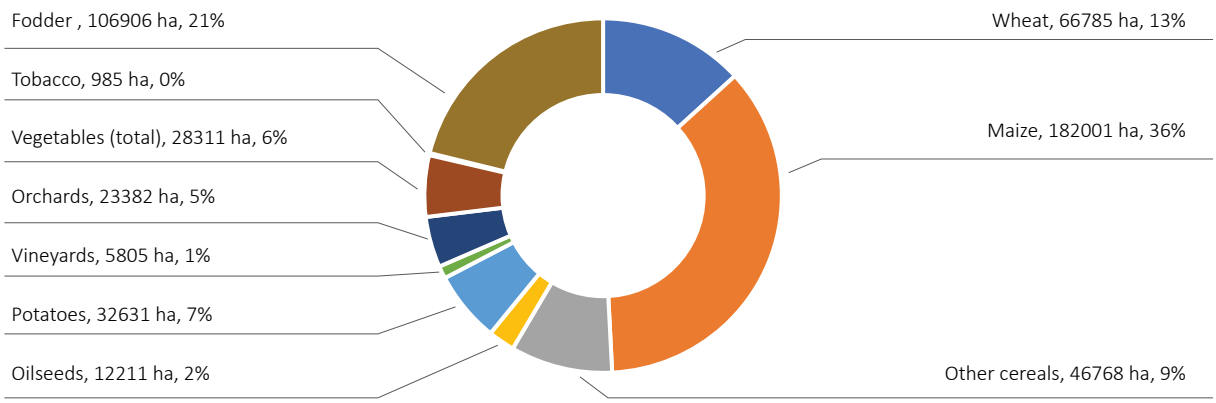


Figure 2.1. Areas under major crops (average 2017-22, in ha)

Source: Agency of Statistics of B&H (2023)

The number of cattle in B&H is decreasing (more detailed in Table 2.4). The number of milking cows has decreased by 40%, and despite the increase in milk yield per head, milk production is also decreasing. The number of pigs was stable, but swine fever, which was raging in 2023, will have drastic consequences on the reduction of the number of pigs in the coming period. During the twenty-year period, the most stable is the number of sheep, which is around one million. Poultry farming is becoming increasingly intensive, but despite the possibility of exporting chicken meat to the EU market, it has a decreasing trend. The drastic drop in the last few years may also be the result of a change in the data collection methodology. The number of beehives increased, then decreased and now is at the level of twenty years ago. Climate change is (only) one of the reasons for the reduction in the number of livestock through the reduction in the amount of animal feed and the increase in the price of animal feed. Climate change is particularly affecting beekeeping because of large variations in the availability of honey plants.

Table 2.4. Number of livestock heads

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
Cattle	000	470	450	403	95,7	89,5	85,7
(of which dairy cows)	000	297	245	181	82,6	73,8	61,0
Pigs	000	587	548	535	93,4	97,6	91,1
(of which breeding sows)	000	122	76	78	61,9	102,9	63,7
Sheep and goats	000	1,089	1,088	1,062	99,9	97,6	97,5
(of which breeding ewes/goats)	000	747	632	617	84,6	97,5	82,5
Poultry	000	15,888	21,007	18,665	132,2	88,9	117,5
Beehives	000	317	392	373	123,8	95,2	117,8

Source: Agency of Statistics of B&H (2023)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

There is a constant trend of increasing the yield of the most commonly cultivated agricultural plants and milk yield (Table 2.5). The average yield of maize ranges between 3 and 7 t/ha, and wheat between 3 and 5 t/ha. There are significant differences in yield achieved between regions and between producers in the same region, depending on the level of applied technology (fertilization, chemical protection, irrigation, etc.), but also depending on climate conditions. In years with favourable climates, the total production of maize grain approaches one and a half million tons, and in bad years, it can be three times less.

Table 2.5. Yield of major crops and livestock

Indicator	*Unit*	*Average*			*Index 1*	*Index 2*	*Index 3*
		2005-2010	*2011-2016*	*2017-2022*			
Wheat	t/ha	2,662	3,657	4,405	137.4	120.4	165.5
Maize	t/ha	4,521	4,293	6,148	95.0	143.2	136.0
Potatoes	t/ha	10,457	10,063	11,931	96.2	118.6	114.1
Grapes	t/ha	2,049	2,105	7,538	102.7	358.2	367.8
Cow milk	t/cow	2,615	2,821	3,318	107.9	117.6	126.9

Source: Agency of Statistics of B&H (2023)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

2.1.5. Farm structure

Registration of farms in Bosnia and Herzegovina is voluntary, so data from farm registers managed by two entity ministries of agriculture and BD B&H can be an indication of the number of farms that are more seriously engaged in agriculture because they apply for subsidies. About 100,000 farms are registered in three farm registers. B&H has not had an agricultural census since 1960, and during the population census in 2013, about 360,000 rural households declared that they were engaged in agriculture to a certain extent, and about 55,000 farms declared that they sold their agricultural products on the market. These data indicate that there is a large number of rural households in B&H engaged in agriculture only for their own needs, without major ambitions to modernize farms or intensify production technology. At the same time, these farms are less sensitive to climate change effects. Such a situation is not in favour of increasing national food self-sufficiency and reducing food import, but at the same time, it has a positive effect on mitigating the impact of agriculture on climate change, because a significant part of agricultural land is cultivated applying environmentally friendly practices. Given the absence of an agricultural census and FSDN database, the exact data on farm size in B&H, as well as their structure depending on the dominant type of production, gender, education, or age is not known. There is no official division of the territory of B&H into urban and rural areas. According to World Bank data (WB, 2023), Bosnia and Herzegovina has 0.31 ha of agricultural land per capita, which ranks it 32nd in the world. The average size of agricultural holdings in B&H is about 3.5 ha, with the fact that there is a virtual consolidation of agricultural land because larger farms specialized in certain types of agricultural production use their neighbourhood land. Farm owners in B&H are getting older, because younger generations rarely continue the family agricultural business, and their parents are getting old. Due to the absence of generational transfer, more and more farms are abandoned, especially in mountainous parts of Bosnia and Herzegovina.

2.1.6. Legislative framework and institutional setup

Due to the complex administrative structure of Bosnia and Herzegovina, there are several legal and strategic documents that regulate the same area. This also refers to climate change, with a special focus on adaptation of the agricultural sector to climate change.

Table 2.6. Laws, strategies, and competencies for agriculture in Bosnia and Herzegovina

	Legal framework	Strategic framework	Institutional competence
B&H	Law on agriculture, nutrition and rural development of Bosnia and Herzegovina (adopted in 2008)	Strategic plan on rural development of Bosnia and Herzegovina 2023-2027 (in draft)	Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina
RS	Law on agriculture (adopted in 2006)	Strategy on the development of agriculture and rural areas of the Republic of Srpska 2021-2027 (adopted in 2021)	Ministry of Agriculture, Forestry and Water Management of the Republic of Srpska
FB&H	Law on agriculture (adopted in 2007)	FB&H Agriculture and Rural Development Strategy 2021-2027 (in the process of adoption)	Federal Ministry of Agriculture, Water Management and Forestry
BD	-	Strategy on the Development of Agriculture and Rural Areas of the Brčko District of Bosnia and Herzegovina 2021-2027 (adopted in 2022)	Department of Agriculture, Forestry and Water Management

Source: Own compilation.

The laws on agriculture in Bosnia and Herzegovina were adopted fifteen years ago and they do not mention any provisions regarding adaptation and mitigation to climate change. According to those laws, one of the objectives of the agricultural policy is the rational use and preservation of natural resources, environmental protection and improvement of integral and organic agriculture (in the RS and FB&H), and ensuring the rational use and protection of natural resources and biodiversity (B&H). Climate change was only taken into account in the latest agricultural development strategies in Bosnia and Herzegovina, given the time of their recent adoption. These strategies mainly consider climate change as a threat to agriculture, farmers' yields and income. The measures foreseen in those strategies mainly relate to the adaptation of the agricultural sector to climate change, and little to the mitigation of their occurrence. The ministries of agriculture in their organizational structures do not have departments/sectors/ divisions that explicitly deal with climate change issues and it is usually attached to the units that are responsible for agricultural land.

Climate and climate change are not only the focus of the ministries of agriculture but also of the ministries responsible for ecology and environmental protection. The issue of climate change is partly covered by laws on environmental protection and laws on nature protection, of which there are also several at different administrative levels of B&H. The best and most concrete responses to reducing the consequences and prevention of climate change in B&H are provided by the 2020-2030 Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina. This Strategy is followed by the Climate Change Adaptation Road Map and Action Plan for Bosnia and Herzegovina (which contains 33 specific adaptation measures only for the agricultural sector), which is mainly aimed at adaptation to climate change. The problem is the weak transposition of provisions from that plan into other strategic and legal documents and their slow implementation.

2.1.7. Literature review on climate change linked to socio-economic aspects

There are few literature sources dealing with climate change in B&H, especially from the socio-economic aspect.

Over the past decades, climate change has contributed to extreme weather events; for example, the years 2002, 2003, 2007, 2008, 2011, 2012, 2013, and 2015 were considered very dry to extremely dry, while the floods of 2001, 2002, 2009, 2010, and 2014 severely impacted the economy, people and environment. These events are predicted to become more severe and frequent in the coming decades (Kapovic-Solomun, 2022). Srdic et al. (2023) state that the transition to drier periods in B&H can have implications for reduced soil moisture, decreased water availability for irrigation, and increased water stress on crops, ultimately impacting agricultural productivity and increasing the vulnerability of producers.

The projected increase in temperature, together with changes in precipitation and evaporation, is likely to have a significant negative impact on agricultural systems in Bosnia and Herzegovina, especially in the Mediterranean areas and in the north. Adaptation approaches will need to focus on improved water management and irrigation, new farming systems appropriate for warmer and more arid environments, and a variety of improvements of local crops to maximize agricultural production under more acidified conditions (Climate Change Adaptation and Low Emission Development Strategy for Bosnia and Herzegovina, 2013).

The economies of the Western Balkans are in the process of joining the European Union, which, among other things, requires harmonization of their policies, especially with the EU legislative framework on climate change (Županić et al., 2021).

Bosnia and Herzegovina prepared a Climate Change Adoption Plan. According to that plan, it is necessary to develop a proper agricultural policy aligned with the Common Agricultural Policy (CAP) 2023-2027 and the Green Agenda measures. This also includes the need to establish the baseline for reliable data and evidence, in particular on issues illustrating the relations between agriculture and the environment: the use of pesticides and fertilizers, greenhouse gas emissions level from agriculture, etc. (RCC, 2022).

Previous data and information on greenhouse gas emissions were limited (Climate Change Adaptation and Low Emission Development Strategy for B&H, 2013). Recently, there have been certain projections on GHG, for particular sectors, including agriculture, and they mainly originate outside B&H. The participation of agriculture in GHGs in B&H decreased from 14% in 1990 to 9% in 2014, and it can be expected that its participation will continue to decrease (The 2020-2030 Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina, 2023). Climate Action Network Europe provides almost identical data (Berishaj, 2020).

The number of livestock, especially ruminants, is decreasing in B&H, which results in a decrease in methane emissions. Grazing livestock density (GLD) in Bosnia and Herzegovina is 0.51, which means there is nearly one-half of LSU per 1 ha of grassland, or that one LSU has 2 ha of grasslands at its disposal (Vaško & Rokvic, 2021).

In B&H, there is a trend of changing the way of use of agricultural land in the direction of reducing arable land and increasing natural meadows and pastures. In the past period, significant areas of neglected agricultural land have become overgrown (Govedar et al., 2023).

The application of synthetic and organic fertilizers in B&H is still below the average level of many economies in Europe, and below the level allowed by the Nitrates Directive of 170 kg N/ha of agricultural land (Ćustović et al., 2015). According to FAOSTAT data (FAOSTAT, 2023), in the period 2012-2020, B&H consumed an average of 124.7 kg of nitrogen fertilizer per ha of cropland (63.5% of

the EU-27 average). The average consumption of phosphorus fertilizers was 10.31 kg per ha (52% of the EU-27 average), and the consumption of potassium fertilizer was 38.78 kg per ha (65.5% of the EU-27 average). Consumption of fertilizer has a slight downward trend. According to the same source (FAOSTAT), the consumption of pesticides in B&H is 2.7 kg per ha, and it is below the EU-27 average (with a trend of their increasing use).

Legislation related to the mandatory application of good agricultural practices does not exist in B&H. Some farms, mostly larger ones, voluntarily apply these practices within certain projects (when they are usually financially compensated for changing practices) or as a condition for exporting their products.

The JRC, using the CAPRI model, determined that the desired change in agricultural practices in the direction of achieving Green Deal targets in agriculture would result in a decrease in yield and volume of production in both crop and livestock farming, an increase in producer prices and reduction in revenues (Barreiro-Hurle et al., 2021). USDA reached similar results in its projections (Jayson et al., 2020). So far, there have been no similar calculations in B&H, but similar effects determined for the EU can be expected in B&H as well. A decrease in income of farms following the "greening approach" could be gladly accepted by farmers if the difference is compensated through extra subsidies. Zurovec et al. (2015) pointed out that it is necessary to create capacities to deal with climate change in agriculture and guide the development of agriculture accordingly, which requires significant funds and time for implementation. The allocation of financial incentives to the agricultural sector in B&H is gradually increasing, but the funds are mainly directed to increase productivity (dominate market and direct producer support measures). There was no serious approach to the introduction of green measures, as well as budgetary support and allocations for this purpose until the end of 2021 (Martinovska Stojcheska A., et al. 2023).

A good example of a scientific contribution to research into the impact of climate change on agriculture is the SmartWater project, which is funded by the EU HORIZON programme. In this project, two agricultural faculties from Bosnia and Herzegovina (Banja Luka and Sarajevo) in cooperation with experienced partners from Italy, Spain and Portugal exchange knowledge and experience and conduct research in the field of sustainable agricultural water management (Marković et al., 2022).

2.1.8. Agricultural policies linked to climate change

B&H has not adopted the IPARD programme, so sensitivity to climate change can only be assessed through the prism of current agricultural and rural development policies formalized through strategic documents (already adopted or in the adoption phase).

In the Strategy for the Development of Agriculture and Rural Areas of the Republic of Srpska (2021), the third of the five strategic goals is Nature protection and sustainable use of natural resources. Measures are mainly related to the adaptation of agriculture to climate change, such as soil protection from erosion, increasing soil fertility (with application of conservation tillage), investments in irrigation and drainage and flood defence, water protection from pollution, organized collection and disposal of solid waste in rural areas and hazardous waste from agriculture, protection of autochthonous varieties of plants and domestic animal breeds. Among the measures that directly lead to the reduction of the negative impacts of agriculture on climate change, the introduction of agroforestry practices, the increase of energy production from renewable sources (biogas and biomass from agriculture), and the subsidization of organic agricultural production are foreseen.

In the Agriculture and Rural Development Strategy of the Federation of B&H (in the process of adoption), the second strategic objective is Strengthening the application of ecological practices in production that adapt to and mitigate the impact of climate change with four priorities: (1)

Strengthening the application of ecological practices in production that adapt to and mitigate the impact of climate change, (2) Contribution to the mitigation and adaptation of the impact of climate change and greater use of sustainable energy, (3) Support (encourage) sustainable development and more efficient management of natural resources such as water, soil and air and (4) Contribution to the protection of biodiversity, improvement of ecosystem services and preservation of natural habitats and landscape.

In the Strategy on the Development of Agriculture and Rural Areas of BD B&H (2022), the fourth strategic objective is the Restoration, preservation, and improvement of ecosystems dependent on agriculture and forestry through the introduction of agricultural production practices that protect the environment and mitigate impacts on the climate, thereby achieving climate neutrality along the lines of the EU Green Deal, the Farm to Fork Strategy and the Green Agenda for the Western Balkan economies.

In the Rural Development Strategy of B&H (in the adaptation process), climate change is mentioned in the context of the negative impact of extreme weather events on the results of agricultural production. One of the measures in the strategy is support for domestic seed and planting material production programmes, including those that are more resistant to climate change. A measure of granting extraordinary financial aid in the event of major damage due to extreme weather events (drought, flood, storm, etc.) is also foreseen. The third strategic goal is the Sustainable management of natural resources and support for the development of climate-resistant agriculture, with measures to prevent climate change by increasing organic production, introducing good agricultural practices, reducing processing, increasing energy production from renewable sources originating from agriculture, and respecting the limitations arising from the Green Agenda for the Western Balkans, as well as adaptation measures such as the expansion of the application of irrigation and drainage of agricultural land, the regulation of watercourses and defence against high water, and adequate disposal of hazardous waste from agriculture.

There are no consistent national plans for the adaptation of agriculture to climate change, but there is a multi-sectorial 2020-2030 Climate Change Adaptation and Low-emission Development Strategy for Bosnia and Herzegovina (adopted in 2023). As a solution for reducing the high vulnerability in the agricultural sector to climate change, this Strategy recommends increasing soil water retention capacity, applying soil conservation measures, growing adequate species and varieties resistant to climate change, introducing irrigation systems in all agricultural areas of B&H, building water reservoirs for the needs irrigation, application of anti-erosion measures and introduction of agroforestry, protection of biodiversity and landscaping.

In all the mentioned strategic documents, climate change is treated as a limiting factor in the development of agricultural production and the cause of a decrease in yield and income in agricultural business, and not as a consequence of current agricultural practices. Budget allocations to support the implementation of measures that contribute to the adaptation of agriculture to climate change and the mitigation of agriculture to climate change are low, which indicates that the commitment to active action in this area is more symbolic than real.

The principles of circular economy are fragmented and present in strategic documents through measures to support the production of energy from solid and liquid manure and biological origin waste. With the assistance of FAO, an Action Plan for Reducing FLW in B&H was prepared for B&H in 2022, but this plan has not been officially adopted and its implementation is not yet monitored.

Public agricultural advisory services are available mainly in one (RS) and fragmented in other parts of B&H (FB&H). The private advisory service has the function of improving the sale of some inputs and promoting certain suppliers' breeds. In general, advisory support lags behind delivering useful advice to farmers on how better to adapt to new climate conditions.

2.1.9. Data availability and quality for the analysis of climate change socio-economic issues

The main source of data on agriculture and socio-economic development in B&H are statistical authorities (there are two entity institutes and one state agency). In general, the coverage of agricultural and socio-economic statistics in B&H is insufficient, and data are often unreliable. Data series have a non-logical continuity, so there is a risk of making faulty conclusions based on such data. The problem of changing the statistical methodology of data collection (from expert assessments to farm structure surveys) has already been mentioned, which made it difficult to analyze the multi-year data series. Fifty years without an agricultural census (which has been agreed upon for years, but not yet implemented) and without the obligation to register all farms in farm registries in Bosnia and Herzegovina, makes it really difficult to determine the state of agricultural resources and agricultural production in the economy.

Usually, the most accurate data is at the NUTS 2 level (entity data) which is sometimes not compiled at the NUTS 1 (state) level. In the Federation of B&H, some data are available at the NUTS 3 level (10 counties in FB&H), and since the Republic of Srpska is not regionalized, there is no data of that level for that part of B&H. With the switching of the data collection system according to FSS methodology, there are no more agricultural statistics data at the NUTS 4 level (municipalities). Some socio-economic data such as data on employment and unemployment are available at the municipal (NUTS 4) level.

Since there is no FADN or similar data collection system based on farm accounting data in Bosnia and Herzegovina, there is no data that could be selected based on the size and type of farms. The same applies to socio-economic data that would refer only to rural areas because, in Bosnia and Herzegovina, there is no demarcation of rural and urban areas.

There is also no data on poverty and income inequality in B&H. It mostly refers to data that is ten or more years old.

2.1.10. Conclusions and key recommendations

Agricultural producers and their businesses in B&H have suffered a lot in recent years due to frequent negative climate conditions. They manifest as increasingly frequent droughts, heavy rainfall, late frosts, hailstorms, etc. Individually and collectively, farmers undertake activities as their response to reduce and mitigate the negative impacts of climate change. Farmers generally do not consider themselves guilty of climate change, but rather as victims of climate change. Climatologists, using different models, develop different scenarios according to which the climate will have an even greater negative impact on agriculture in the future. Therefore, the application of various adaptation and mitigation measures to climate change will be more and more necessary and frequent. Individual and joint investments in irrigation and drainage, hail protection, flood protection, and facilities for indoor production (especially vegetables), are just some of the measures that farmers have to undertake to prevent damages and losses from adverse effects of the climate. The increase in the mentioned type of investments will also require a change in agricultural policy and subsidy schemes.

It is recommended that new knowledge, new technologies, and innovations be used for effective adaptation of agricultural production to changed conditions due to climate change. That is why it is necessary to involve the scientific community and the advisory service in finding new technological and other solutions and in the dissemination of this knowledge and innovations. An effective fight against the negative consequences of climate change requires the integration of climate change into the AKIS system.

In general, the awareness of farmers, advisors, and even scientists, about the cause-and-effect relationships between the present farming practices and climate change is modest and neglected in B&H. The changes that lead to the reduction of the negative impacts of agriculture on the climate in B&H are happening more spontaneously than intentionally.

2.2. Status of soils linked to climate change in agriculture

2.2.1. Exposure and sensitivity of soils to climate change and its influence on overall soil health

Climate change and its consequences are felt in all parts of the world and affects many aspects of our lives. Agriculture, but also soil within it, is not spared from the impact of climate change. It negatively affects the physical, chemical and biological properties of the soil (Gelybo et al., 2018). Therefore, climate change increasingly leads to soil degradation processes that are manifested in the form of erosion, floods, droughts, landslides, reduction of the amount of organic matter in the soil, loss of biological diversity in the soil, salinization, desertification, fires, etc.

Increasingly longer and more frequent dry periods and floods, as well as the increasing threat to agricultural crops from heat stress during the last few decades, are a clear signal that the implementation of climate change adaptation measures should be started as soon as possible. This is especially visible after the large floods that hit Bosnia and Herzegovina in mid-May 2014 (Figure 2), when precipitation exceeded the records of the last 120 years – in 48 hours, about 150 l/m² of rain fell in the area of central, northern and northeastern Bosnia. Almost all rivers in Bosnia and Herzegovina overflowed their banks and flooded surrounding fields, roads and settlements. The damages were enormous and amounted to several billion KM. These and later floods have had great consequences on agricultural lands with numerous physical, chemical and biological properties of the soil damaged, and erosion, pollution and contamination by various pollutants occurred. The most dominant soil types along river courses in B&H, which are often affected by floods and their degradation, are Fluvisols, Glaysols and Eutric Cambisols on alluvial deposits. In response to these problems, Flood Hazard Maps and Flood Risk Maps for the water area of the Sava River and its basins were created in the Federation of Bosnia and Herzegovina (Annex 2.1). The Institute for Water Management of the Republic of Srpska from Bijeljina created the same maps for the Vrbas and Trebišnjica watersheds. Also, this Institute has realized a number of projects for the regulation of the riverbed and the construction of embankments in the lower reaches of the Drina River. According to the data of the European Environment Agency, the area potentially threatened by floods in B&H is 3,227 km^2 or about 6.3% of the total land area of B&H (51,187 km^2).

The consequences of droughts are the next serious problem which is becoming more and more common in B&H and the region. Prolonged, severe and frequent droughts cause habitat loss, migration of local species and spread of foreign invasive species, and consequently loss of biodiversity. Droughts affect water resources and agricultural production, cause soil erosion, reduce carbon sequestration and generally contribute to soil degradation. Due to the lack of moisture in the soil, its productivity decreases, the soil structure deteriorates, especially in clay soils. That is why some measures work well as prevention against drought and erosion, such as growing cover crops, especially legumes, using mulch material and agroforestry. In FB&H, the Federal Meteorological Institute created drought assessment maps (Annex 2.1) based on the Standardized Precipitation Index (SPI). Thus, wet or dry conditions are determined based on the amount of precipitation on the 2-month SPI-2 or 1-month SPI-1 scale. According to EEA data, the impact of drought on the total area and land cover in Bosnia and Herzegovina is 4,904 km^2. The average area affected by drought annually is 258 km^2 or 0.56% of the total land area. According to the mentioned data, B&H is among the last economies in Europe in terms of the mentioned influence.

Since more than 80% of the terrain in B&H has slopes greater than 13%, erosion caused by water is an

increasingly present problem, especially in areas that have suffered unplanned exploitation of forests and complete deforestation of the terrain. This phenomenon is the most common in the central and southern parts of the economy, where the annual amount of precipitation is as much as 2,000 mm. Erosion is the reason for the great barrenness in our economy (Šarić et al., 2003). The consequences of erosion processes is the creation of bare surfaces, less fertile soils, transport and the formation of deposits. According to the Erosion Map of SR Bosnia and Herzegovina (1985), sediment production was 16,518,030.89 m^3/year, and sediment transfer is 8,805,286.42 m^3/year. (Lazarevic R., 1985, cited according to Tošić, 2008). The Water Management Institute of Bijeljina in the RS has worked on the collection of data on erosion from the period of 1985, and based on that has created the Revitalization Programme and Erosion Maps of the Republic of Srpska (Annex 2.1).

As a result of climate change in B&H, fires have become more frequent in the last decade. Thus, in October 2022, more than 71,000 hectares of forest burned, and in 2020, fires covered about 100,000 hectares (Annex 2.1). The consequences caused by fires are almost unfathomable because they leave behind not only devastation due to destroyed forests and vegetation, but also seriously impair or destroy the biogenicity of the soil and its health condition.

The geological base and its properties, as well as the sloping and steep terrain in B&H, are natural grounds for the occurrence of landslides (Annex 2.1). There are around 1,800 active landslides in B&H, 754 of which in FB&H, over 1,000 in RS and 43 in Brčko District. Depending on the climatic conditions, B&H has more than 1,000 landslides per year. The number of landslides has increased significantly in the last 20 years, and it should be noted that landslides represent one of the primary environmental problems in B&H and pose a great threat to human life and the environment.

2.2.2. Producers' adaptive capacities relevant for sustainable use of soils

Agriculture, forestry and fishing occupies a significant part in the economy of B&H and constitutes 5.49% of the total GDP. According to survey data from 2021, the number of employees in this sector is 108,194 people or 9.4% of the total employed population. However, the age and educational structure of agricultural employees is very unfavourable. This is one of the significant limiting factors for the transfer of new knowledge and technologies to this sector, especially those related to sustainable land management and adaptation to climate change. For example, when it comes to management practices related to soil cultivation such as reduced tillage, no-tillage, contour tillage and strip tillage, there is no accurate data and no record is kept of these practices in B&H. An example of good practice and reduced tillage could only be singled out in modern orchards with intensive cultivation systems. There are about 95,030 ha of such orchards in B&H or 4.5% of the total agricultural area, and it is estimated that this is also the area under reduced tillage. Good practice is that all registered producers (84,895 in FB&H, 42,238 in RS and 4.081 in BD, according to data from 2021), who exercise the right to financial support, in addition to other conditions, are obliged to carry out agrochemical soil analysis in accredited and authorized laboratories. This is a good basis for proper fertilization and control, however, other implementation mechanisms are lacking, such as advisory services, which would professionally help farmers and at the same time supervize the correct implementation of these measures. The use of organic and mineral fertilizers in B&H is significantly lower compared to developed economies. The reasons are the insufficient livestock fund and the weak financial power of farmers in B&H to purchase fertilizers. The estimated production of manure in B&H is about 5956769 tons, which in relation to the total agricultural areas in B&H of 2,158,271 ha represent an average dose of 2.7 t/ha, and in relation to the total arable land in B&H of 1,004,931 ha, the average dose is 5.93 t/ha.

Based on the research and assessment of the consumption of mineral fertilizers in B&H for the year 2019, it amounted to 126,489.66 tons, with 64,368.96 tons of Nitrogen fertilizers, 35,856 tons of Potassium and 26,264.90 tons of Phosphorus. The estimated consumption of Nitrogen, Phosphorus and Potassium from mineral fertilizers per hectare of arable land in 2019 was 40.50 kg N/ha, 16.52 kg P_2O_5/ha, 22.56 kg K_2O/ha for the reference year (Čivić, 2021.). Data from FAOSTAT also shows similar consumption of mineral fertilizers in Bosnia and Herzegovina. These data show that the amounts for optimal doses of manure and mineral fertilizers per hectare are insufficient and are far below optimal.

Some of the new techniques, tools and knowledge related to sustainable soil management in B&H exist but are not fully used, or there are no established mechanisms for their implementation in practice. So, for example, there are maps related to agroecological zoning, maps of the use value of soil, then there are creditworthiness maps, but many maps are missing for individual indicators, such as organic carbon content, acidity, pollution, erosion, etc. Almost 40% of agricultural land in B&H has acidic or very acidic soil pH reaction. It is estimated that only about 5-8% of these surfaces are occasionally calcified.

An example of a good online service is the Farmer Web Portal, an application that allows access to certain data, such as the FB&H Register of Agricultural Farms/Clients, the FB&H Register of Beekeepers and Apiaries, an overview of the status of requests for financial incentives from the FB&H budget, and the download of all necessary forms, user instructions, etc. (https://www.farmerportal.ba/#/).

Likewise, the technical capacity of farmers and agricultural holdings is on average at a low level. This especially applies to outdated machinery, application of new technologies, irrigation systems, plant nutrition and protection, and other systems that would contribute to sustainable soil management. Political decision makers declaratively or formally support measures and activities related to sustainable soil management only through certain documents, but they are mostly not implemented in practice. Thus, for example, in FB&H, the only supported measure within the framework of incentive policies is support for the measure for the protection of the rural environment, and it only refers to the certification of organic production within the framework of the rural development model. Certain difficulties for sustainable soil management can be due to the fragmentation of landholdings and some traditional ways of tillage and soil management. The average area of a farm in B&H is about 2 ha, which is usually divided into 6-8 plots. Bearing in mind all of the above, especially the potential of farmers in terms of education and technology, it is necessary to work as soon as possible on the establishment of a free and mandatory system of continuing education for farmers. Education and training of farmers exist, but they are not the result of a systematic and organized approach of domestic institutions, but are mainly the result of ad hoc activities of individual projects and the work of international organizations. It is necessary to establish advisory services as soon as possible, involve scientific educational institutions (agricultural faculties and institutes) and put everything into the function of spreading knowledge, awareness and the need for the establishment of a system of sustainable soil management. It is also necessary to promote sustainable soil management measures through incentive policies.

2.2.3. Existing gaps and challenges to meet the newly adopted EU strategic and legal documents on soil and adaptation

The goals and activities defined in the Soil Strategy until 2030 and in the European Green Deal represent serious challenges, but also an opportunity to adopt all the necessary strategic and legal documents in B&H that will deal with soil protection, sustainable management and health, and harmonize with EU standards. In this way, the preconditions for contributing to the challenges and adaptation to climate change would be created. In addition to the above, it is necessary to strengthen the existing institutional and other capacities in the economy, which would be able to make and implement the necessary decisions on soil protection and its sustainable management. Also, it would be necessary to establish much better inter-institutional and inter-sectoral cooperation within the economy than the case is now, especially considering the fact that the problem of soil health is multi-sectoral. So, for example, the most significant pressure on the soil in B&H is represented by the change of land use. The conversion of agricultural land into construction land is a pronounced phenomenon. At the level of B&H, there is no body responsible for spatial planning and adoption of spatial plans, these are bodies at the entity and BD level, and therefore it is difficult to control and reduce the negative trend of this type of soil degradation in B&H. A serious challenge for B&H will be the achievement of a zero net rate of greenhouse gases by 2050, that is, the achievement of climate neutrality based on the soil by 2035. All this would be possible to achieve by adopting the aforementioned missing acts in which the measure of sustainable soil management and its protection would be binding. The challenge will be the obligation to reduce nutrient loss by 50% of the total amount and the risk of chemical pesticides by 50%. Unfortunately, the nitrate directive and the framework directive on waters in B&H are not a legal obligation, and in this sense there is no systematic management and control of the use of organic and mineral fertilizers in B&H. With the Sofia Declaration on the Green Agenda, Bosnia and Herzegovina committed itself to the implementation of the EU Green Deal for the Western Balkans. This plan, among other things, includes the implementation of environmental measures, and within them, monitoring, preserving and increasing the state of soil biodiversity. Agroecological measures and good agricultural practices, although they are provided for in various strategic and other legal documents, are mostly not implemented in practice. Thus, for example, in the Strategic Plan for Rural Development of B&H (2018-2021), a number of measures and sub-measures were defined that were to be implemented throughout the economy. One of these measures is “Support for organic production, environmental protection and reduction of the impact of climate change”. Within this measure, there are 6 sub-measures, of which only the sub-measure “Support for production, certification and control of organic production at all levels, in accordance with EU best practices and market requirements” has been fully implemented. Other sub-measures have been partially or not implemented at all. Partially implemented measures include the “Development and implementation of programmes to support the conservation and sustainable use of genetic resources” (for example, gene banks, field collection, botanical gardens, awareness raising, publications, etc.) and “Support to targeted programmes to reduce the effects of climate change on agricultural production and innovative actions” (e.g. investment in renewable energy sources on the farm – solar and geothermal energy, energy from organic waste, etc.). The measures that have not been implemented include “Development and implementation of agricultural land monitoring programmes (fertility, pollution, erosion, conversion, etc.) and the creation of a regulatory framework for efficient monitoring of the state of agricultural land”; “Development and implementation of a pilot programme for the development and protection of areas with natural restrictions (disadvantaged areas)”; “Development and adoption of the revitalization programme for pastures and natural meadows”. Unfortunately, Bosnia and Herzegovina does not use the financial resources of IPARD, so it has not adopted the IPARD

programme, through which agroecological measures and measures of sustainable soil management would be supported and financed.

2.2.4. Sustainable measures and best practices already applied for protection of agricultural land

Soil degradation processes in B&H are caused by climatic and anthropogenic influences. The most serious type of soil degradation refers to erosion, excessive and uncontrolled exploitation, such as the exploitation of mineral raw materials, peatlands, unplanned construction, etc. A significant problem is also represented by landslides, deforestation caused by unplanned logging and fires, depletion of the soil by organic substances, then physical and chemical pollution and soil contamination, especially by mines.

Water erosion is pronounced in B&H. It is aided by the hilly terrain and a large amount of precipitation. About 80% of the hilly terrain has a slope greater than 13%. These terrains are mainly located in the central and southern parts of the economy where the average annual precipitation is high and amounts to over 2,000 mm. This problem is particularly pronounced in areas that have suffered unplanned exploitation of forests and complete deforestation. About two-thirds of meadow areas in B&H are also exposed to erosion. Erosion is the cause of large soil bareness in our economy (Šarić et al., 2003). As a positive example, we can point out projects focused on the creation of maps of land use values at the municipal level, which contribute to the planned use of land, and thus contribute to the reduction of erosion. An example of good agricultural practice is the reduced tillage system in almost all orchards in B&H (tillage only in rows, but not in the spaces between rows). Sowing grass in the inter-row space and using it as mulch (sideration) greatly contributes to reducing erosion on sloping terrain and increasing organic carbon in the soil. Unfortunately, there are no official data on how much agricultural land in B&H is covered by this measure. The expert estimate is that they amount to about 95,030 ha or 4.5% of the total agricultural land.

Another significant type of soil degradation is related to their pollution and contamination. This problem is mainly related to the disposal of industrial waste from mines, other industry and communal waste. Coal mines are a very important part of the energy sector in B&H. There are 12 active mines in B&H (9 in FB&H and 3 in RS). In B&H, coal is exploited on an area of 18,000 ha, while the area for depositing waste material occupies almost 6,000 ha. Surface mining or surface exploitation of mineral ores (coal, iron, bauxite and clay) have so far left around 15,000 ha of damaged land. The main consequence of this type of exploitation is the direct loss of land and also putting land out of use on the areas where tailings are disposed of. Soils are often contaminated with heavy metals, and their physical characteristics are permanently impaired. Thanks to positive legal solutions and obligations prescribed by law, recultivation and remediation measures are implemented on these lands. Pollution can also come from unprofessional and excessive use of fertilizers and pesticides. However, in B&H this problem is not expressed because farmers use fertilizers significantly below European averages, especially mineral fertilizers. The reasons are mainly financial in nature, as farmers in B&H are in a weaker financial position compared to farmers in the EU. The application of organic fertilizers is also insufficient due to the lack of livestock to cover the required production of organic fertilizers for the total cultivated area in B&H. However, this does not mean that the unprofessional and inadequate use of fertilizers and pesticides in B&H cannot pollute and contaminate the soil. It is a good practice, and at the same time, a legal obligation of farmers in B&H who exercise the right to incentives, that they must do regular agrochemical analysis of the soil and get an expert recommendation for fertilization. In this way, fertilization is carried out based on expert analysis and recommendations. What is lacking is the absence of a further system of control and management of fertilization.

Frequent occurrences of extreme droughts and floods caused by climate change increase the need for planned development of irrigation and drainage in B&H. In recent years, work has been done on the renovation of the old and the construction of new irrigation infrastructure. The largest part of this project was financed by loans from the World Bank and requires large financial resources, which is also the reason areas under irrigation and drainage systems are extremely small. As an example of good practice in B&H, we could single out irrigation and fertigation systems (drip irrigation system).



Picture 2.1. Example of good agricultural practice, reduced soil tillage and the use of UV nets (fruit nursery in Srebrenik)



Picture 2.2. Recultivation of degraded soil (planting Aleppo pine on the reclaimed soil of the Banović mine)



Picture 2.3. Experimental collection orchard with different types and varieties of fruit trees. Application of modern agrotechnical measures: fertigation system, plant protection control system, UV nets (experimental field of the Faculty of Agriculture and Food Science in Sarajevo)



Picture 2.4. Irrigation projects financed by loans from the World Bank are in the implementation phase in B&H



2.2.5. Already adopted mechanisms and opportunities for effective adoption of adaptation measures for soil health protection

The consequences of climate change have not escaped B&H, as well as their impact on soil health. Bosnia and Herzegovina adopted the first Strategy for adaptation to climate change and low-emission development in 2013, and the second for the period 2020-2030 was also adopted too. These documents identify measures for mitigating and adapting to climate change by sector. In these strategies, the agriculture sector is identified as one of the priorities for mitigation and adaptation to climate change.

However, unfortunately, not much progress has been made in the implementation of these strategies and the realization of the foreseen measures. This especially applies to the agricultural sector because no strategy, programme or plan for adapting agriculture and soil to climate change has been adopted. However, several of them could be singled out as positive examples, such as mapping and defining agroecological zones in B&H, according to which the zones for optimal plant and soil cultivation are marked, created on the basis of climatic and edaphic factors. Organic agriculture, i.e. production, although very little represented (4,431.3 ha or about 0.2% of the total agricultural land in B&H) is nevertheless recognized and favoured through financial incentive programmes in agriculture. As an example of good practice of adaptation measures for soil protection, the use of organic fertilizers and mineral water-soluble fertilizers through the fertigation system can be mentioned. Fertigation is mainly carried out in vegetable growing, in greenhouses, then in vineyards and on significant areas under orchards. Also, when it comes to irrigation, micro-irrigation systems are mostly represented: drip and sprinkler irrigation. The irrigated areas are very modest. The total area under irrigation in the Republic of Srpska is currently 2,180 hectares in the Trebišnjica river basin and 2,604 hectares in the Sava river basin. There are no official data on irrigated areas and crops on the territory of the Federation of Bosnia and Herzegovina. According to unofficial data, a total of about 362.5 ha are irrigated in the Sava river basin, and about 1,250 ha in the Adriatic Sea basin. Overall, according to unofficial data, only 1,615.5 hectares, or 0.2 percent of arable land, is irrigated in FB&H.

Regular monitoring of the content of heavy metals and polycyclic aromatic compounds in the soil has been established in FB&H, and based on this, certain recommendations and measures have been provided for the rehabilitation and recultivation of the soil. Unfortunately, this monitoring system has not been established on the territory of the entire economy, that is, the Republic of Srpska. A legal obligation to control soil fertility was introduced as one of the conditions for exercising the right of farmers to incentives in plant production. It also contributes to better control of the use of plant nutrients and fertilizers. The hydrometeorological systems in the economy, that is, the entities (FB&H and RS) have been modernized a lot in terms of technical capacities, but there is a lack of systems for monitoring soil parameters.

When it comes to the development of awareness and knowledge about climate change and its impact on soil health, as well as to sustainable soil management measures, these are not at an enviable level. There is no systematic training of farmers on this issue, but there are mandatory annual educations and training of authorized agricultural advisors in advisory services in FB&H and RS. However, it should be emphasized that the establishment of advisory services in RS is in the initial phase, and in FB&H and BD the establishment process has not yet started.

2.2.6. Analysis of the current institutional and legal setup for effective adaptation of soils to climate change

In Bosnia and Herzegovina, due to the complex constitutional structure, the authority to enact certain policies, measures related to soil and its management is very complex and is related to different levels of government and institutions. The primary responsibility for the management of this resource rests with entity governments, that is, their relevant ministries. In the FB&H entity it is the Ministry of Agriculture, Water Management and Forestry, in RS it is the Ministry of Agriculture, Forestry and Water Management, and in Brčko District it is the Department of Agriculture. These ministries and the BD Department are responsible for the creation of soil policies and the adoption of laws and by-laws on soil. They are also co-responsible for monitoring the condition of agricultural soils, then for proposing technical, hydrotechnical, agrotechnical measures to improve the conditions of agricultural production, increase the fertility and production potential of the soil. Also, part of the responsibility for soil, especially the aspect of protection and promotion of sustainable soil management, also applies to entity ministries of the environment. In the Federation of Bosnia and Herzegovina, some responsibilities, especially those related to spatial planning, are delegated to lower levels of government, i.e. to the cantons. Professional and other tasks (mapping, monitoring of contamination, monitoring of soil fertility, soil conditioning, etc.) are the responsibility of the Federal Institute for Paedology and the Institute for Agriculture of the RS. In addition to the above, the personnel training and capacity, as well as the technical equipment of the mentioned institutions responsible for the soil, are very modest. At the state level, the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina has a coordinating role within the state, when it comes to policies and issues related to soil and the environment. This ministry has the authority to represent B&H on the international level when it comes to these areas. Such a complex institutional structure and competences at different levels of government represent a serious limiting factor for the adoption of functional strategic documents, laws and by-laws on land. Despite the above-mentioned complex administrative structure and shortcomings, B&H managed to pass some key documents related to the fight against and adaptation to climate change. Thus, in December 2022, the B&H Council of Ministers adopted the National Climate Change Adaptation Plan (NAP) to the United Nations Framework Convention on Climate Change (UNFCCC), which it ratified in 2000. The Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, as the coordinating ministry at the state level, in cooperation

with the competent authorities in B&H and UNEP, created an Action Programme for combating soil degradation and mitigating the consequences of drought in B&H. This programme was adopted in accordance with the UNCCD strategy and its reporting process. The goal of this project was to provide support to B&H in formulating the first Action Programme (AP) in accordance with the Climate Change Adaptation Strategy, in order to contribute to better planning and implementation of the Convention at the state level. Such improved planning and implementation monitoring should lead to a more efficient decision-making process in the field of desertification, soil degradation and drought (DLDD) and issues of sustainable land management in B&H.

However, apart from these documents adopted at the state level, which to the greatest extent correspond and are harmonized with EU regulations and UN conventions related to the protection, management and adaptation of soil to climate change, there is insufficient coordination with lower levels of government and institutions that should implement certain activities defined in the mentioned documents.

2.2.7. Existing soil data availability and quality, constraints and data gaps

The availability of data on soil in B&H is very limited for several reasons, one being that there is no single institution at the state level which is responsible for soil. There is no unified information system about soil, nor common policies at the state level that would enable the adoption of appropriate legal solutions that would protect soil from various forms of degradation and poor management. Instead, the responsibilities over soil are divided and brought down to lower levels of government: entity, cantonal, Brčko District, and for certain issues also to local communities. Key competences are related to entity levels of government. In FB&H, they are implemented through the line Federal Ministry of Agriculture, Water Management and Forestry, Federal Ministry of Environment and Tourism and the Federal Institute for Agropaedology, and in the Republic of Srpska, they are implemented through the Ministry of Agriculture, Forestry and Water Management, Ministry of Spatial Planning, Construction and Ecology.

The Institute for Agroecology also has jurisdiction within the Agricultural Institute of the RS. Ministries create policies and regulate legal issues about land, and institutes perform professional and other tasks such as mapping and determining the creditworthiness of agricultural land; control of soil fertility; arrangement of agricultural land; monitoring soil contamination; rezoning agricultural land and its rational use; monitoring (monitoring the state of agricultural land and changes in and on the soil); establishing a soil information system (SIS) on agricultural land and keeping records on agricultural land; giving instructions for management of agricultural land resources; granting consent for the use of agricultural land as well as issuing opinions and certificates for the use of agricultural land; participating in and giving an expert opinion on the regulations prepared by other bodies, which refer to agricultural land.

In addition to the above, the key drawback is that there is no unified system of soil data for the entire economy of B&H and that the quality of the data held by the aforementioned institutes is not at a level that can meet numerous challenges. Only a small part of this data is in GIS format, such as pedological soil maps, land use maps, physical and chemical properties of the soil, and they are not publicly available in digital form. The land cover data set in GIS format CORINE Land Cover is available through the international Copernicus platform and is updated every 6 years. A big gap is the lack of data, especially in digital form, related to monitoring the state of erosion, organic carbon in soil, acidification, soil sealing. Public data on the state of soil is mostly available only through the preparation of various studies, strategies, plans and programmes carried out by institutions in B&H in cooperation with international institutions and organizations for certain needs.

2.2.8. Main issues/conclusions with key recommendations and priorities referring to soil adaptation to climate change

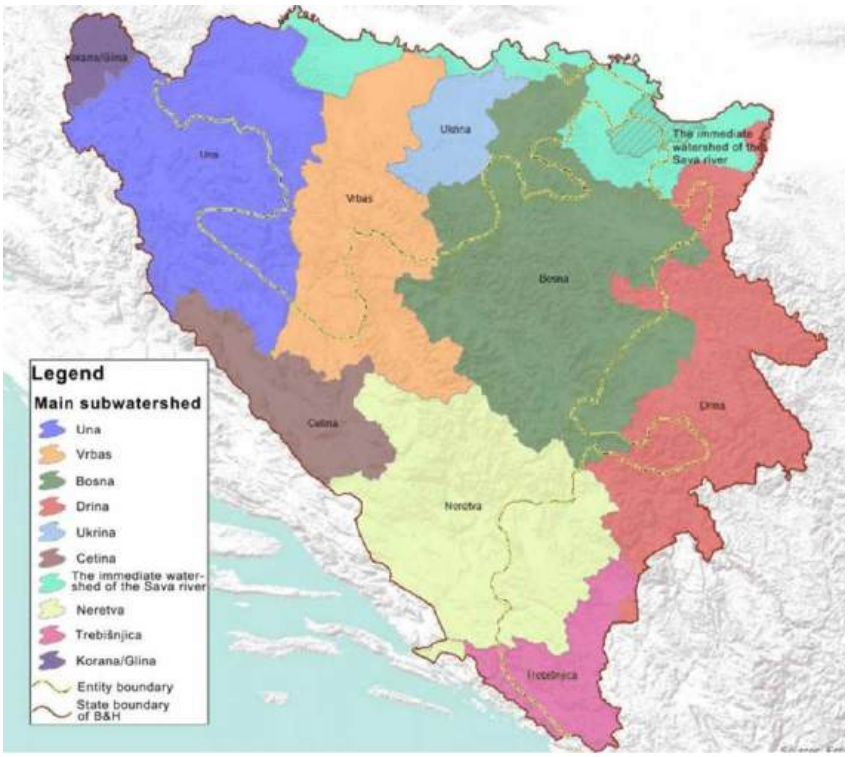
The importance of soil and its role in adaptation to climate change is of exceptional public interest, which is why it is necessary to urgently solve several key problems and deficiencies in B&H, when it comes to this topic:

- It is necessary to adopt appropriate legal and other acts on soil that would be in line with the European Strategy on Soil and the objectives of the European Green Plan on a climate-neutral Europe by 2050.
- Establish the missing institutional infrastructure and functional mechanisms that would enable successful adaptation to climate change.
- It is necessary to establish stronger, better and more functional inter-institutional cooperation within the economy, defined on the basis of a protocol on mandatory cooperation and exchange of relevant data between all actors who in any way participate and influence the state of the soil and its protection.
- Establish a digital information system for soil on the entity and state levels, enable transparency and availability of these data.
- Strengthening and raising social awareness of soil, its importance, the need for protection and the process of adaptation to climate change. Here, it is necessary to include all actors who, with their competences, knowledge and practice, can contribute to soil protection and adaptation to climate change. This certainly refers to everyone in the chain, from political decision-makers, through scientific and educational workers to citizens and farmers who need to apply this information and knowledge in practice.

2.3. Status of water resources linked to climate change in agriculture

2.3.1. Analysis of water resources in the economy and their importance for agricultural production

Bosnia and Herzegovina (B&H) hydrographically belongs to the Black and Adriatic Sea basins. There are seven river basins in B&H: Una, Vrbas, Bosna, Drina, Sava, Neretva and Trebišnjica, and Krka and Cetina (Map 2.1).



Source: http://www.voders.org/index.php/slivovi)

Map 2.1. Water catchment area in B&H

With an average rainfall of about 1,250 mm, the territory of Bosnia and Herzegovina is one of the wateriest areas in Europe, especially southern Europe. Precipitation volume of about $64 \cdot 10^9$ m^3, is equivalent to the average flow of about 2,030 m^3/s. Since the average flow of all rivers in B&H is about 1,155 m^3/s, it turns out that on an annual level, the average outflow coefficient is about 0.57. High outflow coefficient indicates several circumstances: flow regimes of even larger rivers are torrential, with very rapid flow concentrations, so losses are also reduced; hydrogeological boundaries of some watersheds are greater than orographic, so that in some watersheds underground inflows from the territories of other economies also participate.

On the basis of hydrological analyses, which due to the war events are not based on continuous series, it is possible to show the key runoff indicators in the main watersheds of the entire B&H area, showing about 722 m^3/s (62.5%) from the Black Sea Basin through all the tributaries of the Sava in Bosnia and Herzegovina, while about 433 m^3/s (37.5%) runs from the Trebišnjica and Neretva basins and Cetina into the Adriatic Sea.

The key problem is the extremely large spatial and temporal distribution of precipitation and runoff. Distribution of water is such that there is not enough of it where it is most needed (in the northern part of B&H, where the most valuable land resources and industrial potentials are located), and flows are scarcest in periods of the year (vegetation, warm part of the year), when needs are the greatest and when the problems related to water quality protection are the most serious. The total flow in the Sava basin in periods of low water in HS Jasenovac drops below 100 m^3/s. Low water periods are frequently very long (on average, it usually includes a period between mid-June and the beginning of November), and then all favourable average specific relations and indicators of available water radically worsen and reduce the average available water per capita seven to ten times in larger basins.



Source: Strategic plan of B&H for the harmonization of agriculture, food and rural development (2008-2011)

Map 2.2. Average annual precipitation in Bosnia and Herzegovina

Since small waters occur as a rule in the period of the highest water demand, this clearly indicates the need to improve the water regime by regulating flow in reservoirs with seasonal/annual regulation. When population data is included in the analysis of individual watersheds, an even more unfavourable picture is obtained. About 40% of the population lives in the Bosna river basin, while only about 14% of average flow is available in that basin. If the analysis were to include component of water quality (available flows on the most densely populated watersheds are of the worst quality, often unusable, so they do not fall under the category of usable water resources), we have a less favourable picture of the spatial distribution of water and specific availability per inhabitant. In this respect, the most favourable situation is in the Trebišnjica and Neretva river basins, covering 19.8% of the area of B&H basins, where about 9.6% of the population lives, and with a flow of about 34.8% is water of the highest level of quality.

The availability of water becomes even more unfavourable when one leaves the domain of average flows and when the temporal unevenness of the flow is considered in more detail. In the basins of Bosnia and Herzegovina, annual flows can decrease to only about 40% of average values. However, an even bigger problem is the very marked unevenness within the years. Analyses show that over 50% of the time during the year flows are lower than 80% on average.

All this means that most of the water flows into short-term floods, followed by long periods with low flows, when rivers are endangered as eco-systems, and no abstraction of water is possible without regulating the flow in reservoirs. In the months of peak consumption (July, August, September), average flows drop to only 40%, and even 30% of average annual values, so low water periods can last continuously for two, three months. Also, the analyses show that all watercourses in B&H have a pronounced phenomenon of successive accumulation of dry/low water periods during year, which can only be neutralized by implementation complex systems, with large reservoirs volumes.

2.3.2. Brief analysis of irrigation status in the economy

The State of Bosnia and Herzegovina represents the central authority, but has only limited and specific powers, whereas the two entities: the Republic of Srpska (RS) and the Federation of Bosnia and Herzegovina (FB&H) and the Brčko District (BD) are politically, administratively and legally largely autonomous.

Republic of Srpska: According to the Framework Water Management Development Plan of the Republic of Srpska from 2006 [2], it is possible to cover 158,000 ha of agricultural land in RS with irrigation. It is considered that this is an overestimate of the data and that it is possible to cover 79,912 ha (7,262 ha existing + 72,645 ha new), as stated in the Strategy on Integrated Water Management of the Republic of Srpska, July 2012 [5]. This document stated that 4,432 ha were covered by irrigation systems, but only 1,700 irrigation systems are functional. Since then, this situation has changed a lot, thanks to significant public investments in irrigation systems that have taken place in the meantime. Since 2019, about 23,418 ha of arable land have been covered by irrigation systems.

Construction of an irrigation system is very expensive and must satisfy certain requirements such as:

- that the areas are protected from flooding,
- that parcelling and organization of the land has been carried out in an appropriate manner,
- that ownership relations have been resolved,
- that the area has quality water resources for irrigation,
- that there is a stable organization of the system, within which the cycle of production, purchase, processing, placement and maintenance of the system is completed.

Based on the previous allegations, it is a realistic projection that by 2034, it is possible to irrigate new 10,032 ha of arable land [5].

Federation of B&H: The current situation in the field of irrigation in FB&H is still being evaluated, and incomplete data indicate that only about 3,000 ha are irrigated. It is certain that expert opinions and recommendations from the previous FB&H agriculture development strategy were not respected and implemented. In that document, it is stated that in the southern parts of the FB&H, it is necessary to provide irrigation for about a third, in the northern parts about 15%, and in the central part about 8% of the annual water needs of agricultural plants, and it is suggested that surface irrigation systems be built in the upcoming five-year period of 5,000 ha and rehabilitate drainage systems on an area of about 20,000 ha [1].

Brčko District: There are currently 4 hydro melioration systems in the BD area (HMS Objeda, HMS Tinja – Brka, HMS Lukavac and HMS at the location Kurjakovići – Brezovo polje). The constructed systems include only the drainage of excess water from agricultural areas, while the irrigation systems have not been constructed. The current situation of all existing hydro-melioration systems is such that it requires a detailed maintenance and reconstruction programme because these systems have not been properly maintained, some of them even since their construction and commissioning.

As part of the study [8], four localities where agricultural irrigation is planned were considered area under certain crops (Vučilovac, Klađe, Omerbegovača and Tinja – Dubrave – Bijela) on a total area of 1,837 ha. In addition to these proposed sites, Brčko District has a much larger area of fertile land suitable for irrigation, which represents a great potential for the development of agricultural production. Limiting factors for the installation of large irrigation systems are the small area of plots, the ungrouping of plots, and the lack of appropriate infrastructure.

Considering that there are no existing irrigation systems in the subject area, it is necessary to prepare a feasibility study first in order to examine the profitability of such systems for the selected agricultural areas. Precisely, this feasibility study is an initial step that provides answers to those questions. In the next step, as part of the next activities, it would be necessary to prepare detailed system projects for irrigation, to show their economic justification.

Table 2.7. Irrigated area in the economy with brief analysis of the capacities and their use in agricultural production

Hydro ameliorative systems in the Economy	Irrigated area in BiH, according to project documents, in ha	Possible irrigated area in ha in 2019	Real irrigated area in ha			Use of hydro ameliorative systems in comparison with irrigated area according to project documents, %
	~1970-1980	2019	2017	2018	2019	2017-2019
1. Sava river basin in Republic of Srpska entity	19,750	33,450	21,078	22,078	23,418	66.90
2. Trebišnjica river basin in Republic of Srpska entity						
3. Sava river basin in Federation of Bosnia and Herzegovina entity		25,000	3,000	3,000	3,000	12.00
4. Adriatic sea river basin in Federation of Bosnia and Herzegovina entity						
5. Sava river basin and Brčko district of BiH		5,037	500	500	500	9.93
Total	**19,750**	**63,487**	**25,142**	**25,578**	**26,918**	

Table 2.8. Drainage systems in the economy with brief analysis of the capacities and their use in agricultural production

Drainage systems in the Economy	Drainage area in BiH, according to project documents (ha)	Possible area in the economy, covered by drainage systems (ha)	Real drainaged area in ha			Cleaned shanel network (km)	Main recipient
			2017	2018	2019	2017-2019	
1. Sava river basin in Republic of Srpska entity	33,599	45,032	35,000	35,000	35,000 Sava river	35	Danube river
2. Trebišnjica river basin in Republic of Srpska entity							
3. Sava river basin in Federation of Bosnia and Herzegovina entity	20,000	25,000	3,000	3,000	3,000 Adriatic sea	12	Danube river
4. Adriatic sea river basin in Federation of Bosnia and Herzegovina entity							
5. Sava river basin and Brčko district of BiH	34,000	5,037	3,200	3,200	3,200	3	Danube river
Total	**89,599**	**75,069**	**41,200**	**41,200**	**42,200**	50	

2.3.3. Drought risk assessment and crop water requirement

Drought is a natural phenomenon defined as sustained and extensive occurrence of below average water availability [15]. Drought, as an adverse climatic phenomenon, has often occurred in recent years in the Western Balkans and B&H. From the beginning of October through the end of May, there is usually no drought in most parts of B&H. The need for potential evapotranspiration is covered by precipitation. July and August are usually drier months especially in the southern parts of B&H. Sometimes September can be dry, but usually September marks the beginning of the recovery of the available soil water reserve. It was found that the strongest droughts occur in the Mostar area, where a catastrophic drought with annual soil water deficiency of over 400 mm occurred in 1952. Very gentle droughts or no droughts at all were found in Bihać area. Severe droughts have caused enormous damage to agriculture in the years 2000, 2003, 2007 and 2011.

B&H is located in the part of Europe that is the most exposed to climatic changes, which are causing a significant increase in temperature in the cities and changes in the precipitation regime. In the future we can expect longer drought periods in summer, and more rain with less snow in winter. All of the above is the result of changes in the hydrological regime.

Table 2.9. Irrigation water requirement, irrigation techniques and irrigation regime by group of crops*

	Average irrigation water requirements by season (mm)	Applied irrigation techniques	Irrigation efficiency	Average Irrigation application rate (mm)	Number of aplications during the season
Cereals	±40	Sprinkler	Not measured	20-40	0-3
Maize	302	Sprinkler	60-70%	50	6
Industrial crops- sugar beet	/	Sprinkler	60-70%	64	6
Industrial crops- sunflower	145,135	Sprinkler	60-70%	3	0-5
Fodder crops + alfalfa	1,751,100	Sprinkler	/	20-40	0-8
Pods/Leguminose- soybeans	170,170	Sprinkler	/	20-40	0-10
Vegetables	115,160	Sprinkler/drip/ furrow	~70 %	/	>20
Orchards- apple, pear, cherry	320,185	Drip irrigation	~70 %	/	>21
Orchards- appricots, plums, peaches	265,180	Drip irrigation	~70 %	/	>22
Vineyards	70,140	Drip irrigation	/	/	/
Meadows/clower	183,158	Sprinkler	/	/	/
Potato	205±60	Sprinkler/drip/ furrow	/	/	/

*Note: The table shows the average estimate of B&H data according to data taken from Serbia, with respect to that the climate in B&H is more humid and colder than in Serbia.

2.3.4. Overview of farmers' existing adaptive practices regarding proper water use under climate change

Extreme weather events, such as increased drought intensity, frequency of heat waves and heavy rainfall resulting in floods and landslides are increasingly occurring, and have already caused significant economic losses and environmental degradation [16].

In Bosnia and Herzegovina there are some adaptive practices employed by farmers regarding proper water use under climate change, including improved water management with irrigation (using different methods) as the main measure, capturing water from watercourses or underground water, storing water in smaller or larger water reservoirs, and agrotechnical measures: reduced tillage, application of mulch, selection of hybrids and varieties more resistant to drought and use of hybrids and varieties of plants with shorter vegetation, monitoring the occurrence of pests and diseases and timely application of spray treatments, changing in sowing density, anti-hail nets, land drainage, practices for protection against water erosion, etc. [17], [18]

Adaptation approaches focus on improved water management and irrigation, new farming systems suitable for hotter and drier climates, and varietal improvements to local crops, in order to maximize agricultural production under more acidified conditions. Crop yield response to climate change varies greatly depending on species, variety, soil condition, treatment of direct CO_2 effects, water availability

and other location-specific factors. Owing to existing infrastructure-related constraints, current problems cannot be solved by a reliable irrigation system alone, as agriculture is considered one of the largest consumers of water and appropriate sustainable irrigation practices are rare. Irrigation will certainly be one of the key adaptation mechanisms, as will flood protection, drainage of excess water and regulation of water and air regimes in irrigation systems and/or in the soil. In general, this will be a priority for further development of the agricultural sector in B&H. Knowing that precipitation does not fully satisfy the water needs of cultivated plants, which negatively affects the yield of most agricultural crops, reference evapotranspiration (ET_0) is, in addition to soil and plant characteristics, the main input in any soil balance model and, therefore, constitutes a very important element in estimating the impact of climate change on irrigation needs. Thus, an accurate estimate of ET_0 is crucial for determining net and crop irrigation, irrigation schedule support, irrigation water management, drought and flood analyses, and climate change impact models [19]. Data of the reference evapotranspiration are used (ET_0) from the Republic Hydrometeorological Institutes of FB&H and RS, and the occurrence of rain to coordinate the start of watering and determine irrigation depths. Agricultural producers who irrigate small areas are generally guided by empirical norms. There are no official data on water use efficiency . Governments of FB&H and RS plan budgets and funds for subsidies for irrigation equipment and anti-hail protection every year. Also, in recent years many projects have been financed in the field of water management and the use of nature-based solutions in water conservation.

2.3.5. Summary of national strategies and adaptation plans for water use in agriculture, including reports, R&D, projects and communications of the international CC (adaptation) framework (UNFCCC)

Agriculture, especially the water sector, is extremely vulnerable to climate change. Therefore, many strategies, adaptation plans, reports, projects and research are focused on adaptation measures in agriculture and the water sector.

Bosnia and Herzegovina is one of 41 economies in the world, and the second in the Western Balkans, which has finalized and submitted its Climate Change National Adaptation Plan (NAP) to the United Nations Framework Convention on Climate Change (UNFCCC) that was officially published on 21 December 2022 at https://napcentral.org/submitted-naps.

This document is the result of long and intensive work and coordination of more than 1,300 representatives of institutions at all levels of government in the economy, with the support of the United Nations Development Programme in B&H (UNDP) within the project “Advancing the National Adaptation Plan Process in B&H” financed by Green Climate Fund (GCF).

The Council of Ministers of B&H adopted this important document at the session held on 26 October 2022, and previously it was supported by the Government of the Republic of Srpska, the relevant ministries of the Federation of B&H and by the Brčko District of B&H, thus showing readiness to advance planning of adaptation to climate change in the economy, with the aim of reducing negative climate consequences on all aspects of the environment and the economy.

NAP is a comprehensive document that was prepared on the recommendation and in accordance with the guidelines of the UNFCCC, which provides an analysis and assessment of vulnerability and risk from climate change, and defines specific activities and measures for adapting to climate scenarios.

Changes in climate patterns and behaviour represent a growing challenge for humanity, and in the last few years in B&H this has caused extreme climate phenomena, such as heavy rainfall, hail, devastating floods, extremely high temperatures, droughts, heat waves and stormy winds. It is already clear that they endanger human lives and cause significant material and financial damage, and that it is therefore

extremely important to work on improving climate change adaptation planning.

NAP contains an analysis of the current regulatory framework and technical studies in B&H, climate change trends, future climate projections, an overview of the impact of climate change by sector, and proposals for medium-term measures to reduce the negative effects of climate change in the most vulnerable sectors, including agriculture, water and forest resources, biodiversity and tourism.

Furthermore, other strategic framework related to the Climate Action focuses on the water sector and adaptation measures in agriculture in B&H:

- Agriculture and rural development strategy Federation of Bosnia and Herzegovina for the period 2021-2027, draft January 2022.
- Strategy for integrated water management of the Republic of Srpska, Annex 6 Irrigation of agricultural areas, Zavod za vodoprivredu d.o.o. Bijeljina, July 2012.
- Strategy on the Development of Agriculture and Rural Areas Republic of Srpska 2021-2027, September 2021.
- Study of the feasibility and economic justification for building the irrigation system for hydro-technical melioration in the area of Brčko District of B&H, January 2017.
- Strategy on Agricultural Land Management, January – September 2011.
- Strategic plan for rural development of Bosnia and Herzegovina (2018-2021) – framework document.
- Water Management Plan for the Sava River Basin in RS (2017-2021), November 2017.
- Water Management Plan for the Trebišnjica River Basin in RS (2017-2021), November 2017.
- Water Management Strategy for the Federation of Bosnia and Herzegovina 2010-2022, March 2012.
- Zurovec, O., Vedeld, P.O., Sitaula, B.K. (2015): Agricultural Sector of Bosnia and Herzegovina and Climate Change – Challenges and Opportunities. Agriculture 2015, 5, 245-266.
- Markovic M. et al. (2019) Alleviation of Negative Climate Change Effects on Maize Yields in Northern Bosnia by Liming and Phosphorus Fertilization. In: Leal Filho W., Trbic G., Filipovic D. (eds), Climate Change Adaptation in Eastern Europe. Climate Change Management. Springer, Cham.

Almost all these national strategies, documents, programmes, action plans, strategic plans, among other things, put special emphasis on climate change, new challenges related to water, construction of new and rehabilitation of existing irrigation systems, policies for rational and efficient water use, promotion and application of modern irrigation techniques, preparation of development plans for each irrigation and drainage system, undertaking institutional reforms regarding water management in the agriculture sector, etc.

2.3.6. Overview of the political and institutional setup, and legislative framework for adaptation activities relevant to the sector

Institutional framework for water management and agriculture in Bosnia and Herzegovina (B&H) is complex. The State of Bosnia and Herzegovina represent the central authority, but has only limited and specific powers, whereas the two Entities: the Republic of Srpska (RS) and the Federation of Bosnia and Herzegovina (FB&H) and the Brčko District (BD) are politically, administratively and legally largely autonomous.

By adopting the Law on Ministries and Oher Administrative Bodies of Bosnia and Herzegovina in March 2003, the Ministry of Foreign Trade and Economic Relations (MoFTER) was given authority

to deal with environmental issues and natural resources in international relations at the state level. Entering into international agreements (multilateral, bilateral) as well as the duties arising from the signed international conventions and agreements (such as the Stabilization and Association Agreement, International Commission for the Protection of the Danube River, International Sava River Basin Commission, etc.), are the responsibility of B&H, but institutions at lower levels of government are involved in the operational implementation.

Article III.3a of the B&H Constitution defines the responsibilities and relations between the institutions of B&H and its two constituent entities: FB&H and RS. However, according to Article III.3a of the B&H Constitution, "all state functions not expressly designated under this Constitution as the jurisdiction of the State of B&H shall be the exclusive competence of the Entities". In accordance with this article of B&H Constitution and the Constitutions of the FB&H and RS and the Arbitrary Decision of the BD, responsibility for water management and agriculture is the responsibility of RS, FB&H and BD, which specifically means that the entities and BD regulate issues of water management and agriculture through their regulations.

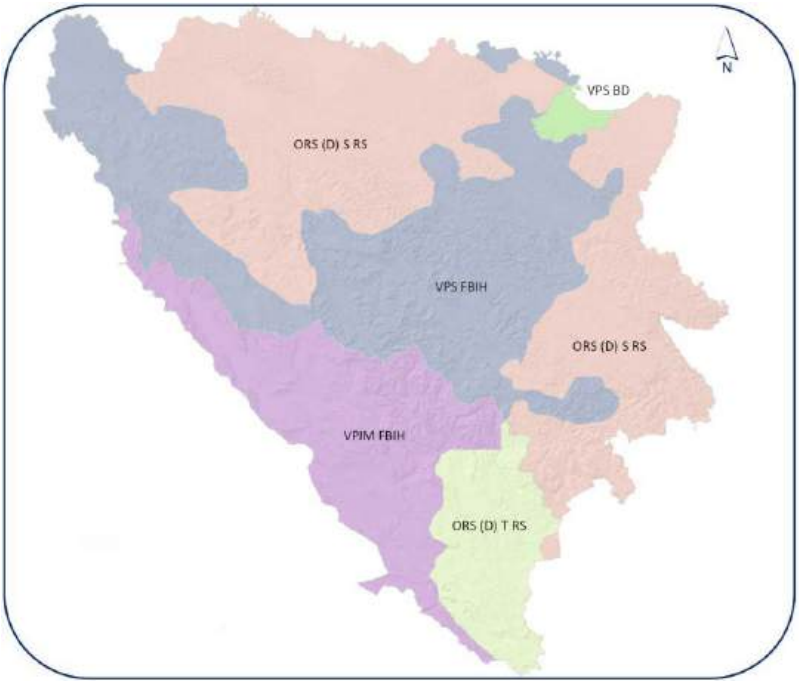
The legal framework for water management in the Republic of Srpska is regulated by the Law on Waters of the Republic of Srpska (Official Gazette of the Republic of Srpska, No. 50/06, 92/09, 121/12 and 74/17). This Law stipulates that the following are responsible for the adoption of regulations: President of the Republic of Srpska; National Assembly of the Republic of Srpska; Government of the Republic of Srpska; Ministry of Agriculture, Forestry and Water Management, as the competent administrative organization of the Republic of Srpska. The institution that operationally implements the Law on Waters, by-laws and other acts relating to waters is the Public Institution Vode Srpske in Bijeljina.

At the FB&H level, ministries were established in accordance with the Law on Federal Ministries and other bodies of the federal administration. In FB&H, the jurisdiction for water management is divided between the FB&H and the cantons. In accordance with Article 179 of the FB&H Law on Waters, the Federal Ministry performs administrative supervision over the implementation of the same and the regulations adopted on the basis of this law, as well as administrative supervision over the work of water agencies in the performance of the tasks assigned to the water agencies by the FB&H Law on Waters (Art. 152 of the Law on Waters of FB&H). Cantonal laws on waters describe in more detail the activities of relevant cantonal ministries within their respective jurisdiction in water management. The relevant institutions for flood risk management in FB&H are presented in the diagram below.

For the purposes of water resources management and agriculture, the Brčko District established the Department of Agriculture, Forestry and Water Management, under the BD Government.

Administratively, Bosnia and Herzegovina is divided into 5 Management Units (by districts), 2 in RS, 2 in FB&H and one in BD (Map 2.3):

- Sava River Basin in the Republic of Srpska (ORS (D) S RS),
- Trebišnjica River Basin in the Republic of Srpska (ORS (D) T RS),
- Sava River Basin in the Federation of B&H (VPS FB&H),
- Adriatic Sea Watershed in the Federation of B&H (VPJM FB&H) and
- Sava River Basin in Brčko District (VPS BD).



Management Unit	Competent Authority
Sava River Basin in FB&H (VPS FB&H)	Sava River Watershed Agency
Sava River Basin in RS (ORS (D) S RS)	PI Vode Srpske
Adriatic Sea Watershed in FB&H (VPJM FB&H)	Adriatic Sea Watershed Agency
Trebišnjica River Basin in RS (ORS (D) T RS)	PI Vode Srpske
Sava River Basin Brčko District (VPS BD)	Government of BD

Map 2.3. Units of Management in Bosnia and Hercegovina

Source: Technical Assistance for the Preparation of the Flood Risk Management Plan for Bosnia and Herzegovina

2.3.7. Existing data availability and quality, data constraints and data gaps

Existing data in the water sector and agriculture are unreliable. There are no data on ground waters, nor data on the required amount of water for irrigation, industry, thermoelectric and thermal plants, and other needs. It is evident that certain data are copied from study to study, without precise measurements in the field. In FB&H and BD, there are no exact data on agricultural areas that are irrigated and drained, but only estimates. Unlike FB&H and BD, there are certain data in the Republic of Srpska, but it is noticeable that they are copied from study to study without updates, however, the construction of the irrigation system in the meantime is known.

During the work on this document, the aridity index by De Martonne was obtained for meteorological stations in RS, but not in FB&H and BD.

Also, in the field of adaptive measures, capacities and results of their application by farmers in the field, there are no official documents where such data can be found. Keeping a register of the application and results of appropriate adaptive practices can contribute to increasing their application and their traceability.

2.3.8. Conclusions with key recommendations and priorities referring to proper water use and adaptation to climate change

The situation concerning hydro melioration systems and irrigation in Bosnia and Herzegovina currently falls short of expectations. To elaborate, there exist expansive areas that have been developed and equipped for irrigation, yet they remain largely unused due to various constraints. Of the total of 63,487 hectares of arable land earmarked for irrigation, only 26,918 hectares are currently under irrigation, as indicated by various strategies and reports. Addressing this issue necessitates not only rehabilitating the existing systems through construction but also instituting profound changes in the approach to irrigation and system management. This entails conducting a comprehensive inventory of the available facilities and equipment, seamless integration of systems like LPIS into water utility operations, and raising public awareness regarding the pivotal role of irrigation systems in agriculture.

- Given the multitude of stakeholders responsible for water management in Bosnia and Herzegovina, conducting an institutional mapping exercise is essential. It is necessary to identify overlapping functions, potential collaboration opportunities, and even recommend legal adjustments to enhance inter-institutional cooperation.
- A standardized methodology for estimating irrigated and potential irrigated areas, as well as water extraction for irrigation, must be established. To achieve this and ensure adherence to European standards, coordination among competent institutions is imperative.
- Furthermore, it is crucial to align the water management sector and the agriculture sector with overarching strategic and planning documents and assess the compatibility of policies within these sectors and with others. Encouraging farmers and other stakeholders to make greater use of the existing measures requires incentives, such as additional subsidies.
- Efficient water use demands attention through support for farmers in acquiring equipment for measuring irrigation time and quantities, alongside educational initiatives to underscore the significance and methods of rational water use in agriculture.
- Investing in the construction of new facilities, with a focus on end-users and small, efficient irrigation systems, holds the key to success. Additionally, evaluating and adjusting the existing agricultural water management system, or embarking on institutional reforms, is indispensable, and requires investment in field equipment, workforce development, and employee training.
- Thoroughly documenting actively used areas and wells within and beyond irrigation systems is paramount, as is the development of water use programmes at the hydro meliorative system level.
- Encouraging innovative companies to contribute to the digitalization of agriculture, including irrigation, is a significant priority.
- Implementing volumetric delivery and billing of irrigation water can promote a more rational and efficient use of water in agriculture.
- External donor support is essential to increase investments in the sector, particularly for the rehabilitation or construction of new irrigation systems.
- Bolstering domestic and international donor support for research projects and training initiatives conducted by higher education institutions is vital. These initiatives aim to disseminate findings, experiences, practices, and new technologies to extension services, farmers, and other stakeholders.
- Maintaining a registry of applied adaptive irrigation practices and their traceability is critical.

In addition to the above, the following key recommendations and priorities are significant for Bosnia and Herzegovina:

- Raise public awareness about water conservation and climate change adaptation through educational campaigns, public service announcements, and outreach activities.
- Invest in research and development to foster new technologies for water conservation and climate change adaptation, allowing Bosnia and Herzegovina to develop innovative solutions for the challenges posed by climate change.

Possible limitations preventing the introduction of sustainable practices

The main causes of the slow increase in areas under irrigation are: economic instability (instability of product prices, high bank interest rates, lack of markets, observed reductions in livestock and processing capacity), lack of strategy and plan for developing irrigation in agriculture, poor infrastructure (inadequate road network and inability to connect irrigation pumps and valves to the power grid on remote farms), state of repair of drainage canals (terrain drainage is an essential condition for irrigation), professional/advisory assistance, better supply of raw materials (high-yielding varieties and hybrids, mineral fertilizers, plant protection, age structure of farming population and EF (ecological flow), where there is no balancing of water with reservoirs.

When developing irrigation, one should anticipate the difficulties that may arise in practice. Thus, if there are not enough farmers interested in irrigation, the problem can be twofold: the cost-effectiveness of bringing water to a plot and the cost-effectiveness of irrigation on the plot. Past research has shown that irrigation can be profitable if at least 60 percent of the total number of owners/users use an irrigation system in one irrigated area. Managing the systems in B&H is also one of the potential problems. In many economies, individual irrigation systems are managed by water user associations. There are good practice examples in B&H in Herzegovina. However, there are also bad practice examples in B&H, where the newly established system management methods were sustainable only during the project.

2.4. Crop production analysis linked to climate change in agriculture

2.4.1. Analysis of meteorological data availability and accessibility

During the 1980s, Bosnia and Herzegovina had over 100 operational weather stations (FHMZ, 2023). The devastation of stations during the conflict from 1992 to 1995 resulted in their cessation of operation and their restoration took place from 1997 to 2000. This resulted in a data gap, which, depending on the location, varies from January 1992 to December 1999.

Responsibility for data collection in B&H is divided between the entities, the Federal Hydrometeorological Institute B&H (FHMI) for FB&H and the Republic Hydrometeorological Service of the Republic of Srpska (RHMS) for RS. In case of research needs, data can be accessed from both institutions.

The number of stations managed by FHMI is 15 (Sarajevo, Mostar, Bjelašnica, Bihać, Tuzla, Gradačac, Ivan Sedlo, Bugojno, Livno, Sanski Most, Zenica, Jajce, Drvar, Neum and Stolac), while the number of stations covered by RHMS is 20 (Drinić, Ribnik, Šipovo, Mrkonjić Grad, Prijedor, Bosanski Novi, Banjaluka, Srbac, Doboj, Bijeljina, Zvornik, Sokolac, Hanpijesak, Foča, Rudo, Višegrad, Čemerno, Gacko, Trebinje and Biljeća). Therefore, the total number of public stations for the entire territory of B&H is 35.

The Federal Hydrometeorological Institute provides annual reports with monthly data (FHMZ, 2021b) available on their website for the period 1996 to 2022 while RHMS has monthly reports for the last several years. Both institutions collect their data based on World Meteorological Organisation (WMO) standards, conducting daily and scheduled (07:00, 14:00 and 21:00) measurements of all significant climatic parameters, including air pressure, air temperature (mean, minimum and maximum), relative air humidity, cloud cover, insolation, precipitation, and wind speed. In addition to these public stations, there are also private stations. However, they typically lack reliable long-term data, or they are situated in urban areas or at airports.

Based on everything mentioned, we can conclude that B&H has quality climate data sufficient for numerous climate analyses and indices. These data are accessible to researchers through proper request. One potential issue may be data gaps, particularly during the period from 1992 to 1999. Furthermore, when compared to EU economies, we can say that B&H has a lower weather station density. B&H typically relies on future climate scenarios and data sourced from the Copernicus database (CORDEX regional climate model) (NAP, 2021; TNC, 2016; Trbic et al., 2022).

2.4.2. Analysis of the most common agrometeorological indices available and used in the national context

In B&H, various agrometeorological indices are used. Some indices are monitored through public hydrometeorological services (FHMI and RHMS), and their values can be obtained continuously on their web page. Within the information provided from FHMI and RHMS, there is a section called Agrometeorology. In this section FHMI reports data on: Reference Evapotranspiration (ET_0) calculated using the Hargreaves method (Hargreaves & Samani, 1985), as well as soil temperature data at 5 and 20 cm depths, along with the Standardized Precipitation Index (SPI) for 1, 3, 6 and 12 months. The agrometeorological review for the past 7 days contains information about temperatures and precipitation, as well as advice for farmers on agricultural activities such as soil cultivation, sowing, fertilization, harvesting, and other activities (FHMZ, 2023a). In the same section, RHMS provides

information on soil temperature (at 5 and 20 cm depth) and SPI (SPI1, 3, 6, and 12). Additionally, it offers agro-alerts and an agro-bulletin with information tailored for farmers. Both institutions provide short-term (3 days) and medium-term weather forecasts for the next 15 days. In addition to temperatures and precipitation, the forecast includes evapotranspiration, SPI, wind, and thunderstorms.

In the following text, all indices categorized by their type will be presented, along with references to studies conducted under B&H conditions:

a. Drought indices – Standardized Precipitation Index (SPI) is based on the probability of precipitation for any timescale, and is currently the most widely used index in B&H. SPI can provide agriculture drought information if relevant timescale is a month or two. There are studies in B&H where this index has been used (Ducic et al., 2015; Hodžić et al., 2013; J. Žurovec et al., 2011). Standardized Precipitation Evapotranspiration Index (SPEI) is an improved version of the previous one, because it includes evapotranspiration data (Čadro et al., 2017a), Palmer Drought Severity Index – PDSI (J. Žurovec & Čadro, 2015), precipitation percentiles, rainfall factor by Lang, de Martonne drought index, and hydrothermal coefficient by Seljaninov (Popov, 2020; Trbić et al., 2013). Of all the mentioned indices, regular observation is carried out only for SPI.

b. Temperature indices – Growing Degree Days (GDD), sum of temperature above 5°C (FHMZ, 2021a, 2022) and length of vegetation season (FHMZ, 2021a) are continuously monitored data available on the websites of meteorological institutes (FHMI and RHMS). The Extreme Temperature Index (TNC, 2016), number of frost days, number of summer days, number of tropical nights, length of warm and cold spells (FNC, 2021; Popov et al., 2019a; Popov et al., 2018a; Popov et al., 2018b; Popov et al., 2019b; Popov et al., 2017; Trbic et al., 2017), are based on conducted research, often in the context of tracking their trend. These data are regularly monitored, but their use is mainly limited to periodic reporting without specific application.

c. Soil water balance – data obtained as a result of soil water balance include actual evapotranspiration, soil moisture, water surplus, soil water deficit, and aridity index. These are general data that represent general conditions without specific crops and are the result of scientific research without continuous calculation. (Čustovic et al., 2014; Čadro et al., 2020; Čadro et al., 2018; Čadro et al., 2019b; Čadro et al., 2023; Hodžić et al., 2013; Miseckaite et al., 2018; Čustović et al., 2015).

2.4.3. Analysis of phenological monitoring

Continuous long-term phenological observations in B&H are done for three major groups (FHMZ, 2013; RHMZ, 2023): wild plant group, which includes wild herbaceous plants, forest trees and shrubs, and grasses; cultivated plant group, which includes clovers and meadow grasses, field crops (cereals), fruit trees, and vineyards; and group of plant diseases and pests primarily those the occurrence and development of which depend on weather conditions. These observations also follow and record the dates of general fieldwork activities such as pre-sowing soil preparation, mowing of meadows, harvesting of winter crops, and final preparations before winter (RHMZ, 2023).

For the FB&H, for field crops, legumes and meadow grasses observation includes time for: sowing, germination, tillering, heading (tasselling), flowering, ripening, harvest and yields. For those phenological observations, the following crops are monitored: maize (*Zea mays*), potato (*Solanum Tuberosum*), clover (*Trifolium pratense*) and alfalfa (*Medicago sativa*). In some reports, but nor regularly, the following crops are observed: wheat (*Triticum vulgare*), barley (*Hordeum sativum*), rye (*Secale cereale*), oats (*Avena sativa*), sugar beet (*Beta vulgaris*), sunflower (*Helianthus annuus*) and tobacco (*Nicotiana tabacum*). Sixteen types of fruit crops are observed for start of leafing, start and end

of flowering, start of ripening, harvesting, yellowing and time of leaf fall. Types of fruit crops observed include apple (*Pirus malus*), pear (*Pirus communis*), plum (*Prunus domestica*), cherry (*Prunus avium*), wild cherry (*Prunus cerasus*), peach (*Prunus armeniaca*), apricot (*Prunus persica*), almond (*Amygdalis communis*), walnut (*Juglans regia*), red currant (*Ribes rubrum*), black currant (*Ribes nigrum*), olives (*Olea europaea*), lemon (*Citrus lemonia*), orange (*Citrus sinensis*), pomegranate (*Punica granatum*), and fig (*Ficus carica*). In addition, there is an observation of vineyards that also includes start of shoot growth, appearance of the first leaves, start of flowering, end of flowering, start of ripening, full ripening, harvesting, yield, sugar content, and acidity. Vegetables other than potato are not monitored; the focus is on observing wild plant species, as they serve as good indicators of weather conditions and changes. FHMI is annually publishing a phenological yearbook (FHMZ, 2021a) that can serve as a valuable source of information. The phenological yearbooks are available from 1961, with a gap in data for the years 1991 to 1999. These records are accessible for 13 major weather stations in FB&H (Bihać, Bugojno, Drvar, Gradačac, Ivan-sedlo, Livno, Mostar, Neum, Sanski Most, Sarajevo, Stolac, Tuzla, Zenica). For RS, the RHMS does not have available phenological yearbooks, but it provides information on current timings for field and vegetable crops (maize, wheat, potato, barley, rye, and oats), such as sowing/planting, germination, flowering, and harvest, as well as for fruit trees (apple, pear, cherry, peach, apricot, and walnut) and vineyards, including the emergence of first leaves, onset of flowering, full bloom, and start of ripening. These data are available for eight meteorological stations: Banja Luka, Bijeljina, Doboj, Sokolac, Mrkonjić Grad, Prijedor, Bileća, and Trebinje. However, not all plant species are monitored at all locations, but rather based on their significance. A significant portion of the data is not available in digital format, particularly for the period before 1990. This complicates the process of analyzing the impact of climate change on phenological characteristics, emphasizing the need for the digitization of these valuable datasets. Based on research, for the regions with a warming trend, changes in plant phenology were mainly manifested in the earlier occurrence of spring phenophases (e.g. budding, leafing and flowering) and delayed occurrence of autumn phenophases (e.g. leaf colour change and leaf-fall) (NAP, 2021). Also, it can be noted that there is a significant lack of (especially long-term organized) research on the impact of climate change on phenological characteristics of plants in B&H. This is particularly evident in agricultural production (PSP-B&H, 2023b), unlike forest and wild plant populations where there is some research (Subotić et al., 2020).

2.4.4. Analysis of crop models used for estimating crop response to climate change

Crop models in B&H are not used systematically, but rather by individual researchers. The most commonly used software models in B&H for determining crop response to climate change include: CROPWAT (Smith, 1992), SPAW (Rao & Saxton, 1995), CROPFLEX (Karleuša, 2007), AquaCrop (Raes et al., 2009) and SIMDualKc (Ran et al., 2017). These models differ in the amount of information required to perform a specific calculation. For a long time, the simple CROPWAT model was extensively used, as it came with a set of climate data (CLIMWAT) and standard values for various agricultural crops. Recently, especially through the implementation of activities within the SMARTWATER (Marković et al., 2021) project, the use of other models has been improved, with the AquaCrop model (Čadro, 2019; Čadro et al., 2019a) seeing greater utilization.

A significant contribution towards demonstrating the utility of various models for agricultural crops (maize) in B&H was made by a study titled *Comparative Analysis of Different Software Models for Determination of Irrigation Requirements in Maize* (Crljenković, 2022). This research presented and compared the capabilities of three models (AquaCrop, CROPWAT and SIMDualKc) through practical application.

2.4.5. Analysis of extreme weather events

The most common natural disasters which are registered on the territory of B&H relate to earthquakes, severe storms with hail, winds of devastating intensity, powerful electric discharges, blizzards, rains of high intensity and short duration caused by flash floods, landslides and mudslides, floods, drought, early and late frosts, and forest fires (FACP, 2014). There is an increased variability in weather conditions observed in all seasons, with rapid changes occurring over short periods (five to ten days) from extremely cold to warm weather, or from periods of extremely high rainfall to extremely dry periods (TNC, 2016). In terms of agricultural production, the greatest risks are droughts, followed by spring frosts, autumn frosts, hail, and floods (Zurovec & Vedeld, 2019).

The two most significant events were the drought in 2012 and the floods in 2014 (TNC, 2016). During the last 20 years, nearly every year was characterized by extreme weather conditions: floods in 2001, 2003, 2004, 2009, 2010, 2014, 2019; droughts and heatwaves in 2000 2003, 2007, 2011, 2012, 2013, 2015, 2016, 2017, 2019; cold snaps in early 2012; windstorms in mid-2012 and late 2017; and an exceptionally high number of days with hail in 2018 (FACP, 2014; NAP, 2021; TNC, 2016; UNDP, 2020). In recent decades, B&H has experienced several severe droughts, notably in 2000, 2003, 2007, 2011, 2015, and 2018. These droughts had significant agricultural consequences, with the 2000 drought being the worst in the last 120 years, affecting around 60% of agricultural production. In the summer of 2003, some regions in B&H faced a drought that resulted in over 2 billion EUR in agricultural damage and impacted nearly 200,000 people. In the summer of 2007, extremely high temperatures and limited rainfall destroyed more than 40% of the economy's agricultural production and led to forest fires covering approximately 250 hectares of land while in 2012 severe drought reduced yields of vegetables and grain crops by 70% (Čaušević et al., 2020; PSP-B&H, 2023b; UNDP, 2020).

Changes in precipitation are more pronounced by seasons than annually. Because of the increased intensity and variability of precipitation and increased share of heavy rains in the total distribution of precipitation, the risk of floods increased, in particular in the central and northern parts of the economy. Such event is the catastrophic floods in May 2014 (NAP, 2021). The floods that occurred in June 2001, when between 50 and 100 l/m^2 fell, affected the North B&H (Posavina, Tuzla, Zenica-Doboj) and Central Bosnia Canton and caused enormous damage to agriculture. In the spring of 2004, floods affected 13,455 hectares of agricultural land, and the damage caused by the flooding amounted to 12,212,081 EUR. In 2010, B&H was affected by heavy floods that caused considerable damage to agricultural production, with the greatest damage registered in Tuzla, Zenica-Doboj (central), Posavina (north), Bosnia Podrinje (east), and Herzegovina-Neretva Cantons (south) (WBIF, 2019). Also, in late April and early May and early August of 2014, floods were caused by heavy storms. Total agricultural damages in B&H resulting from the 2014 floods were estimated at 187.21 million EUR (CMBH, 2014).

2.4.6. Information on the most important crops sensitive to climate change

Climate change impacts agriculture in B&H, with both positive and negative effects. Longer growing seasons benefit winter crops, while higher temperatures and water shortages threaten spring crops. Fruit and vineyard cultivation areas expand due to milder winters. However, there is risk of reduced yields and quality for pasture and forage due to extreme weather events (TNC, 2016).

In B&H, the Annual Crop Statistics information is provided by the entity statistical offices, the Federal Institute of Statistics and the Institute of Statistics of the Republic of Srpska. Based on the analysis of data collected by these institutes from 2000 to 2020 (ASBH, 2016, 2023), the most cultivated crops in B&H are corn for grain followed by wheat. Other important crops are available in Annex 2.2.

The main problem of the B&H agricultural sector is low productivity. Agriculture is based on small-scale, subsistence production, usually with a low level of agricultural technology use, such as drainage systems, irrigation techniques or application of smart agriculture solutions (Čadro et al., 2019a; MAWFFiBH, 2013; O. Žurovec et al., 2015). Such cropping system is highly sensitive to climate change, as it heavily relies on weather conditions. This is particularly significant for open-field crops like tomatoes, peppers, and cucumbers, which require substantial amounts of water. New orchards, especially those growing apples, and raspberry or strawberry plantations are equipped with irrigation systems, often complemented by protective nets for shading and hail protection. This indicates a certain level of adaptation to climate change. The traditional production system primarily involves crops such as potatoes (Stricevic et al., 2017), corn, and winter wheat, as they are less labour-intensive and possess a certain degree of resilience to climate change (O. Žurovec et al., 2017; O. Žurovec et al., 2015).

The changing climate in B&H has significant impacts on current cropping systems. While there are some positive aspects, such as extended growing seasons for certain crops due to milder winters, there are also substantial challenges. High temperatures and water scarcity during summer months pose a threat to spring crops. Moreover, there is an increased risk of plant diseases, pests, and weeds, influenced by climate shifts. Warmer and drier conditions may necessitate changes in agricultural practices, like intensifying irrigation, potentially increasing production costs and environmental impact. Mild winters may lead to the spread of harmful insects, potentially requiring additional pest control measures. Invasive heat-loving fast-growing weeds and pests are likely to expand their range. Weakened plants due to drought become more susceptible to diseases and insects, potentially leading to increased pesticide use, which can have negative effects on health and the environment (TNC, 2016; UNDP, 2013; O. Žurovec et al., 2015).

2.4.7. Information on vulnerable regions and crops and their combination

Considering both historical data and projections, the northern Continental region of B&H, along with the southern Mediterranean region (NAP, 2021), are identified as the most sensitive regions to climate change in agriculture. According to the RCP8.5 climate scenario, B&H can be divided into four distinct agroecological areas, each with different vulnerability and requiring specific adaptation measures to climate change (FNC, 2021; NAP, 2021). These regions include: high karst areas with karst fields (south), lower Herzegovina area (south), central hilly-mountainous area with river valleys (central), and lowland hilly area (northwest).

a. **High karst area with karst fields** (south) – exposed to the impact of heavier precipitation and, consequently, greater erosion and dry summer periods with forest fires. These areas are generally not utilized for agricultural production.

b. **Lower Herzegovina area including the upper Neretva and karst fields** (Livanjsko Polje, Duvanjsko Polje, Glamočko Polje, Popovo Polje, etc.) – anticipated more significant rise in temperatures coupled with reduced summer precipitation, leading to intensified heavy rainfall events and extreme climate events in general, also hail occurrences and milder winters with diminished snow cover. This is the area where vegetables are predominantly produced in greenhouses, followed by vineyards and various perennial crops. Traditionally, modern cultivation technologies are applied, which are completely adapted to contemporary climatic requirements and can be applied in future climatic conditions (NAP, 2021). Orchards will be the most affected by climate change due to their long vegetation. High temperatures and more intense solar radiation cause burns, affecting the quality and class of fruits. On the other hand, heavy rainfall during the flowering and ripening

of fruits, especially cherries, sour cherries and berries (strawberries, blackberries, raspberries), causes mould to occur, which either leads to a loss of yield or requires the use of more pesticides. On shallow soils, usual for this area, orchards will be at a greater risk.

c. **Central hilly-mountainous area with river valleys** (central B&H) – compared to other regions, this area is under least threat from climate change. The greatest pressure can come from heavy precipitation, which can cause intense erosion and torrential floods, especially in the higher parts of this region (NAP, 2021). In this area, there is no intensive large-scale agricultural production; primarily, these are smaller family farms along with meadows and pastures.

d. **Lowland hilly area** (northwest) – challenges include intensive precipitation, potentially leading to floods and varying levels of excessive moisture, ranging from waterlogging to swamping of arable land. Additionally, there is an increase in the frequency and intensity of heatwaves, droughts, windstorms, and hailstorms. Warm winters trigger flowering of fruit trees during winter months, subsequently leading to reduction in yields, both in terms of quantity and quality of fruit. Another pressing concern arises from late spring frosts, which can partially or entirely devastate blossoming fruit trees, especially those varieties that bloom slightly earlier due to the prolonged growing season (NAP, 2021). This is an area where the production of fruit varieties such as plums, apples, pears, as well as raspberries and strawberries (ASBH, 2023) and various cereals (corn, wheat, barley) is most intensive. For these fruits, during extremely dry years (2012, 2017 and 2019), the recorded yields (kg per tree) were the lowest (ASBH, 2023). It is evident that drought and high summer temperatures along with late spring frosts are key climatic risks to fruit production in B&H (Trbic et al., 2022). Vegetable crops (cabbage, cucumber, beans, onions) and modern orchards (plum, apple, pear, peach, and berry orchards), especially those raised on shallow to medium-deep soils, will require increased use of irrigation in order to ensure regular and good quality yields (MAWFFiB, 2022; NAP, 2021). Changes in agri-environmental conditions will have a greater impact on corn than wheat (FNC, 2021). This division of B&H into four areas is supported by other studies that consider historical data and trend analyses (Čadro et al., 2019b; Čadro et al., 2023; WBG, 2021). Based on the Vulnerability Index, the most vulnerable B&H municipalities to climate change are located across the north (Bijeljina, Orašje, Doboj Jug) with gradual decrease towards central, eastern and western parts of B&H. In the south, most of the municipalities in the lowland region of Herzegovina (Čapljina, Ljubuški, Čitluk, Posušje, Široki Brijeg, Grude) are classified as highly vulnerable (O. Žurovec et al., 2017).

2.4.8. Information on practices used by the farmers to protect their crops from damages caused by weather variability

The bottom-up approach to innovation recognition by farmers has not gained traction in B&H. There are no records or mechanisms in place to track this, and most technology transfers follow a top-down principle. Farmers in B&H generally lack awareness of climate change and often rely on weather conditions with a 'good-bad year' approach. Modern orchards with fruit trees and berries are being established with irrigation and protective netting. However, a common issue arises from irrigation being carried out based on subjective assessments without proper monitoring of actual crop needs (Čadro et al., 2017b). Challenging economic situation, cultivation of relatively resilient crops such as maize, wheat, and potatoes, subsistence agriculture-oriented production as well as low cost-effectiveness of implementing climate change adaptive and sustainable solutions, are the main reasons why farmers hesitate to adopt these practices.

2.4.9. Information on climate change adaptation measures and practices already tested/ promoted in the economy or established in national documents related to climate change and agriculture

Environmental responsibilities lie with the Ministry of Foreign Trade and Economic Relations (MOFTER) and climate change efforts are coordinated through MOFTER and the Council of Ministers. United Nations Framework Convention on Climate Change (UNFCCC) focal point is the RS Ministry of Spatial Planning, Construction and Ecology. These institutions participate at various levels in the creation of documents related to climate change (Annex 2.2).

The economy has committed to supporting a wide range of adaptation measures, including, the implementation of improved water resource management systems, investments in new irrigation (WB, 2020), the improvement of irrigation-drainage systems, and new farming systems more appropriate for hotter and more arid climates (NAP, 2021; TNC, 2016; Trbic et al., 2018; UNDP, 2013, 2020; WBG, 2021). The list of these measures is presented in Annex 2.2.

B&H has planned all these measures for the upcoming period, up until the year 2030 (NAP, 2021; UNDP, 2020). Generally speaking, this represents an ambitious plan, and its implementation should primarily focus on the most vulnerable areas where intensive agricultural production is already taking place. In the context of B&H, this refers to the Mediterranean region and the northern lowlands.

2.4.10. Information on measures in the national agricultural policy, and on national systems for support to agriculture related to climate change adaptation

Recent agriculture development strategies for FB&H (GFB&H, 2020) (MAWFFiB, 2022), RS (MAFWRS, 2021), and BD (GBD, 2022) set objectives that align with EU Common Agricultural Policy (CAP) goals. The implementation of these policies in B&H is delayed; while there are initiatives, the economy's agriculture policy has yet to be harmonized with the new CAP and Green Deal. Most of the activities being implemented are adaptation measures, such as supporting the development of organic production, implementing irrigation or hail protection systems, while preventive measures are not considered and implemented.

With regards to climate change adaptation, B&H is currently developing sectoral Nationally Appropriate Mitigation Actions (NAMAs). Also, B&H has made investments to increase its adaptive capacity through the establishment of additional hydrometeorological stations, a database to collect, store and analyze observed weather data, and an agro-meteorological early warning system is currently under development (WBG, 2021). According to APM (agricultural policy measures) data base, in the last ten years (2011- 2021) B&H government (FB&H, RS and Brčko District) allocated some founds for climate change adaptation actions in agriculture (A. Martinovska Stojcheska et al., 2022). Financial support was provided for the modernization of farms (23,924,482 EUR), followed by technical assistance for farms in RS mainly for hail protection (12,799,295 EUR), soil amelioration (4,347,807 EUR), improvement investment on farm – irrigation systems and improvement of soil quality (4,361,896 EUR) and seminars and education programmes for farmers (3,567,305 EUR).

The strategic objectives for B&H in the Strategy on Agriculture and Rural Areas Development (GBD, 2022; MAFWRS, 2021; MAWFFiB, 2022) for the period 2021-2027, related to climate change adaptation in agriculture, can be summarized in the objective titled "Strengthening the application of ecological practices in production to adapt to and mitigate the impact of climate change". This involves the following tasks: (1) enhancing market orientation by increasing competitiveness, with a greater emphasis on research, technology, and digitalization; (2) supporting sustainable development

and more efficient management of natural resources such as water, soil, and air; and (3) contributing to mitigation and adaptation to the impacts of climate change and increasing the use of sustainable energy sources.

In order to achieve the proposed climate change adaptation measures in B&H, a strong institutional, policy and legislative framework for risk management and adaptation to climate change as well as sustainable financial mechanisms for their implementation are needed (FNC, 2021). What is noticeable when it comes to adaptation measures is that there are measures defined in the strategies that are fully aligned with European objectives, but at the same time, there are no practical results related to the creation of policies and the provision of funds for their implementation. In these strategic documents, it is even concluded that in the absence of specific experiences in implementing tailored measures for adapting agriculture to climate change or mitigating its impact, it can be beneficial to budget reward or incentives applied in other sectors with same purpose. In addition to irrigation, which is often mentioned in this context, other proposed solutions include introducing agricultural plant species and varieties more resistant to drought or plant diseases and pests, grassing, mulching, and using green manure, installing hail protection nets, and setting up UV radiation protection nets. It is crucial to emphasize that measures to adapt agriculture to combat climate change require the strongest support from the knowledge and innovation system in agriculture (MAWFFiB, 2022).

2.4.11. Brief analysis of the current infrastructure and systems for preventing and mitigating the negative effects of weather extremes on crop production

B&H is a decentralised economy comprised of two Entities (FB&H, RS) and one District (BD). According to Annex IV of the B&H Constitution, issues such as foreign policy, foreign trade policy and customs policy fall under the competence of the B&H institutions. All functions and powers that are not explicitly assigned by the Constitution to B&H institutions belong to the entities. Thus, FB&H, RS and BD manage environmental issues by implementing laws, regulations and standards (UNDP, 2020). In FB&H, the institutions responsible for data collection, analysis, alignment with EU objectives, and the formulation of strategies and policies related to climate change in agriculture are the Ministry of Agriculture, Water Management and Forestry FB&H, cantonal ministries of environmental protection, FB&H Ministry of Environment and Tourism, FB&H Hydrometeorological Institute, Adriatic Sea Watershed Agency, Sava River Basin Agency, FB&H Bureau of Statistics and FB&H Institute of Agropaedology; and in RS, these are Ministry of Agriculture, Forestry and Water Management, Ministry of Spatial Planning, Construction and Ecology, Republic Hydrometeorological Institute, Institute of Statistics, Public Institution Vode Srpske and Agricultural Institute RS.

Collecting, processing and data flow fall under the jurisdiction of the entity meteorological institutes. They conduct regular measurements of all key climate and crop parameters (phenology) and have specific support and alert systems, which include issuing warnings through media channels such as radio, television, and websites, as well as utilizing global models. According to the B&H National Adaptation Plan (NAP, 2021), the plan is that the Environmental Protection and Energy Efficiency Fund of the Republic of Srpska (EPEEFRS), the Environmental Fund of the Federation of Bosnia and Herzegovina (EFFB&H); and the Brčko District Department of Agriculture, Forestry and Water Management (BDDAFW) will be responsible for presenting meteorological, hydrological, socio-economic and other data through the climate change lens. These institutions will ensure the existence of climate change projections and all required indicators. Also, the plan is that these institutions will establish an electronic system in the form of an interactive web application and platform with consolidated climate data and observations (NAP, 2021). It is recommended that Climate Change

Committees (CCCs) in FB&H and RS should be established, which would include representatives of institutions involved in monitoring and evaluation, those responsible for climate-sensitive sectors, relevant local communities, and representatives of the academia. CCCs would ensure transparency and monitoring of progress on the B&H NAP implementation (NAP, 2021).

2.4.12. Existing data availability and quality, data constraints and data gaps

The databases for climate parameters, phenology, and overall plant production have a gap for the period between 1992 and 1999. Even though climate data is available for a longer timeframe, it can be noted that the network of meteorological stations is insufficiently dense for the topographically, climatically, and pedologically heterogeneous terrain that characterizes B&H. A significant portion of data, especially prior to 1961, has not been digitized and therefore remains inaccessible. The quality of climate data is considered good, as all measurements follow WMO standards. On the other hand, data on agricultural production, cultivated areas, yields, etc., collected and published by entity statistical agencies, often do not correspond accurately to the actual situation in the field and should be taken with caution. This is due to poor organization and record-keeping of agricultural households, as well as a high number of unregistered smallholder farms.

2.4.13. Conclusions with key recommendations and priorities referring to crop production and adaptation to climate change

One of the first points to note is that climate and phenological data are available, but there is a need to streamline and expedite the process of obtaining this data. This can be achieved by establishing web portal services, which will allow data download and contain interactive maps and continuously and in real-time display various data and indicators, ensuring their accessibility to a wider audience and users. It is imperative to digitize all historical data as soon as possible. Furthermore, there is a need to enhance the data analysis system by establishing national services for the analysis and presentation of crucial indices, encompassing both agrometeorological and ecological aspects, among others. The development of an early warning system for extreme situations, droughts, floods, frost, hailstorms, and fires is essential. This system should incorporate mobile applications to ensure timely alerts to service users. If possible, artificial intelligence (AI) and machine learning (ML) should be integrated into these IT solutions as decision support tools. Establishing competent institutions, as outlined in the B&H National Adaptation Plan, to act as a bridge between the data collection process (hydrometeorological institutes) and data analysis in accordance with the requirements and standards of international requirements such as UNFCCC, is a good initiative. These institutions could engage experts who would adopt data processing to meet current needs both at the national and global levels. This would, among other things, involve Bosnia and Herzegovina in analyses that incorporate the use of new technologies such as remote sensing (satellite imagery). B&H exhibits a complex topographical and climatic profile, requiring a localized and customized approach for each location. This is especially true for the Mediterranean region of the lowlands in Herzegovina and the northern plains, which represent areas of both significant agricultural activity and heigh vulnerability to climate change. These regions are also expected, according to climate projections, to undergo most pronounced changes, particularly characterized by extremes in temperature and precipitation, droughts, and floods. Therefore, it is imperative to prioritize adaptation measures in areas with the highest population density and extensive agricultural production. The primary focus should be on solutions for droughts, floods, hail and frost.

The strategic plans of B&H align with EU objectives, outlining clear climate change adaptation measures. It is imperative for B&H to swiftly transition into their implementation phase. This primarily involves establishing the political framework, followed by securing the necessary resources for implementation. Given the current circumstances, international support funds represent the main source of required resources. Key recommendations in the sector of crop production would include:

- Strengthen the capacities of hydrometeorological institutes, including both research capabilities and the capacity for data collection (new equipment), processing, and digitalization.
- Develop early warning systems for hazardous climate-related events.
- Ensure the availability of climate and crop data in a fast and user-friendly manner.
- Raise public awareness about climate change and the need for adaptation.
- Increase research related to the impact of climate change on agricultural crops, their characteristics, and phenology.
- Increase the use of modern irrigation systems, tailored to available water resources and crop requirements.
- Improve and establish new drainage systems adapted to extreme rainfall conditions, crops, and soil characteristics, while ensuring funds and mechanisms for their maintenance.
- Establish a comprehensive monitoring system for natural resource utilization in agriculture, including soil and water.
- Utilize technologies to ensure more efficient use of natural resources while ensuring high agriculture productivity.
- Continue to invest in organic production as a sector of agriculture with great potential in B&H, given the low use and pollution of agricultural land.
- Organize training sessions and bottom-up workshops for agricultural producers to develop locally adapted sustainable practices and strengthen capacities of farmers.
- Enhance the capacity for utilizing new technologies and climate-smart solutions.
- Prepare and adopt laws related to climate change that build upon the defined commitments in the Sofia Declaration.
- Prioritize adaptation measures based on regions and crops that hold the highest significance and sensitivity to climate change.
- Increase the capacity of advisory (extension) services, especially in the FB&H.
- Facilitate regional cooperation among Western Balkan economies to highlight the advantages of working together and building strong institutions in the region.
- Create a National Steering Committee for Climate Change to lead and oversee efforts and include climate-friendly practices in development plans.

2.5. Animal production analysis linked to climate change in agriculture

Livestock farming has a great significance for Bosnia and Herzegovina (BH) agriculture, considering the available natural resources and the number of people engaged in this production. The key products from livestock involve milk and dairy products, meat and meat products. Since the number of livestock has stagnated or declined in recent years, except in the case of poultry, growth in meat and milk production is explained by improvements in yields and breed composition, but productivity is still low compared to economies in the region. Low productivity is certainly partly due to still inadequate breed structure, inefficient breeding and selection work, but mostly because of the duality in production. The importance of the development of livestock farming is reflected, among other things, in the fact that the breeding of ruminants utilizes areas under natural grasslands (meadows and pastures), which occupy slightly more than one-third in the total structure of agricultural areas. In addition, the largest part of crop production is in the function of livestock farming, which is the leading source of income for most agricultural farms in B&H. Extensive production on small farms prevails in livestock farming, while on the other hand, a small part of the production is organized on modern, technologically well-equipped farms. Observed by number, the most numerous is poultry (24.7 million), followed by sheep (1.02 million), pigs (0.5 million), and cattle (0.4 million).

2.5.1. Analysis of meteorological data availability and accessibility

The Third National Report on Climate Change in Bosnia and Herzegovina analyzes meteorological data during the period 1961-2018. The report shows that the mean annual temperature kept a continuous increase. By analyzing multi-year series data (1961-2018), a positive linear trend was observed in mean annual temperature, which is especially pronounced in the last 30 years, since 1982. The increase in air temperature on an annual basis ranges from 0.4 to 1.0 °C, while the increase in temperature during the growing season (April-September) goes up to 1.0 °C. In the analyzed period, all indices for hot temperature extremes show positive trends, while indices for cold temperature extremes show negative ones.

At all meteorological stations in Bosnia and Herzegovina, the coldest month is January, with an average temperature ranging from -3.8°C in Sokolac to 5.3°C in Mostar. The largest annual temperature amplitude in the entire research area is in Semberija, which is the most continental part of B&H. Temperature amplitudes are somewhat lower in higher Herzegovina (for example, Bileća 18.8°C) and in Sarajevo (19.9°C). Of the ten warmest years in the observed period, nine were recorded after 2000 (the only other being 1994). Detailed information is presented in the Third National Report, in Part 2.1. Observed changes in climatic conditions.

The number of meteorological stations in the Bosnia and Herzegovina meteorological network is 106 stations (17 main stations and 89 ordinary ones). Drešković and Đug (2012) reported on the spatial distribution of meteorological stations in the Bosnia and Herzegovina meteorological network. The number of meteostations is adequate, but the problem is the publicity available data – there are bulletins with all data summarized (monthly, seasonal, annual), but there is no daily data available for meteorological parameters.

Reports dealing with climate and climate change from B&H did not consider relative humidity (RH) as a climate parameter for monitoring. To monitor heat stress, relative humidity and temperature are necessary. So, it is important in the future, for the adaptation of livestock sector to climate change, to monitoring these two parameters on a daily level. Also, reports are focused on climate and climate change in the BH, without focus on the impact on the livestock sector.

2.5.2. Analysis of extreme weather events

In Bosnia and Herzegovina, six of the last ten years were very dry to extremely dry, and five years were marked by extreme floods. During the period 2009-2018, almost every year was characterized by extreme weather conditions: floods in 2009, 2010, 2014, 2018, 2019, drought and heat waves in 2011, 2012, 2013, 2015, 2016 and 2017, a cold wave in early 2012, strong wind in the middle of 2012 and at the end of 2017; an extremely large number of days with hail in 2018 (78 days the entire anti-hail prevention system was on standby, and during 43 days the meteorological situation required the action of anti-hail missiles, which is twice as much as compared to the average).

Based on previous research on climate and climate change, the biggest changes were identified in the southern, northern and northwestern parts of Bosnia and Herzegovina. These include increases in the intensity and frequency of extreme climate events (floods, droughts, violent windstorms, days with hail, prolonged heat waves, extreme temperatures, etc.).

Due to the increased intensity and variability of precipitation, as well as the increased share of heavy rain in the total distribution of precipitation, the risk of floods increased, in particular in the central and northern parts of the economy, which were hit by the catastrophic May 2014 flood. The area affected by the floods in May 2014 was around 22,900 km^2. Catastrophic floods in 2014 affected the wider area of the Sava river basin in B&H, Croatia and Serbia. The floods were preceded by rainfall that exceeded the record for the last 120 years, since measurements began. In the period of only 48 hours (13-14 May 2014) about 150 l/m^2 fell in some areas of Bosnia and Herzegovina. Estimated losses from this natural disaster amounted to 2,037 million EUR (1,040 million in FB&H and 986.3 million in RS and 29.6 million in Brčko District).

These climate changes and extremes that have occurred in the last ten years have caused enormous damage to the agricultural sector and agriculture can certainly be considered one of the most vulnerable sectors in Bosnia and Herzegovina. Estimates show that only the floods in May 2014 caused damages and losses in agriculture estimated at 187 million EUR. The floods in 2014 primarily affected cereal crops and fodder crops (over 80% of the total estimated damages), while the livestock sector and other infrastructure had damages of around 20%.

The problem is that there is no systematic monitoring of extreme weather events in B&H. Also, there is no early warning system that can be useful to livestock farmers. Finally, there is no available data on the economic loss of livestock farming, so there is no possibility of monitoring damage caused to the livestock sector. In all the reports and documents that deal with this climate change in B&H, the information about losses in the livestock sector (directly or indirectly) caused by extreme events is small, or none at all.

2.5.3. Heat stress risk assessment for ruminants, pigs and poultry

The impact of climate change on the livestock sector in B&H is reflected not only in the appearance of heat stress in animals, which significantly affects the production and quality of animal products, but also through the availability and the quality of fodder, whose production is also threatened, as well as draining puddles and watering places.

Climate change, which includes an increase in temperature, as well as a change in spatial (geographical) and weather patterns of precipitation, leads to the emergence and spread of new exotic animal diseases. Significant changes in the appearance and distribution of some vector-borne diseases have been recorded in recent decades, including Lyme disease, Leishmaniasis, Trypanosomiasis, Dengue fever and African plague.

Unfortunately, modelling of the Thermal Humidity Index (THI) is not in use in B&H for any farm animals. There is no literature data showing that some research related to THI has been conducted. There is no early warning system that can be useful to livestock farmers. In the future, it would be good to implement pilot projects that would monitor THI on individual farms, with the goal of making recommendations for farmers. It is also necessary to educate farmers and give them instructions on how to monitor the presence of THI in the summer period and the steps that need to be taken in order to reduce the damage to the production of animals themselves. Parallel with farmers, it is necessary to educate extension services in agriculture on this topic. And finally, negotiate with the relevant ministries to provide funds for establishing an early warning system that could be useful for farmers to monitor the presence of THI in the coming period.

2.5.4. Overview of farmers' existing adaptive practices for mitigating climate change impacts

There is no information in official records about investments in new technological solutions aimed at reducing the occurrence and consequences of heat stress. Also, there are no measures by the government and the ministries including incentives to agricultural/livestock farming for adaptation to climate change. But according to personal experience in communications with farmers, there are examples of farmers' practices, who invest independently in order to reduce the negative consequences of heat stress. An example of the Jokić dairy cattle farm, which introduced a ventilation and cooling systems in 2019. The assumption is that there are more such examples in Bosnia and Herzegovina. Poultry farms in B&H are characterized by high-intensity production, which includes both temperature and humidity control inside the facilities, and thus both control and elimination of heat stress in their facilities.

According to other recommended adaptation measures, such as adapted nutritional and feeding techniques, biosecurity and measures against disease outbreaks, feed security, breeding for resilient/robust animals, etc., there is no evidence that they exist in practice. There is a realistic basis for the introduction of some of these adaptation measures in the livestock sector, especially feeding and farm management in heat waves. For this opportunity, it is necessary to work on education of farmers, as well as extension services. It is also necessary for the government to provide funds for incentives for the implementation of these measures. According to measures of breeding for resilient/robust animals, there is also a possibility in the fact that B&H has local breeds with gene pools with a high level of resistance to environmental conditions. But, to implement these measures, a long time is necessary, as well as significant financial investments. To improve farmers' adaptive practices in B&H, first off, it is necessary to start with training and education of farmers. The B&H scientific community has enough knowledge in this area that could be transferred to farmers through some training (vocational, targeted or long-life learning programmes). Continuous training and education of the scientific community in this area is also necessary, through participation in national and international projects, mobility programmes, etc.

2.5.5. Summary of national strategies and adaptation plans in the livestock sector, including reports, R&D, projects and communications within the international CC (adaptation) framework (UNFCCC)

The most important technical studies that look at climate change issues in Bosnia and Herzegovina are the Initial National Communication of Bosnia and Herzegovina under the UNFCCC (INC), the Second National Communication of Bosnia and Herzegovina under the UNFCCC (SNC), the Third National Communication of Bosnia and Herzegovina under the UNFCCC (TNC) and the Climate Change

Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina. The First and Second National Communications laid the foundations for the development of the B&H Initial Climate Change Adaptation Strategy. Currently, the preparation of the Fourth National Communication of Bosnia and Herzegovina under the UNFCCC (FNC), the revised Climate Change Adaptation Strategy and the revised NDC that will include a chapter on climate change-induced losses and damages is underway. Bosnia and Herzegovina finalized and submitted its Climate Change Adaptation Plan (NAP) to the United Nations Framework Convention on Climate Change (UNFCCC), which was officially published in December 2022.

Most of these documents, when describing the impact of climate change on the agricultural sector, focus on crop production, while the livestock sector is not analyzed enough. The Climate Change Adaptation Plan (NAP) in the part on climate change impact on livestock farming, mentioned only that climate change can certainly affect livestock farming due to feed shortages, which can reach serious proportions due to drought. Another disadvantage that may occur is the drying out of water sources for livestock watering. The third disadvantage, albeit occurring less frequently, concerns potentially excessive temperatures in stables, barns and poultry houses, necessitating the use of appropriate cooling devices, such as an adapted irrigation system that can create water droplets in the form of mist, which evaporates and lowers the temperature in the building.

According to the NAP, the proposed measures for agriculture, as one of the most vulnerable sectors, are: (I) Switch to more resistant varieties; Introduce more tolerant species, varieties and hybrids; Proper selection of varieties; Rational fertilization; Changes in the timing and density of sowing; Increase the share of winter crops; (II) Improve disease and pest monitoring; (III) Improve cultivation techniques; Conservation agriculture and agroforestry, Ecosystem-based Approaches (EbAs); Crop rotation adjustment; (IV) Selection, breeding and creation of tolerant genotypes; (V) Change of plant species (growing modern orchards, vineyards); (VI) Reconstruction, construction and maintenance of drainage systems; (VII) Reconstruction, construction (development) and maintenance of irrigation systems; (VIII) Development of an early warning system for meteorological and climatic extremes; (IX) Development of an anti-hail protection system; (X) Development of climate data collection software; (XI) Increased scientific research on climate change, as well as the need and measures (ways) to adapt to climate change; (XII) Awareness raising and education on the need to adapt to climate change.

Out of all the proposed 12 measures, only measure 4 can be directly related to the livestock sector, which proves insufficient involvement of the livestock sector in the preparation of the documents listed above. To improve this, greater involvement of livestock experts in the development of strategies or other documents addressing adaptations to climate change is necessary.

2.5.6. Overview of the political and institutional setup and legislative framework for adaptation activities relevant to the sector

Bosnia and Herzegovina is a decentralized state consisting of two entities (the Federation of Bosnia and Herzegovina and the Republic of Srpska) and the Brčko District of Bosnia and Herzegovina. The Federation of Bosnia and Herzegovina and the Republic of Srpska, as well as Brčko District manage environmental issues by implementing laws, regulations and standards. The Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina is responsible for coordinating activities and harmonizing the plans of bodies and institutions of entity governments at the international level, among others in the areas of energy, environmental protection, development and exploitation of natural resources. The Focal Point institution, according to the UNFCCC and the authorized state body (DNA) for the Clean Development Mechanism (CDM) is the Ministry of Spatial Planning, Construction and Ecology of the Republic of Srpska.

The current legislative framework in Bosnia and Herzegovina does not provide a sufficient basis to adequately address climate change impacts, which further compounds the process of adapting to changing climate. Under the Constitution of Bosnia and Herzegovina, legislative competences in the field of environment belong to the entities in B&H (the Republic of Srpska and the Federation of Bosnia and Herzegovina) and the Brčko District of B&H. Analysis of the entire legislative framework in B&H shows that all primary and secondary legislation in the economy addresses this problem within the broad concept of 'climate', which is certainly insufficient. The only piece of legislation that, in terms of content, indeed addresses climate change is the Rules on the manner of preparation, content and formation of spatial planning documents (2013) in the Republic of Srpska, which lays down the methodological approach to drafting spatial planning documents and emphasizes climate change as one of the aspects that must be taken into account in spatial planning and the preparation of spatial documents. Accordingly, the Law on Spatial Planning and Construction of the Republic of Srpska, as a related piece of legislation, also addresses the issue of climate change, but only to a minimal extent.

The existing spatial plans in BH have not in the least factored in climate change as a dynamic impact factor. Thus, the existing legislation and its accompanying regulatory framework do not contain provisions on, and do not in any way address, the problem of climate change as a dynamic impact factor. To that end, appropriate procedures need to be initiated to amend the current legislation in B&H in such a way as to ensure the integration of 'climate change' and 'climate change adaptation' in the most vulnerable sectors. Addressing climate extremes and projected climate change will bring about a shift in the strategic approach to the development of sectors that are vulnerable to climate change impacts in B&H. In that case, the strategic development of such sectors (agriculture, water management, hydropower, etc.) will be accompanied by appropriate measures and plans that will integrate climate change adaptation.

Furthermore, the integration of climate change into strategic and spatial plans at the entity level will also lead to the integration of climate change into master and spatial plans at the municipal level. It is necessary to develop and enact the Law on Climate Change in both entities, though it is worth noting that the Republic of Srpska has already started this process in cooperation with UNDP Bosnia and Herzegovina.

One general conclusion that could be drawn is that livestock adaptation to climate change is not particularly stressed in all policy documents in Bosnia and Herzegovina.

2.5.7. Existing data availability and quality, data constraints and data gaps

Climate parameters which are recommended by NAP for monitoring are: change in annual temperature, mean monthly temperature, number of hot days, change in annual precipitation, monthly precipitation and extreme precipitation events, and they are available. There is no data about relative humidity. Also, there is a lack of official data about THI, the losses in the sector of livestock caused by extreme weather events, as well as any investment in farm management with the aim of adaptation to climate change. There is also insufficient interest and desire of employees in the government and ministries for communication and cooperation on this issue. Therefore, there are no concrete instruments for monitoring and adopting sustainable measures which farmers take on their farms, as well as extreme weather events and losses in the livestock sector caused by them.

2.5.8. Conclusions with key recommendations and priorities in livestock adaptation to climate change

The challenges of adaptation to climate change in the livestock sector are many. It is crucial to take a long-term, strategic view and to conduct research in order to meet future climate challenges and to develop approaches to facilitate the transfer of new knowledge and technologies into practical application. Extension services have played a key role in promoting livestock productivity and dissemination of knowledge and their role in promoting adaptation measures to climate change will certainly have the same importance. Therefore, it is necessary to strengthen the capacity of underdeveloped public agricultural extension services, enabling them to take a leading role in terms of strengthening the innovation process, building linkages between farmers and other agencies, and institutional development. Research institutes and agricultural universities, as a economy's leaders in knowledge generation, need to create linkages and provide direct transfer of information by educating extension workers regarding the advantages and potential technologies and practices. This can be accomplished in different ways, such as demonstration fields, joint research projects, field trials, training seminars, etc. Therefore, strengthening technologies, human resources and developing monitoring, warning and forecasting networks related to hydrological, meteorological, climatic and environmental risks should be considered as one of the priorities.

The main conclusion is that currently, farmers in B&H are acting independently without significant support from the profession and the government sector in adaptations to climate change. Any investment or insurance is up to the farmers from their own resources and there are no funding opportunities. However, there are a lot of opportunities and recommendations that can be implemented in the future, such as:

- Improved data necessary to monitor the impact and adaptation of the livestock sector on climate change (RH data, THI data, etc.)
- Establish the availability of basic meteorological parameters on a daily level
- Establish an early warning system that can announce floods, heat waves, excessive precipitation
- Establish a monitoring system to record losses in the livestock sector caused by extreme weather events
- Change of institutional policy (introduction of financial support and insurance system compared with the introduction and the development of prognostic systems and alarm systems in order to be on time could take measures to protect animals and livestock farming in general)
- Improve legislation (primary and secondary) with concrete measures for the adaptation of the livestock sector to climate change
- Research and development of technologies (to better understand the impact of climate change on the livestock sector, development of new genotypes, protecting animal health and improving land and water management)
- Strengthening the capacity of the scientific community in the area of adaptation of the livestock sector to climate change (projects, papers, books, recommendations...)
- Continuous training and capacity building of farmers (training, education, recommendations, etc.)
- Strengthening the capacities of agricultural extension services (training, education, etc.);
- Establish regional networks for the faster transfer of knowledge in the region
- Greater involvement of livestock experts in the development of strategies or other documents which address climate change adaptation

2.6. References

Action programme to combat land degradation and mitigate the effects of drought in Bosnia and Herzegovina (2014). https://www.unccd.int/sites/default/files/naps/2019-10/AP%20B&H%20BHAP_eng_FINAL%202017%20-%20adopted%20by%20the%20B&H%20Council%20of%20Ministers.pdf

Agency of Statistics of B&H (2023). Demography, Thematic Bulletin.

Agriculture and rural development strategy of the FB&H (2023). Government of the Federation of Bosnia and Herzegovina.

Ali, E., Cramer, W., Carnicer, J., Georgopoulou, E., Hilmi, N., G., L. C., & P., L. (2022). *Cross-Chapter Paper 4: Mediterranean Region. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (C. U. Press Ed.). Cambridge, UK and New York. doi:10.1017/9781009325844.021

ASBH. (2016). *Godišnji izvještaj iz oblasti poljoprivrede* Sarajevo: Agencija za statistiku BiH. Retrieved from http://www.mvteo.gov.ba/Content/Read/poljoprivreda-prehrana-sumarstvo-ruralni-razvoj-izvjestaji

ASBH. (2023). Agencija za statistiku Bosne i Hercegovine – Poljoprivreda. Retrieved from https://bhas.gov.ba/Calendar/Category/23?lang=bs#

Bajić, D., & Trbić, G. (2016). *Klimatski atlas Bosne i Hercegovine – Temperature i padavine*. Banja Luka: Univerzitet u Banjoj Luci, Prirodno-matematiči fakultet. Retrieved from http://www.unfccc.ba/klimatski_atlas/klimatski_atlas.pdf

Barreiro-Hurle, J., Bogonos, M., Himics, M., Hristov, J., Pérez-Domiguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E. & Elleby, C. (2021). Modelling environmental and climate ambition in the agricultural sector with the CAPRI model. Exploring the potential effects of selected Farm to Fork and Biodiversity strategies targets in the framework of the 2030 Climate targets and the post-2020 Common Agricultural Policy. Luxembourg: Publications Office of the European Union, doi:10.2760/98160, JRC121368.

Baza podataka. Republički zavod za statistiku, Republika Srpska http://www3.rzs.rs.ba/rzs/faces/indicators.xhtml

Berishaj. V. (2021). Western Balkans greenhouse gas emission reduction targets 2030, Climate Action Network (CAN) Europe. Available at: https://caneurope.org/content/uploads/2021/07/WB-GHG2030-policy-and-recommendations_final_July-22021-1.pdf

Brčko: Government of Brčko District B&H- Department for Agriculture, Forestry and Water Management. Retrieved from https://skupstinabd.ba/2-registar/ba/Odluke/2021/2290.%20Strategija%20razvoja%20BD%20B&H___bos.pdf

Čadro, S. (2019). *Razvoj i primjena softvreskih modela u cilju održivog upravljanja vodom i povećanja produktivnosti poljoprivrednih kultura u B&H.* (PhD), University of Sarajevo, Sarajevo.

Čadro, S., Berjan, S., El Bilali, H., Žurovec, O., Simić, J. and Rajčević, B. (2012). Governance of Adaptation to and Mitigation of Climate Change on Agricultural, Forest and Water Resources in Bosnia. Third International Scientific Symposium "Agrosym Jahorina 2012", Jahorina.

Čadro, S., Marković, M., Kaloper, S. E., Ravlić, M., & Žurovec, J. (2020). Soil Water Balance Response to Climate Change in Posavina Region. *AgriConf 2019. IFMBE Proceedings, 78*. doi:https://doi.org/10.1007/978-3-030-40049-1_2

Čadro, S., Miseckaite, O., Gavrić, T., Baublys, R., & Žurovec, J. (2018). *Impact of Climate Change on the Annual Water Balance in a Humid Climate* (Vol. 64). Podgorica. doi:10.17707/AgricultForest.64.4.15

Čadro, S., Škaljić, S., Rakita, N., & Žurovec, J. (2019a). *A Modern Hardware and Software Solutions for Corn Irrigation*. Paper presented at the 4th International Symposium Agricultural Engineering ISAE 2019, Belgrade. https://www.researchgate.net/publication/339018754_A_MODERN_HARDWARE_AND_SOFTW ARE_SOLUTIONS_FOR_CORN_IRRIGATION

Čadro, S., Uzunovic, M., Cherni-Čadro, S., & Žurovec, J. (2019b). Changes in the Water Balance of Bosnia and Herzegovina as a Result of Climate Change. *Agriculture and Forestry, 65*(3). Retrieved from https://web.archive.org/web/20200208072304id_/http://www.agricultforest.ac.me/data/20190930-02%20Cadro%20et%20al.pdf

Čadro, S., Uzunović, M., Marković, M., Žurovec, O., & Gocić, M. (2023). Climate change impacts on water balance components in Bosnia and Herzegovina and Croatia. *Agriculture and Forestry, 69*(2), 101-116. doi:10.17707/AgricultForest.69.2.08

Čadro, S., Žurovec, J., & Husić, S. (2017b). Kalendar navodnjavanja mladog krompira u skladu sa aktuelnim vremenskim uslovima na području Hercegovine. Works of the Faculty of Agriculture and Food Sciences, University of Sarajevo, *LXII*(67/1), 12.

Čadro, S., Žurovec, J., Cherni-Čadro, S. (2017a). Severity, Magnitude and Duration of Droughts in Bosnia and Herzegov-

ina Using Standardized Precipitation Evapotranspiration Index (SPEI). Agriculture & Forestry, 63(3), 199–206. doi: DOI: 10.17707/AgricultForest.63.3.20

Čaušević, A., Beslik, S., Hadžić, F., & Griffin, R. (2020). *Bosna i Hercegovina uticaj i rizici klimatskih promjena*. Sarajevo: Multi, Damira Hadžibeganovića 115.

Climate change adaptation and low emission development strategy for Bosnia and Herzegovina (2013). Available at: https://www.undp.org/bosnia-herzegovina/publications/climate-change-adaptation-and-low-emission-development-strategy-B&H

CMBH (2014). *Action Plan for Flood Protection and Management of Rivers in B&H 2014-2017*. Sarajevo: Council of Ministers of Bosnia and Herzegovina. Retrieved from https://neighbourhood-enlargement.ec.europa.eu/system/files/2017-02/ipa_2016_37889_8_B&H_support_to_flood_protection_and_flood_risk_management.pdf

Crljenković, B. (2022). *Comparative Analysis of Different Software Models for Determination of Irrigation Requirements in Maize.* (Master), University of Sarajevo, Sarajevo.

Croatian Agency for Agriculture and Food (https://www.hapih.hr/kako-klimatske-promjene-utjecu-na-tlo-izazovi-i-mogucnosti/)

Čustović H., Tais M., Hodžić S., Ljuša M. (2013). Assessment of the climate change impact on agriculture in Bosnia and Herzegovina, vulnerability and adaptation measures. 24th International Scientific-Expert-Conference of Agriculture and Food Industry, Sarajevo, Bosnia and Herzegovina, 25–28 September 2013. Sarajevo, Bosnia and Herzegovina.

Ćustović, H., Ljuša, M. & Sitaula K.B. (2015). Adaptacija na klimatske promjene u sektoru poljoprivrede (vrijeme je da djelujemo odmah). Sarajevo: Poljoprivredno-prehrambeni fakultet.

Custovic, H., Misilo, M., & Markovic, M. (2014). Water balance of Mediterranean karst soil in Bosnia and Herzegovina as a water conservation and erosion control factor. *Soil Science and Plant Nutrition, 60*(1), 100-107. doi:10.1080/00380768.2013.862489

Dreskovic N. and S. Dug. Applying the inverse distance weighting and kriging methods of the spatial interpolation on the mapping the annual precipitation in Bosnia and Herzegovina. https://www.researchgate.net/publication/325973930_BYU

Ducic, V., Ivanovic, R., Mihajlovic, J., Gnjato, R., Trbic, G., & Curcic, N. B. (2015). Dendroindication of Drought in Rogatica Region (Eastern Bosnia). *Archives of Biological Sciences, 67*(1), 201-211. doi:10.2298/Abs141114025d

EC. (2020). *Guidelines for the Implementation of the Green Agenda for the Western Balkans* (E. Commission Ed. Vol. SWD(2020) 223 final). Brussels: European Commission. Retrieved from https://networknature.eu/nbs-resource/25083#:~:text=It%20further%20details%20the%20five,the%20natural%20wealth%20o f%20the

EC. (2022). *Common Agricultural Policy for 2023-2027 28 Cap Strategic Plans at a Glance* (Vol. Agriculture and Rural Development): European Commission.

EU Mission: A Soil deal for Europe – EU Mission: A Soil Deal for Europe, European Commission (europa.eu) https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-deal-europe_en

European Commission (EC). Bosnia and Herzegovina recovery needs assessment, floods 14–19 May, UNDP, Bosnia and Herzegovina floods 2014, Recovery needs assessment, 2014, pp 1–302.

FACP (2014). *Risk Assessment of Federation Bosnia and Herzegovina Regarding Natural and Other Disasters* (F. a. o. c. protection Ed.). Sarajevo: Federal administration of civil protection. Retrieved from http://fucz.gov.ba/download/18129

FAOSTAT (2023). Cropland Nutrient Budget. Available at: https://www.fao.org/faostat/en/#data/ESB

FHMZ (2013). *Upustvo za fenološka osmatranja*. Sarajevo: Federal Hydrometeorological Institute Bosnia and Herzegovina.

FHMZ (2021a). *Fenološki godišnjak* (F. H. I. B. a. Herzegovina Ed.). Sarajevo: Federal Hydrometeorological Institute Bosnia and Herzegovina. Retrieved from https://www.fhmzB&H.gov.ba/PUBLIKACIJE/fenologija/godisnjaci/F-2021.pdf

FHMZ (2021b). *Meteorološki godišnjak 2021* (B. Federalni hidrometeorološki zavod Sarajevo Ed.). Sarajevo. Retrieved from https://www.fhmzB&H.gov.ba/podaci/klima/godisnjak/G2021.pdf

FHMZ (2022). *Meteorološki godišnjak*. Sarajevo: Federal Hydrometeorological Institute Bosnia and Herzegovina. Retrieved from https://www.fhmzB&H.gov.ba/podaci/klima/godisnjak/G2022.pdf

FHMZ (2023a). Agrometeorološki pregled u proteklih 7 dana. Retrieved from https://www.fhmzbih.gov.ba/latinica/AGRO/agroPregled.php

FHMZ (2023b). The history of the meteorological service in Bosnia and Herzegovina Retrieved from https://www.fhmzB&H.gov.ba/latinica/O%20NAMA/povijest.php

FNC (2021). *Fourth National Communication of Bosnia and Herzegovina Under the United Nations Framework Convention on Climate Change* (UNDP Ed.): UNDP. Retrieved from https://unfccc.int/sites/default/files/resource/FNC%20B&H_ENG%20fin.pdf

Gantner V., Gavran M., Dokić D., Važić B., Gregić M., Bobić T. (2019). The Effect of Breeding Region on Differences in Persistency of Heat Stress Effect in First Parity Simmentals Agro-knowledge Journal, vol. 20(2): 75-83.

GBD (2022). *Strategy of Agriculture Development and Rural Areas for period 2021-2027. Draft* (FAO Ed.).

Gelyboo G., Toth E., Farkas C., Horel A., Kasa I., Bakacsi Z. (2018). Potential Impacts Of Climate Change On Soil Properties. Agrochemistry And Soil Science, 67 (2018) 1, 121-141

GFBiH. (2020). *Development Strategy Federation of Bosnia and Herzegovina 2021 - 2027* (G. o. F. o. B. a. Herzegovina Ed.). Sarajevo: Government of Federation of Bosnia and Herzegovina. Retrieved from https://parlamentfB&H.gov.ba/v2/userfiles/file/Materijali%20u%20proceduri_2021/Strategija%2 0razvoja%20FB&H%202021-2027_bos.pdf

Godišnji izvještaj iz oblasti poljoprivrede, ishrane i ruralnog razvoja za Bosnu i Hercegovinu (2022). Ministarstvo vanjske trgovine i ekonomskih odnosa Bosne i Hercegovine

Govedar, Z., Mataruga, M., Dukić, V., Čomić, D., Stupar, V., Glavonjić, B., Vaško, Ž., Dražić, S., Bosnić, M. & Marković, B. (2023). The guidelines for forestry development strategy of the Republic of Srpska (2022-2032), Faculty of Forestry, Banja Luka.

Hargreaves, G. H., & Samani, Z. A. (1985). Reference crop evapotranspiration from temperature. *Transaction of ASAE, 1*(2), 96-99. Retrieved from https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/referencespapers.aspx?refere nceid=1225457

Hodžić, S., Marković, M., & Čustović, H. (2013). *Drought Conditions and Management. Strategies in Bosnia and Herzegovina - Concise Country Report* (Vol. 11). Retrieved from https://www.researchgate.net/publication/270816670_Drought_Conditions_and_Management_Strategies_in_Bosnia_and_Herzegovina_-_Concise_Country_Report

https://napcentral.org/submitted-naps

https://reliefweb.int/sites/reliefweb.int/files/resources/delegacijaEU_2014070913592248eng.pdf

https://water.europa.eu/freshwater/data-maps-and-tools/metadata/dashboards/floodplain-statistics-viewer#floodplain-statistics-viewer_preview

https://www.eea.europa.eu/ims/drought-impact-on-ecosystems-in-europe

https://www.statista.com/statistics/1322246/area-burned-by-wildfire-in-bosnia-and-herzegovina/

INC (2009). *Initial National Communication of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change*. Banja Luka. Retrieved from https://unfccc.int/sites/default/files/resource/INCB&H_ENG.pdf

INCBH (2009). Initial National Communication of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change. Ministry of Environmental and Spatial Planning.

Izvještaj o stanju okoliša Federacije Bosne i Hercegovine (2022.) Fond za zaštitu okoliša Federacije Bosne i Hercegovine.

Jayson, B., Ivanic, M., Jelliffe, J.L., Baquedano, F.G., & Scott, S.G. (2020). Economic and Food Security Impacts of Agricultural Input Reduction Under the European Union Green Deal's Farm to Fork and Biodiversity Strategies. U.S. Department of Agriculture, Economic Research Service.

Kapović Solomun, M. (2022). Enhancing Nature-based Solutions in Bosnia and Herzegovina: the role of ecosystems in disaster risk reduction and climate change adaptation. Gland, Switzerland: IUCN. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://portals.iucn.org/library/sites/library/files/documents/2022-009-En.pdf

Karleuša, B. (2007). Suvremene metode upravljanjima sustavima za navodnjavanje. *Građevinski fakultet Sveučilišta u Rijeci*, 287-319.

MAFWRS. (2012). *Integrated Water Management Strategy of Republic of Srpska* (F. a. W. m. R. Ministry of Agriculture Ed.). Banja Luka: Ministry of Agriculture, Forestry and Water Management RS. Retrieved from https://www.vladars.net/sr-SP-Cyrl/Vlada/Ministarstva/mps/Documents/STRATEGIJA%20%20TEKST%20RADNA%20VERZIJA.pdf

MAFWRS. (2021). *Strategy of Agriculture Development and Rural Areas of Republic of Srpska for the period 2021-2027* (F. a. W. M. o. R. S. Ministry of Agriculture Ed.). Banja Luka: Ministry of Agriculture, Forestry and Water Management of the Republic of Srpska. Retrieved from https://www.vladars.net/sr-SP-Cyrl/Vlada/Ministarstva/mps/Documents/Strategija%20razvoja%20poljoprivrede%20i%20ruraln ih%20podru%C4%8Dja%20RS%202021-2027.pdf

Management and Forestry. Retrieved from htmhttps://predstavnickidom-pfbih.gov.ba/files/Prijedlozi zakona/01,02-02-2013_22- BOS-Strategija PRR FBiH- 27 07 2022- nakon Ex-ante.docx

Marković, M., Čereković, N., Hajder, Đ., Šipka, M., Zapata, N., Paco, A.T., Rezzio E.E., Čadro, S. & Todorović, M., (2022). SMARTWATER Project (H2020 Twinning). Book of proceedings of international scientific conference Urban Water 2022, Velike Bilovice, Czech Republic, 232-238.

Marković, M., Čereković, N., Hajder, Đ., Zapata, N., Paçoc, T. A., Riezzod, E. E., . . . Todorović, M. (2021). *Promoting the Application of Smart Technologies in Agricultural Water Management in Bosnia and Herzegovina.* Paper presented at the SERBIAN SOCIETY OF SOIL SCIENCE Soils for Future under Global Challenges. 3rd International and 15th National Congress., Sokobanja, Serbia.

Martinovska Stojceska, A., Koteska, A., Janeska Stamenkovska A., Dimitrievski, D., Zhlima, E., Vaško, Ž., Bajramović, S., Kreolli Mustafa, M., Marković, M., Kovačević, V., Ali Koc, A. & Bayaner, A. (2023). Agricultural policy developments in the EU pre-accession economies, final report. Publications Office of the European Union, Luxemburg.

Martinovska Stojcheska, A., Kotevska, A., Janeska Stamenkovska, I., Dimitrievski, D., Zhllima, E., Vaško, Ž., . . . P., C. (2021). *Recent agricultural policy developments in the context of the EU approximation process in the pre-accession economies* (P. O. o. t. E. Union Ed.). Luxembourg. Retrieved from https://publications.jrc.ec.europa.eu/repository/handle/JRC124502

Martinovska Stojcheska, A., Kotevska, A., Janeska Stamenkovska, I., Dimitrievski, D., Zhllima, E., Vaško, Ž., . . . Ali Koç, A. (2022). *Comparative analysis of agricultural sectors and rural areas in the pre-accession economies: D-3 Draft final report* Skoplje: SWG. Retrieved from https://seerural.org/news/comparative-analysis-of-agricultural-sectors-and-rural-areas-in-the-pre-accession-economies-agricultural-policy-developments-situation-of-the-agri-food-sector-and-economic-context/

MAWFFiB (2022). *Agriculture and Rural Development Strategy for the Federation of Bosnia and Herzegovina 2021–2027* (UNDP Ed.). Sarajevo: Federal Ministry of Agriculture, Water

MAWFFiBH (2012). *Strategy of water management FB&H 2010-2022* (W. M. a. F. F. Ministry of Agriculture Ed.). Sarajevo: Ministry of Agriculture, Water Management and Forestry FB&H.

MAWFFiBH (2013). *Medium-Term Development Strategy of thr Agricultural Sector in Federation of Bosnia and Herzegovina for 2014–2018;* (F. M. o. A. W. M. a. Forestry Ed.). Sarajevo, Bosnia and Herzegovina: Federal Ministry of Agriculture, Water Management and Forestry.

Miseckaite, O., Čadro, S., Tunguz, V., Lukashevich, V., Šimunić, I., & Orlović-Leko, P. (2018). *Climate and aridity change*. Paper presented at the 8TH Asian Regional Conference (8ARC): Irrigation in Support of Evergreen Revolution, Kathmandu, Nepal. https://www.researchgate.net/publication/328277587_Climate_and_aridity_change

MOFTER. (2012). *Environmental Performance Review of Bosnia and Herzegovina* (MOFTER Ed.). Sarajevo: Ministry of Foreign Trade and Economic Relations (MOFTER). Retrieved from https://unece.org/environment-policy/publications/3rd-environmental-performance-review-bosnia-and-herzegovina

NAP (2021). *Bosnia and Herzegovina National Adaptation Plan – NAP with proposed measures* (UNDP Ed.). Sarajevo: UNDP. Retrieved from https://unfccc.int/sites/default/files/resource/NAP-Bosnia-and-Herzegovina.pdf

NDC (2016). *Nationally Determined Contributions of B&H (NDC) 2020-2030*. Retrieved from https://unfccc.int/sites/default/files/NDC/2022-06/NDC%20B&H_November%202020%20FINAL%20DRAFT%2005%20Nov%20ENG%20LR.pdf

Obradović, N., Jusić, M., Oruč, N. (2019). ESPN Thematic Report on In-work poverty – Bosnia and Herzegovina, European Social Policy Network (ESPN), European Commission, Brussels.

Pérez Domínguez, I., Fellmann, T., Witzke, H., Jansson, T., Oudendag, D., Gocht, A. & Verhoog, D., (2012). Agricultural GHG emissions in the EU: an exploratory economic assessment of mitigation policy options. Luxembourg (Luxembourg): Publications Office of the European Union; JRC69817. doi:10.2791/8124

Popov, T. (2020). *Uticaj savremenih klimatskih promjena na fitogeografska obilježja Republike Srpske* (Vol. 50): Geografsko društvo Republike Srpske.

Popov, T., Gnjato, S., & Gnjato, R. (2019a). *Recent Climate Change in Bosnia and Herzegovina*. Paper presented at the Материалы Международной научно-практической конференции Географическая наука Узбекистана и России, г. Ташкент, Республика Узбекистан.

Popov, T., Gnjato, S., & Trbić, G. (2018b). Changes in Temperature Extremes in Bosnia and Herzegovina: A Fixed Thresholds-Based Index Analysis. *Journal of the Geographical Institute "Jovan Cvijić" SASA, 68*(1), 17-33. doi:https://doi.org/10.2298/-IJGI1801017P

Popov, T., Gnjato, S., & Trbić, G. (2019b). Changes in Precipitation over the East Herzegovina Region. *Bulletin of the Serbian geographical society, 99*(1), 29-44. doi:https://doi.org/10.2298/GSGD1901029P

Popov, T., Gnjato, S., Trbić, G., & Ivanišević, M. (2017). Trends in extreme daily precipitation indices in Bosnia and Herzegovina. *Collection of Papers – Faculty of Geography at the University of Belgrade, 65*(1). doi:doi:10.5937/zrgfub1765005P

Popov, T., Gnjato, S., Trbic, G., & Ivanisevic, M. (2018a). Recent Trends in Extreme Temperature Indices in Bosnia and Herzegovina. *Carpathian Journal of Earth and Environmental Sciences, 13*(1), 211224. doi:10.26471/cjees/2018/013/019

Predić, T., Marković, M., & Rogić, B. (2018). *Agri-Environmental Policy in Bosnia and Herzegovina* (SWG Ed.). Skopje: Standing Working Group for Regional Rural Development (SWG).

Procjena ugroženosti Bosne i Hercegovine od prirodnih i drugih nesreća (2011.) Bosna i Hercegovina, Vijeće ministara.

PSP-B&H (2023a). *Benefits of nature and their impact on the quality of life of people in B&H (third draft assessment)* (F. o. S. University of Sarajevo Ed. Vol. 2). Sarajevo: University of Sarajevo, Faculty of Science. Retrieved from phttps://www.procjenaprirode.ba/wp-content/uploads/2023/06/pritisci-na-prirodu-u-bih.pdf

PSP-B&H. (2023b). *Pressures on nature in B&H (third draft assessment)* (Vol. 4). Sarajevo: University of Sarajevo, Faculty of science. Retrieved from https://www.procjenaprirode.ba/wp-content/uploads/2023/06/koristi-od-prirode-u-bih.pdf

Raes, D., Steduto, P., Hsiao, T. C., & Fereres, E. (2009). AquaCrop-The FAO Crop Model to Simulate Yield Response to Water: II. Main Algorithms and Software Description. *Agronomy Journal, 101*(3), 438-447. doi:10.2134/agronj2008.0140s

Ran, H., Kang, S. Z., Li, F. S., Tong, L., Ding, R. S., Du, T. S., . . . Zhang, X. T. (2017). Performance of AquaCrop and SIMDualKc models in evapotranspiration partitioning on full and deficit irrigated maize for seed production under plastic film-mulch in an arid region of China. *Agricultural Systems, 151*, 20-32. doi:10.1016/j.agsy.2016.11.001

Rao, A. S., & Saxton, K. E. (1995). Analysis of Soil-Water and Water-Stress for Pearl-Millet in an Indian Arid Region Using the Spaw Model. *Journal of Arid Environments, 29*(2), 155-167. doi:10.1016/S0140-1963(05)80086-2

RCC (2021). *Action plan for the Implementation of the Sofia Declaration on the Green Agenda for the Western Balkans 2021-2030*: Regional Cooperation Council. Retrieved from https://www.rcc.int/docs/596/action-plan-for-the-implementation-of-the-sofia-declaration-on-the-green-agenda-for-the-western-balkans-2021-2030

Regional Cooperation Council (2021). Action Plan for the implementation of Sofia Declaration on the Green Agenda for the Western Balkans, 2021-2030. Available at: https://www.rcc.int/docs/546/sofia-declaration-on-the-green-agenda-for-the-western-balkans-rn?gclid=CjwKCAjwu4WoBhBkEiwAojNdXrBwO71ctB-_XgYJf23CKN5-PCwTVmniZdRiy4cZ8O-qxdroY1Lck7RoCszEQAvD_BwE

RHMZ (2023). Fenologija. Retrieved from https://rhmzrs.com/meteorologija/agrometeorologija/fenologija/

Šarić, T., Beus, V. Gadžo, D., Đikić, M. (2003). Uništavanje i zaštita zemljišta. Garmond, Sarajevo.

Smith, M. (1992). *CROPWAT: A computer programme for irrigation planning and management*. Rome: FAO land and Water Development Division.

Smjernice za prilagođavanje klimatskim promjenama u poljoprivrednom sektoru (2022). Centar za energiju, okolinu i resurse (Centre for Energy, Environment and Resources) – CENER 21.

SNC (2013). *Second National Communication of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change* (UNDP Ed.). Sarajevo: UNDP. Retrieved from https://www.undp.org/bosnia-herzegovina/publications/second-national-communication-bosnia-and-herzegovina-under-united-nations-framework-convention-climate-change

Srdić, S., Srđević, Z., Stričević, R., Čereković, N., Benka, P., Rudan, N., Rajić, M. & Todorović, M. (2023). Assessment of Empirical Methods for Estimating Reference Evapotranspiration in Different Climatic Zones of Bosnia and Herzegovina. Water, 15, 3065. doi.org/10.3390/w15173065

Steduto, P., C. Hsiao, T., Fereres, E., & Raes, D. (2012). *Crop yield response to water*. Rome: FAO.

Steduto, P., Hsiao, T. C., Raes, D., & Fereres, E. (2009). AquaCrop-The FAO Crop Model to Simulate Yield Response to Water: I. Concepts and Underlying Principles. *Agronomy Journal, 101*(3), 426-437. doi:10.2134/agronj2008.0139s

Strategic Plan for Rural Development of Bosnia and Herzegovina, 2023-2027 (draft), (2023).

Strategija EU-a za tlo do 2030 (EU Soil Strategy for 2030) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0699

Strategija prilagođavanja na klimatske promjene i niskoemisionog razvoja Bosne i Hercegovine za period 2020.-2030.

Strategija prilagođavanja na klimatske promjene I niskokarbonskog razvoja za BH za razdoblje 2013-2025.

Strategija upravljanja vodama Federacije Bosne i Hercegovine (2010–2022), Federalno Ministarstvo poljoprivrede, šumarstva i vodoprivrede, 2010.

Strategy on the Development of Agriculture and Rural Areas of Brčko District (2022). The Government of Brčko District B&H.

Strategy on the Development of Agriculture and Rural Areas of the Republic of Srpska (2021). The Government of the Republic of Srpska.

Stricevic, J. R., Simic, A., Kusvuran, A., & Cosic, M. (2017) *Assessment of AquaCrop Model in the Simulation of Seed Yield and Biomass of Italian Ryegrass*. Archives of Agronomy and Soil Science (Vol 9).

Subotić, J., Dukić, V., Popov, T., Trbić, G., Maunaga, Z., & Petrović, D. (2020). Relationships Between Climatic Variables and Tree-Ring Width of Silver Fir (Abies alba Mill.) in Kozara National Park (Bosnia and Herzegovina). *South-East European Forestry, 11*(1), 17-27. doi:https://doi.org/10.15177/seefor.20-05

The 2020-2030 climate change adaptation and low-emission development strategy for Bosnia and Herzegovina (2023). Council of the Ministries of Bosnia and Herzegovina. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.undp.org/sites/g/files/zskgke326/files/2023-08/BOS_Strategija%20prilagodjavanja%20i%20niskoemisionog%20razvoja%20B&H%202020-2030.pdf

The Council of Ministers of BH. (2013). Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina. October 2013.

The World Bank (2023). The World Bank Development Indicators. Available at: https://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC?most_recent_value_desc=true.

TNC. (2016). *Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia And Herzegovina under the United Nations Framework Convention on Climate Change* (UNDP Ed.). Sarajevo: UNDP. Retrieved from https://www.undp.org/bosnia-herzegovina/publications/third-national-communication-tnc-and-second-biennial-update-report-greenhouse-gas-emissions-sbur-bosnia-and

Tošić R., (2008.) Erozija u Republici Srpskoj i Bosni i Hercegovini. Glasnik geografskog društva Republike Srpske, Volume XII, 2008.

Trbic, G., Bajic, D., Djurdjevic, V., Ducic, V., Cupac, R., Markez, Đ., . . . Popov , T. (2018). Limits to Adaptation on Climate Change in Bosnia and Herzegovina: Insights and Experiences. *Climate Change Management. Springer*, 245–259. doi:https://doi.org/10.1007/978-3-319-64599-5_14

Trbić, G., Bajić, D., Popov, T., & Oprašić, S. (2013). Drought Issues in Bosnia and Herzegovina. *Environmental Science*. doi:10.7251/HER1714103T

Trbic, G., Popov, T., & Gnjato, S. (2017). Analysis of air temperature trends in Bosnia and Herzegovina. *Geographica Pannonica, 21*(2), 68-84. doi:10.18421/Gp21.02-01

Trbic, G., Popov, T., Djurdjevic, V., Milunovic, I., Dejanovic, T., Gnjato, S., & Ivanisevic, M. (2022). Climate Change in Bosnia and Herzegovina According to Climate Scenario RCP8.5 and Possible Impact on Fruit Production. *Atmosphere, 13*(1). doi:https://doi.org/10.3390/atmos13010001

UNDP (2013). *Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina* (UNDP Ed.). Sarajevo: UNDP. Retrieved from https://www.undp.org/bosnia-herzegovina/publications/climate-change-adaptation-and-low-emission-development-strategy-bih;

UNDP (2020). *The 2020-2030 Climate Change Adaptation and Low Emission Development Strategy for Bosnia and Herzegovina* (UNDP Ed.). Sarajevo: UNDP. Retrieved from https://unfccc.int/sites/default/files/resource/ENG_CC%20adaptation%20and%20Low%20emiss ion%20development%20Strategy%20B&H%202020-2030.pdf

UNECE (2018). *Bosnia and Herzegovina Environmental Performance Reviews – Third Review* (UNECE Ed.). New York and Geneva: UNECE. Retrieved from https://unece.org/sites/default/files/2022-09/bosnia_and_herzegovina.pdf09/bosnia_and_herzegovina.pdf

United Nations (2012). United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/convkp/conveng.pdf, July 20, 2012.

Vaško, Ž., Rković G. (2021). Economic valuation of grassland utilization improvement in the Western Balkans. SHS Web of Conferences 95, 01002. doi.org/10.1051/shsconf/20219501002

VFB&H. (2010). *Strategija razvoja Federacije B&H 2010. – 2020.* Tuzla: Bosna i Hercegovina, Federacija Bosne i Hercegovine, Vlada Federacije B&H. Retrieved from https://www.fmks.gov.ba/kultura/legislativa/strategije/StrategijarazvojaFB&H2010-2020.pdf.

WB. (2020). *Implementation Completion and Results Report Credit No. 5098-BA. on a Credit in the Amount of SDR 25.8 Million (US$ 40 Million Equivalent) to the Bosnia and Herzegovina for the Irrigation Development Project* (W. Bank Ed.): World Bank. Retrieved from https://documents1.worldbank.org/curated/en/104601601997109547/text/Bosnia-and-Herzegovina-Irrigation-Development-Project.txt

WBG (2021). *Climate Risk Profile: Bosnia and Herzegovina* (t. W. B. Group Ed.). Washington, DC: the World Bank Group. Retrieved from https://reliefweb.int/report/bosnia-and-herzegovina/climate-risk-country-profile-bosnia-herzegovina

WBIF (2019). *Flood Hazard and Flood Risk Maps Project in B&H Climate Change Working Paper*: the Western Balkans Investment Framework. Retrieved from http://heis.ba/en/projects/flood-hazard-and-flood-risk-maps-project-in-bosnia-and-herzegovina-fhrm

Županić, F.Ž., Radić, D. & Podbregar, I. (2021). Climate change and agriculture management: Western Balkan region analysis. Energ Sustain Soc, 11 (51). doi.org/10.1186/s13705-021-00327-z

Žurovec O., Vedeld P.O., Sitaula K.B. (2015). Agricultural Sector of Bosnia and Herzegovina and Climate Change —Challenges and Opportunities. Agriculture, vol 5, 245-266.

Žurovec, J., & Čadro, S. (2015). *Temporal Drought and Soil Moisture Variability in the Arable Land of Spreča Valley*. Paper presented at the 26th International Scientific Expert Conference in Agriculture and Food Industry, Ilidža, Sarajevo. https://www.researchgate.net/publication/305317890_Temporal_Drought_and_Soil_Moisture_ Variability_in_the_Arable_Land_of_Spreca_Valley

Žurovec, J., Čadro, S., & Murtić, S. (2011). *Drought Analysis in Sarajevo Using Standardized Precipitation Index (SPI)*. Paper presented at the 22nd International Scientific expert Conference in Agriculture and Food Industry, Sarajevo.

Zurovec, O., & Vedeld, P. O. (2019). *Rural livelihoods and climate change adaptation in laggard transitional economies – A case from Bosnia and Herzegovina, Sustainability*. In press. Retrieved from https://www.mdpi.com/2071-1050/11/21/6079

Žurovec, O., Čadro, S., & Sitaula, B. K. (2017). Quantitative Assessment of Vulnerability to Climate Change in Rural Municipalities of Bosnia and Herzegovina. *Sustainability, 9*(1208), 18. doi:10.3390/su9071208

Žurovec, O., Vedeld, P. O., & Sitaula, B. K. (2015). Agricultural Sector of Bosnia and Herzegovina and Climate Change — Challenges and Opportunities. *Agriculture, 5*(2), 245-266. doi:10.3390/agriculture5020245

[1] Agriculture and rural development strategy Federation of Bosnia and Herzegovina for the period 2021-2027, draft January 2022.

[2] Framework water management development plan of the Republic of Srpska, September 2006.

[3] Overview of significant issues in water management for the Sava river basin (district) in the Republic of Srpska, January 2021.

[4] Overview of significant issues in water management for the Trebišnjica river basin (district) in the Republic of Srpska, January 2021.

[5] Strategy on Integrated Water Management of the Republic of Srpska, Annex 6 Irrigation of agricultural areas, Zavod za vodoprivredu d.o.o. Bijeljina, July 2012.

[6] Strategy on the Development of Agriculture and Rural Areas of the Republic of Srpska 2021-2027, September 2021.

[7] Study research on the current situation in irrigation, IRRI project, prof. Mihajlo Marković, April 2013.

[8] Study of the feasibility and economic justification of building the system irrigation of hydro-technical melioration in the area of Brčko District of B&H, January 2017.

[9] Strategy on Agricultural Land Management, Jan-Sep 2011.

[10] Strategic Plan for Rural Development of Bosnia and Herzegovina (2018-2021) – framework document.

[11] The basis of protection, use and arrangement of agricultural land of the Republic of Srpska as components of the land use planning process.

[12] Water management plan for the Sava River Basin in RS (2017-2021), November 2017.

[13] Water management plan for the Trebišnjica River Basin in RS (2017-2021), November 2017.

[14] Water Management Strategy of the Federation of Bosnia and Herzegovina 2010-2022, March 2012.

[15] Jiří Jakubínský, et al. (2019) Repository of Drought Event Impacts Across the Danube Catchment Economies Between 1981 and 2016 Using Publicly Available Sources. https://doi.org/10.11118/actaun201967040925

[16] Ognjen Zurovec, Pål Olav Vedeld and Bishal Kumar Sitaula (2015): Agricultural Sector of Bosnia and Herzegovina and Climate Change—Challenges and Opportunities. Agriculture 2015, 5, 245-266; https://www.mdpi.com/2077-0472/5/2/245

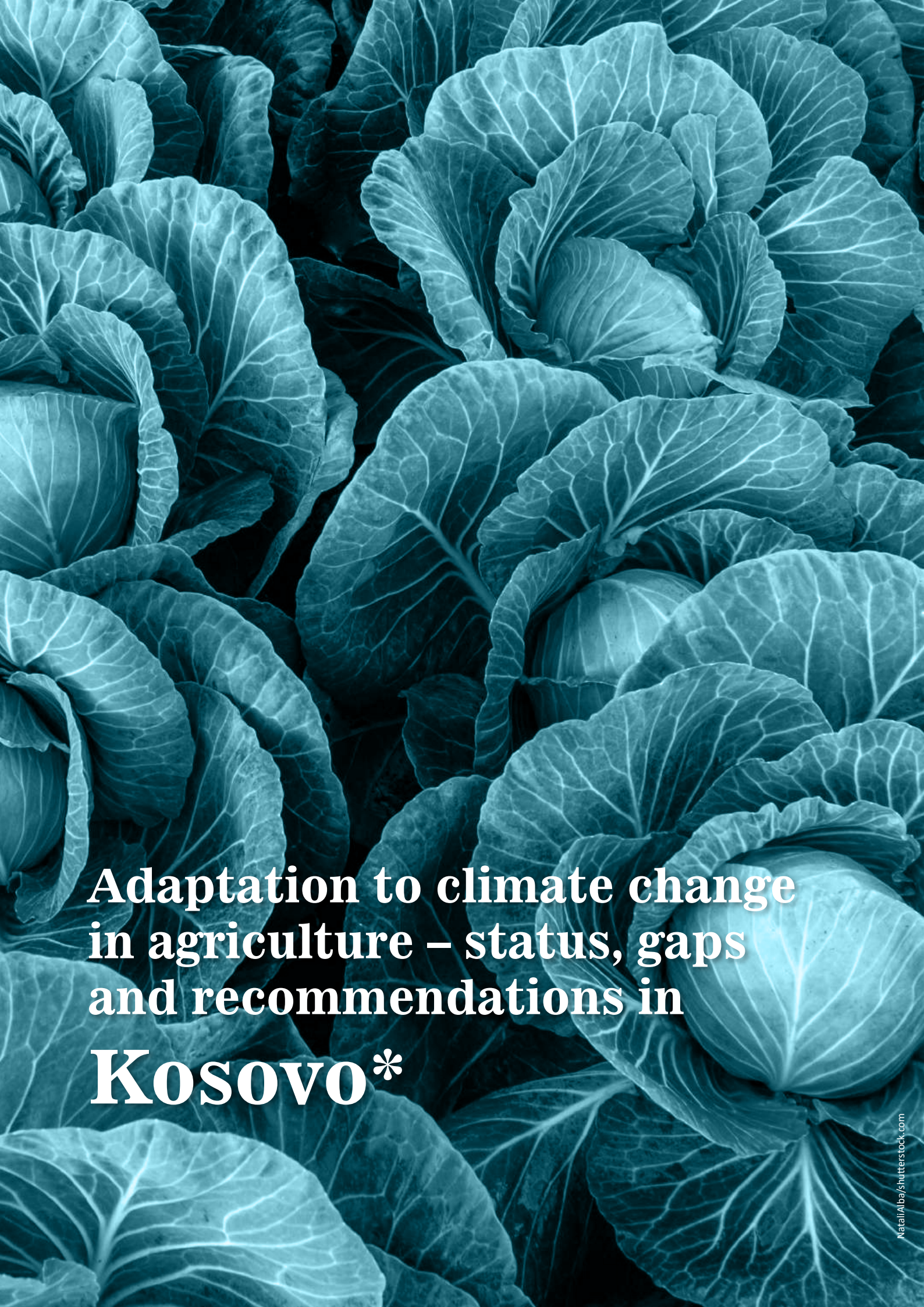
[17] Trbić Goran et al. (2021) Bosnia and Herzegovina National Adaptation Plan – NAP with proposed measures. https://unfccc.int/sites/default/files/resource/NAP-Bosnia-and-Herzegovina%20.pdf

[18] Markovic M. et al. (2019) Alleviation of Negative Climate Change Effects on Maize Yields in Northern Bosnia by Liming and Phosphorus Fertilization. In: Leal Filho W., Trbic G., Filipovic D. (eds) Climate Change Adaptation in Eastern Europe. Climate Change Management. Springer, Cham. https://doi.org/10.1007/978-3-030-03383-5_12

[19] Sabrija Čadro, Salwa Cherni-Čadro, Mihajlo Marković, Jasminka Žurovec (2019) A reference evapotranspiration map for Bosnia and Herzegovina. International Soil and Water Conservation Research 7 (1), 89-101

[20] The basis of land organization – irrigation programme and holdings consolidation programme in Federation B&H, September 2011.

Adaptation to climate change in agriculture – status, gaps and recommendations in Kosovo*



NataliAlba/shutterstock.com

3. Adaptation to climate change in agriculture – status, gaps and recommendations in Kosovo*

Iliriana Miftari[20], Afrim Sharku[21], Avdullah Nishori[22], Ylber Kuci[23], Bajram Imeri[24]

3.1. Status of economic, socio-economic and agricultural sector related to climate change

3.1.1. Macro-economic aspects on the national economy level

Kosovo* is a small landlocked economy with a population size of 1.8 million, and a population density of 166 inhabitants/km^2 (KAS, 2022). It is estimated that around 60% live in rural areas. Despite the positive GDP growth rate (5.2% in 2022 compared to the previous year), the economy is still encountering common challenges of transition economies like poverty, unemployment, income inequality, and political instability. The real economic growth is mainly driven by service activities (34.7%), wholesale and retail trade (18.8%), transportation (14.4%), manufacturing (10.6%) and construction (8.8%). According to the Eurostat data, it is estimated that 28% of Kosovo*'s population lives below the poverty line. Disparities in income distribution remain the highest in WB economies (29, 2017 data) (Bank, 2017), indicating that the economy should have a stronger long-term commitment towards inclusive development strategies and a combination of policies (e.g. progressive taxation, raising the minimum wage, better social welfare programmes, and educational and skills development programmes). Of the annual household income, 43% is spent on food, thus exposing rural households to food nutrition security risks adding to this high dependency on remittances and agri-food trade deficits. A high unemployment rate and a lack of quality jobs have contributed to poverty and income insecurity. The unemployment rate remains high (12.6% in 2022), being higher for women at 16.5% compared to men at 11.0%. Trade, manufacturing, construction, and education sectors employ more than half of employed people.

* This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo* declaration of independence.

20 Agricultural economics expert, University of Prishtinë (iliriana.miftari@uni-pr.edu)
21 Soil expert, Agrovinifera (afrim.sharku@gmail.com)
22 Water expert, Ministry of Agriculture, Forestry and Rural Development / PWC Iber Lepenci (avdullahn@gmail.com)
23 Crop expert, Ministry of Agriculture, Forestry and Rural Development (ylber.kuqi@rks-gov.net)
24 Livestock expert, Ministry of Agriculture, Forestry and Rural Development (bajram.imeri@rks-gov.net)

3.1.2. Macro-economic aspects on the agricultural sector level

Agriculture is an important sector in emerging market economies like Kosovo*. In 2021 the contribution of agriculture, hunting, forestry, and fishing to GDP was 6.9%. The contribution of crop output to the total agricultural output has shown a positive trend since 2018, which is different for livestock output where decreases and increases from one year to another have been observed. In 2021, the contribution of crop output to the total agricultural output was 65%. Forage plants (25%), followed by cereals (24%) and vegetables (23%) made the main contribution to total crop output. According to the Labour Force Survey 2022, the agriculture and forestry sector contributes with 2.2% to total employment, with a significant difference between men (2.7%) and women (0.9%). The COVID-19 pandemic had a short-term disruption in the supply chain and agricultural prices. In the long term, other factors like climate change and evolving dietary preferences will considerably shape and influence prices in agriculture. In 2022, the overall harmonized index of consumer prices was 12.1% higher compared to 2021. The highest rise was observed for oils and fats (26.0%), bread and cereals (21.2%), meat (18.9%), sugar and sweets (18.9%) and vegetables (10.8%). The general Kosovo* trade regime is liberal and export oriented. Kosovo* applies 0% VAT on final exported products and no VAT on imported inputs. The trade policy strategy of Kosovo* is to support the competitiveness of Kosovo*'s economy; however, the increase in trade imbalance in the last decade will be hardly sustained for a long period of time. The trade balance for agricultural products in 2021 was -687.3 (mil. EUR), with the increased share of agricultural imports in total imports of 23.2%. Stipulated by the EU Autonomous Trade Preference (ATP) Regime, Kosovo* enjoys non-reciprocal, customs-free access to the EU market. However, for some food products like wine and beef, numerous restrictions remain in force.

3.1.3. Land use

Kosovo* does not have a system of land monitoring in place, consequently the economy lacks validated data on land cover. The most up-to-date data from satellite imagery is from 2018. According to this data, 57% are forests and semi-natural areas, and 38% agricultural areas. In the last decade, it has been observed that urbanization (buildings, infrastructure for housing, commerce, privatization, and industry) has altered the use of best arable land into industrial one, and this is particularly concentrated around the capital city of Prishtinë. The abandonment of land is occurring mainly in marginal areas with limited access to infrastructure and markets, and unclear land tenure rights. Most of the pastures are state property and used as communal land by livestock herders. Jointly, pastures and meadows used for cutting grass to feed cattle covered an area of 241,000 ha in 2021 (KAS, 2023). According to the latest forest inventory (2012), 45% of the economy's territory is covered by forests. The majority (62%) are state forests, of which 12% are situated in protected zones – national parks (MAFRD, 2022). State-owned forests experience regular wildfires often facilitated by hot and dry weather for long periods. The Law on Agricultural Land No. 02/L-26 (amended in 2022), defines the use, protection, regulation, and leasing of agricultural land, to preserve and protect the agricultural potential permanently, based on the principles of sustainable development.

3.1.4. Brief agricultural sector overview

The territorial area is small, but the climatic conditions and the depth of active soil strata make the economy rich in terms of quality and quantity and suitable for the cultivation of a wide variety of crops. Favourable conditions in mountainous areas provide suitable conditions for the cultivation of non-wood forest products and medicinal and aromatic plants. In 2021, the total Utilized Agricultural Area (UAA) was 420,327 ha, out of which 188,375 ha was arable land (44.8 %), belonging to 103,723

agricultural holdings. The majority of the UAA is used for the production of cereals (30%), followed by fodder (9%), vegetables (3%), trees (2.4%), and vineyards (0.8%). The rest (51.7%) is covered by meadows, pastures, and common land.

Productivity in agriculture remains low if compared to the regional and EU economies; lower yields are particularly observed in cereals like wheat (4.03 t/ha), and maize (4.29 t/ha) (MAFRD, 2022). It has been observed that in 2021 compared to the previous year, yields in t/ha for all types of cereals fell by min-2.8% (maize) to max-6.6 (oat). The self-sufficiency rate for wheat decreased by around 4%, however, this difference is only for 2020-2021 and no clear trend has been observed in other previous years. The trend is clearer for vegetables, where a decrease in yields has been observed in almost all types of vegetables in the last five years. A decrease in vegetable yields can be attributed to both natural and human-induced factors. Changes in temperatures and extreme weather events, floods in particular, might have had an impact on reduced yields. Additional factors like labour shortages for planting, cultivating, and harvesting might have led to reduced vegetable yields. Similar negative trends in terms of yields achieved per ha have been observed for fruits, particularly for berries. The only significant positive increase in yields has been observed in table grapes from 6.9 t/ha in 2020 to 7.9 ha in 2021. While the yields of wine grapes have shown a slight decrease by-5.0%.

According to the Green Report 2020 (MAFRD, 2022), over 66 thousand farmers were engaged in livestock activities. During the past decade, the sector has been characterized by growth driven by significant government and donor support (reflected in more investments) as well as growing local market demand for livestock, especially dairy products. Despite growth and improvements, the sector still faces many challenges, mainly related to low productivity and poor infrastructure. While globally livestock is a major contributor to climate change (GHG emissions), in the local context (Kosovo*), livestock challenges are predominantly associated with pollution of air and local waterways in surrounding communities, including water efficiency usage. The cattle stock in 2021 decreased by 861 heads compared to 2020 (260,528 heads). A similar trend followed the self-sufficiency rate with beef, which constantly decreased from 61.1% in 2017 to 43.9% in 2021. The quantity of milk produced has shown small variations from one year to another; in 2021 the quantity of milk produced was 278,746 t, covering almost 80% of the domestic demand. The sheep and goats stock in 2021 was 241,393 heads (out of which 87.6% sheep), constituting 43.8% of the total number of animals. The decrease in 2021 in the sheep stock was neglectable (0.1%).

3.1.5. Farm structure key indicators and context

Looking at farming, the agricultural landscape is very different from the one in most of the European Union Member States. One important characteristic of the agricultural sector is the overwhelming predominance of small-scale farming with a low level of market integration. In 2020, the average size of agricultural holdings was 1.7 ha, including over 60% of holdings with a size of up to five hectares. Holdings with utilized agriculture area between two and five hectares are the most common – 35 percent of the total number of holdings. Thus, small farms are the prevailing producers, which means that their productivity and sustainability are central to the performance of the overall agriculture as well as for rural economic growth. According to FADN data for 2019, 28% of the farms belong to the field crops, followed by the mixed farm type (crops and livestock) 27%, grazing livestock 21%, perennial crops (7%), and others (mixed crops and mixed livestock). Between 2005 and 2021, the sale of agricultural land reached at 30,823 ha with a total sales value of 160 million EUR. The highest average sale price of one hectare of agricultural land was 25,055 EUR in the region of Prishtinë, while other regions had a much lower sale price for one hectare of land. There is no data on farms owned by

women; however, if we take into consideration the number of applicants and beneficiaries for direct payments, we see that only 5% are female farmers. This shows that efforts should be made to address gender disparities through specific policies, programmes, and initiatives that allow female farmers to have better access to resources and equal opportunities as male farmers.

3.1.6. Legislative framework and institutional setup

Kosovo* is signatory of the Sofia Declaration on the Green Agenda as part of the Berlin Process. This will serve as important bedrock to faster changes and progress of the economy towards the overarching goal of addressing climate change. As the economy is aspiring towards EU accession, the legislative framework is largely approximated with the Acquis Communautaire. The Energy Strategy 2022–2031 highlights the economy's promise to phase out coal by 2050, a higher target for renewable energy sources, followed affordable transition, technology, innovation and strengthening of cyber resilience in the energy sector. In addressing climate change, various institutional setups exist across different levels at national and local levels, responsible to manage, mitigate and adapt to climate change impacts. At the national level, the Ministry of Environment, Spatial Planning and Infrastructure is responsible for monitoring the implementation of the Climate Change Strategy. Kosovo* is not a signatory party to the United Nations Framework Convention on Climate Change (UNFCCC). As a result, there is currently no legal basis for drafting Nationally Determined Contributions, no targets set for 2030 and no regular reporting (National Communications on Climate Change and Biennial Update Reports) is undertaken. However, in November 2023, for the first time Kosovo* started preparing the first inclusive and voluntary Nationally Determined Contributions (NDC) (a booklet already presented at COP28). An initial draft of the National Energy and Climate Plan with outlining strategies for a sustainable and low-carbon future is already prepared, indicating the economy's proactive approach towards climate action. The Kosovo* Climate Change Law, approved by the Government, reflects a strong commitment to combat climate change and foster climate adaptation across various sectors. The Climate Change Strategy 2019-2028 sets out policies and measures to reduce greenhouse gas emissions (GHG) and adapt to climate change. The new Climate Change Law foresees the development of Kosovo*'s first Strategy on Climate Change Adaptation by 2024. In addition, the Strategy on Agriculture and Rural Development 2022-2028 and the Strategy on Forestry Development 2022-2030 foresee policies and measures targeting climate change issues, e.g. aims to reduce illegal logging by 70% and increase the forest area by 3% until 2030.

3.1.7. Literature review on climate change linked to socio-economic aspects

Kosovo* is highly prone to a wide variety of natural hazards – including floods, landslides, droughts, earthquakes, and wildfires. In January 2023, Kosovo* experienced severe flooding, which had a devastating impact on 785 households in 11 municipalities of the economy. About 2,272 people were temporarily displaced, mostly in Skenderaj and about 46% of households experienced flooding of 30-40 cm and more than 30% experienced flooding of 80-160 cm. The total damage to household items was estimated to be 3.75 million EUR with an average of 5,102 EUR per household. In rural areas, 940 farmers lost productive assets, livestock and crops to the floods in January 2023. In the strategic objective for climate change adaptation, the economy plans to improve the existing and establish new mechanisms and measures towards the reduction of flood threats by 60% in 2027. Urban and rural zones were affected by a rapid increase in water levels in a short period of time, which resulted in significant damage. More than 2,656 households, some 21,500 people, were directly impacted – most reported already being highly vulnerable households with low income. With the overwhelming majority of farming households in rural communities practicing subsistence farming, this loss of

livelihood represents a direct threat to food security and further deterioration of the socio-economic status. An increase in temperature will make heat waves and forest fires more likely as since 2000 there has been an increase in forest fires. The contribution of the agricultural sector to the total GHG emissions is estimated to be 6%, which is lower than the EU level (12.55%). However, it should be emphasized that this small contribution relates to high emissions from the energy sector and lower number of animals and a less extensive livestock farming system.

There are significant land surface temperature changes for both water balance and night land surface temperatures for Kosovo* (Sanchez et al. 2023). According to Sanchez et al. (2023) the vulnerability of the viticulture sector in Kosovo* is very high, due to significant changes in water balance and land surface temperature. The impact of climate change will require enhancements towards more sustainable production methods with better understanding of current and future climate change impacts on the sector's productivity. The actual climate change research mainly focuses on energy efficiency and emissions and pollution reduction (hence climate change mitigation), tackling issues in urban areas more than in rural ones (Caka, F. & Caka, N. 2022).

3.1.8. Agricultural policies linked to climate change

Policy efforts and the budget dedicated to the agricultural sector have generally increased over the last years. The sector's productivity remains low despite suitable climatic conditions, and its potential and financial government/donor support given to the sector. It is about 50% below the levels achieved in central Europe. The National Strategy on Agriculture and Rural Development focuses on four strategic objectives: (1) Increasing the competitiveness of the agri-food sector and improving the efficiency and sustainability of farm production; (2) Sustainable management of natural resources (land, forests, and water); (3) Supporting businesses in rural areas and enhancing employment and social infrastructure; and (4) Comprehensive institutional and sector reform to create efficient public services.

The Strategy considers the environmental and climatic actions included in the Green Agreement, namely in the commitments of the Green Agenda for the Western Balkans. The types of interventions are those under Pillar I (subsidies) and Pillar II (rural development grants) of CAP, infrastructure, and institutional reforms aiming to further operationalize MAFRD towards a more efficient public administration (MAFRD, 2021). The strategy will be implemented mainly through the National Agriculture and Rural Development Programme, capital projects, IPA III, and with the contribution of other donors. Agricultural and forestry policies and measures that relate to climate change adoption are listed below.

Kosovo* has already developed a management plan for the Drini i Bardhë basin and the ongoing risk mapping project for Kosovo*'s River Basins. It also aims at reaching 90% afforestation and reforestation of degraded areas around riverbanks by 2027 and to create a heat wave warning system.

A list of policy measures is given in Annex 3.1.

According to the National Strategy on Agriculture and Rural Development 2022-2028, many factors are affecting the development of the agriculture and food sector. Low productivity and profit margins make farm structure the biggest obstacle to the modernization of the sector. Access to finance is very challenging due to very high interest rates (between 6-30%), and this limits investments in outdated mechanization, equipment, and unmodernized technologies. Even though the economy has a young population, the labour availability in agriculture is shrinking and its cost is increasing, hence digitalization in agriculture will become an important factor in the economy's agricultural development. The Master Plan for Irrigation in Kosovo* shows that 7% of cultivated land is irrigated which is mandatory for

the increase of productivity in particular for fruits and vegetables. Land abandonment remains very high, especially in remote mountain areas, and this is expected to increase primarily due to migration of the young generation in particular. The agriculture market is not yet well consolidated in terms of distribution channels and poor insurance schemes on the market. Loss of agricultural land from uncontrolled construction, low level of institutional commitment to protect agricultural land, and insufficient policy formulation including farmers' interest to support the process of land consolidation are the challenging issues heading towards farm structure consolidation.

3.1.9. Data availability and quality for the analysis of climate change socio-economic issues

The lack of inclusive data on the socio-economic impact of climate change was a significant challenge. Understanding the full scope and the comprehensive picture of how climate change affects communities, economies, and the society as a whole requires embracing research and data collection across various sectors and territorial units. Kosovo* has limited extensive research and lacks time series data at regional and municipal levels. Agricultural data is available only at the national level. Addressing the issue of data requires concerted efforts from the government (national, regional and local levels), research institutes and higher education institutions, NGOs, and international organizations. Besides the challenges related to data collection and standardization, there is limited capacity in ability to analyze and use the data related to climate change impacts. Improving our understanding of the socio-economic impacts of climate change is crucial for developing effective policies and strategies to mitigate its effects and build more resilient communities. Improving data availability, accessibility and quality and our understanding of the socio-economic impacts of climate change is crucial for developing effective policies and strategies to mitigate its effects and build more resilient communities.

3.1.10. Conclusions with key recommendations and priorities referring to the socio-economic aspects of climate change

Even though the majority of the Kosovo* population lives in rural areas where agriculture is based, extreme poverty in rural areas remains high and this is due to the lack of government strategy and unreformed social assistance schemes. There are insufficient institutional capacities to implement policies and strategies on agriculture, trade, food, climate and food safety policies. The economy is facing water scarcity and is increasingly vulnerable to flooding and dry spells. This is expected to exacerbate in the future (if no actions are taken), due to climate change, as rising temperatures disrupt precipitation patterns and the entire water cycle. Environmental considerations are integrated into sectorial policies and legislation but marginally. Rural areas face constant power outages and an unstable energy supply. Extremely limited data make it impossible to effectively analyze trends concerning climate change impact on production, prices and consumption. Within climate challenges, the economy suffers from environmental pollution (especially air) and degradation of natural resources, each of which severely impacts livelihood opportunities and public health. The implementation of existing plans is slow toward the transition to a green economy. Socio-economic vulnerability is exacerbating the impact of biodiversity degradation due to the lack of human capacities to control and mitigate risks from illegal logging and other illegal activities such as hunting, urbanization/spatial planning. In addition, the availability and accessibility of sufficient and good-quality data is lacking, making it difficult to properly monitor and evaluate indicators, targets, and progress toward the Green Agenda for WB and the 2030 Agenda.

3.2. Status of soils linked to climate change in agriculture

3.2.1. Exposure and sensitivity of soils to climate change and its influence on overall soil health

The role of soil in the natural and anthropogenic environment is multiple and multifunctional. Earth is a habitat for many animals and microorganisms and a source of water and nutrients for plant vegetation and through the plant world for other living things. The quality of the soil depends on the way it is managed.

Out of the total area of 1,090,800 ha (10,908 km^2) in Kosovo*, in 2021, 420,327 ha were used as agricultural land. Out of the agricultural land, about 44.8% is arable land, 51.7% are meadows and pastures, and 3.5% are various plantations, vegetables, and others. Referring to the Ministry of Agriculture data, the surface of agricultural land from year to year has gradually risen owing to the support provided to farmers through subsidies and development programmes by the Ministry of Agriculture, Forestry and Rural Development.

In Kosovo*, climate change has become one of the most severe threats to the environment, economy, and human health. Climate change, in a reversible way, affects the degradation of agricultural land, primarily through unplanned use of fertilizers and plant protection products, erosion, and various forms of contamination.

Uncontrolled application of mineral fertilizers and pesticides depletes the soil organic carbon and destroys soil structure causing intensive soil erosion processes, which is especially intensified in a climate change affected environment. Inappropriate mechanization and tillage techniques also contribute to erosion.

The increase of average air temperatures results in more frequent heat waves, which affects the appearance of forest fires. Since 2000, there have been more forest fires in Kosovo*. According to the data of the Forestry Agency of Kosovo*, from 2010 to 2014, forest fires affected 8,887 ha. The largest areas affected by forest fires were in the region of Prizren (3,853 ha), region of Pejë with 3,002 ha, and the region of Ferizaj (194 ha). The available data show that from 2015 to 2020 a very high number of 931 forest fire incidents were recorded, involving 10,368 ha of forest, 6,649 ha of which were state-owned forests, while 3,719 ha were privately owned forests. In 2021, a total number of 87 cases of forest fires in public and private forests was recorded, which included a forest area of about 2,653 ha, with the largest areas in the region of Mitrovicë (2,143 ha).

Increased temperatures and decreased rainfall, combined with socio-economic developments, have significantly influenced the appearance of droughts in agricultural lands (1993, 2000, 2007, and 2008) and the need for additional water resources.

In 2011, Kosovo* prepared a proposal for a Drought Management Framework of Kosovo*. The Ministry of Environment and Spatial Planning took the responsibility to produce a National Drought Management Plan (DMP). The national drought plan should be prepared as a part of the River Basin Management Plan. The current status of the hydrometric network in Kosovo* is currently inadequate to provide a comprehensive and reliable drought (and flood) forecasting system. At the moment, Kosovo* does not have relevant datasets for the preparation of a drought map as well as indicators that are in common international use, such as the Standardized Rainfall Index (SPI) and the Surface Water Supply Index (SWSI).

Floods in Kosovo* are a phenomenon that changes over the years. Changes in the amount of rainfall and especially the occurrence of high-intensity rainfall have caused the appearance of floods in agricultural land for many years. There are many data sources for this extreme. In the period of 2000-2014, a total of 264 cases took place. In the last 15 years, floods have occurred at least once in year, while on average there have been 18 cases per year. However, the number of events in the past two decades has rapidly increased, reaching in 2006 the maximum number of 68 cases in one year.

Approximately 491 km of rivers are at risk of flooding. The Preliminary Flood Risk Assessment has analyzed 834 cadastral zones with a total area of 7,056 km², with 123 km², 341,244 inhabitants and 57,784 households, 32 cultural and historical sites, 57 protected areas and hot spots and 538 economically important areas at risk. Studies have identified 398 areas of potential significant flood risk, out of which 108 at extreme risk, 95 are at very high risk, and 195 at high risk.

Within the EULUP project a flood risk map was developed for the whole territory of Kosovo*. The data on the map show that the total area in the flood risk zone is 7,074.35 ha.

3.2.2. Producers' adaptive capacities relevant for the sustainable use of soils

Given the increase in global demand for food, agriculture represents a very important strategic sector of the Kosovo* economy that contributes to the Gross Domestic Product (GDP) by 6.9%. Despite the great importance of the development of agriculture for the provision of food in Kosovo* and the development of rural areas, there are many obstacles to sustainable development of this sector, such as undeveloped infrastructure, insufficient access to markets, insufficient application of technology and the quality of education and social service.

In the period 2017-2021, the number of employees in agricultural businesses recorded a continuous increase. In 2020, the number of employees in the agricultural sector was 14,996 employees or 15.1% lower compared to 2021, when the total number of employees was 17,260. However, there is a great shortage of labour in agriculture.

The recent trends in the economic development of Kosovo* have also affected arable agricultural land, with significant areas of agricultural land changed to construction land. In general, in this period of economic development, farms, as small as they were, have continued to fragment even further, affecting the reduction of the average size of the farm. The main factors for this trend are continuous changes of land use due to the growth of the rural population as well as other factors.

In 2019, the total arable land, namely fields, turned out to be 0.11 ha per capita, while the average total utilized agricultural area per capita was 0.24 ha.

The farm size of 2 to less than 5 ha represents 35% of the total area of arable land, the size of 5 to less than 10 ha covers 21% of the area, the size of 1 to less than 2 ha 16% of surfaces, while the size with a minor area of 0 to less than 0.5 ha. covers 3.1%.

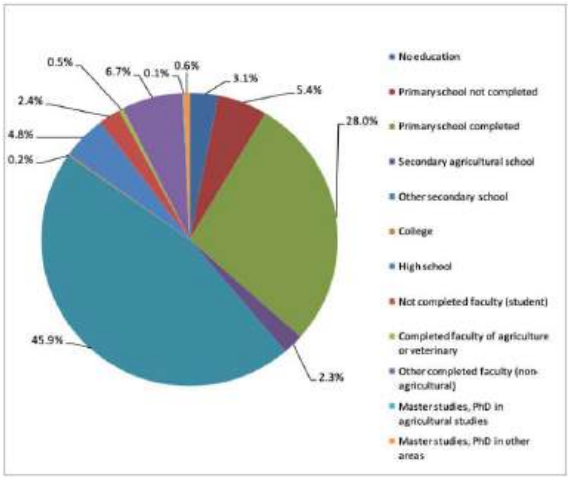


Figure 3.1. Age structure of holders, Kosovo*, 2014

The number of agricultural holdings in Kosovo* is 130,775. The most significant number of agricultural holdings are in the farm size of 0 to less than 0.5 ha (30.4%), followed by 2 to less than 5 ha (23.0%), 1 to less than 2 ha (21.9%) and other groups. The smallest number of agricultural holdings is of the sizes of 20 to less than 30 ha (0.2%) and 30 and more (0.2%).

Every year, the Department of Advisory Services in the Ministry of Agriculture, Forestry and Rural Development (MAFRD), through activities at the central and local levels, supports and offers advice and training and continues to deal with the education and training of advisors and farmers. Capacity-building training and certification training is organized for advisors, while training, advice, and publications are provided to farmers. According to the data of the Department for Advisory Services, the number of farmers who participate in training within one year is 12,140 participants.

Data reported by municipal directorates for agriculture show that in 2021, about 19,958 ha were irrigated from different sources.

According to the Agriculture Census 2014, farm work is expressed in annual work units (1 AWU is equal to 1,800 working hours). In Kosovo*, the majority of holders are men (95.1%), while among other family labour (members of the holder's family) women dominate with 58.2%.

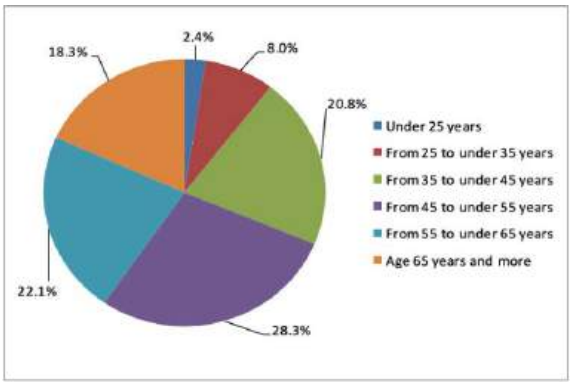


Figure 3.2. Education of holders in agricultural holdings and individual businesses, Kosovo*, 2014

The average age of holders of agricultural holdings and individual businesses is 52 years, while the average age of the members of the holder's family working on the agricultural holding is 40 years.

Less than one-third of holders are under 45 years and almost one-fifth of them are older than 65 years. Among the members of the holder's family working on the farm, about 40% are under 35 years and the share of members older than 65 years is very low (6.6%)

The level of education of holders is quite low, in particular in respect to agriculture. 28.0% completed only primary school, 5.4% did not complete even primary school, while 3.1% have no education. Secondary school was completed by almost half of the holders. Less than 3% of the holders completed agriculture studies (secondary agricultural school, Faculty of Agriculture/Veterinary Science, Master studies, PhD in agricultural studies), while 6.7% of the holders completed other universities (non-agricultural). Among the members of the holder's family working on agricultural holdings, 39.1% have only primary school completed, while, 3.6% have no education. Less than 1.5% of them have education in agriculture.

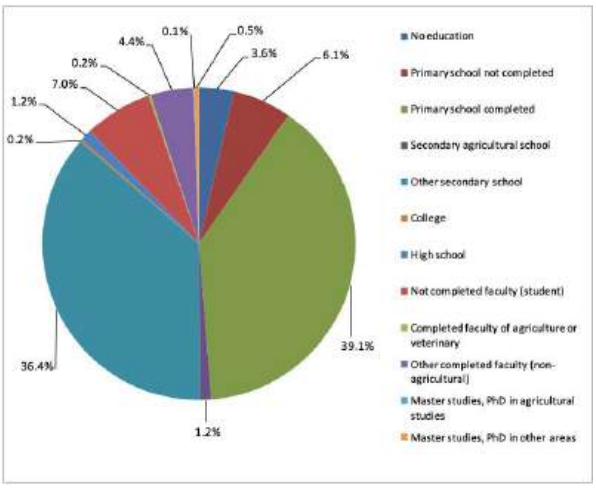


Figure 3.3. Education of family members working on agricultural holdings and individual businesses, Kosovo*, 2014

In 2014, agricultural holdings in Kosovo* owned 66,306 tractors of that 65,859 or 99% were owned by agricultural holdings and 447 or 1% by legal entities carrying out agricultural activities. Only one in two agricultural holdings owns a tractor. Per 100 hectares of utilized agricultural area, there are 16 tractors used. The majority of tractors are single-axle tractors (87%). More than 73% of all tractors owned by agricultural holdings in 2014 were more than 20 years old.

In 2014, 45,867 agricultural holdings owned 48,968 ploughs; 37,633 agricultural holdings owned 39,387 tractor trailers; 27,559 agricultural holdings owned 27,940 harrows; 11,951 agricultural holdings owned 12,335 tractor-pulled mowers; those were the most frequently used connecting tools for tractors.

3.2.3. Existing gaps and challenges to meet the newly adopted EU strategic and legal documents on soil and adaptation

Kosovo* is a developing economy and a economy that aspires to become a member state of the UN and the EU. As such, Kosovo* is not yet a party to the United Nations Framework Convention on Climate Change (UNFCCC); however, according to its categorization, it would be considered a developing economy (non-member states of the Annex I).

Kosovo* aims to become a member state of the EU, which includes changing the legislation and its implementation according to that of the EU, thus gradually passing from the status of a developing economy to that of a developed economy according to the UNFCCC. As a new economy, Kosovo* lacks the capacity and experience to deal with climate change due to other priorities. Information on greenhouse gas emissions, particularly projections for them, is still insufficient. Several policies and strategic documents have been developed and approved, but they remain to be implemented. Under these circumstances, a comprehensive document is needed that brings together all the activities related to climate change as well as sets appropriate priorities, which can be found in the Climate Change Strategy 2019-2028 and Action Plan for Climate Change 2019-2021. This strategy is the initial step of an informed policy process of adaptation management. It also presents an opportunity to seek adequate mitigation measures to promote development.

In 2015, Kosovo* signed a Stabilization and Association Agreement with the European Union, and is working to align its legislation with EU legislation as part of the EU approximation process, including environment and disaster risk reduction. However, during the drafting of the Strategy for Environmental Protection and Sustainable Development 2022-2031 (which is currently being drafted by the Ministry of Environment, Spatial Planning and Infrastructure), the aim should be to incorporate the objectives of EU strategic documents and agreements that target land, such as the **Soil Deal for Europe**, with its primary mission – creating living laboratories, where good practices can be displayed to lead the transition to healthy lands by 2030; the **Green Deal**, which resets the European Commission's commitment to tackle climate and environmental-related challenges, the **Soil Strategy** for 2030, offering an policy framework for soil restoration to assess the status of European soil and take action against overarching its degradation and the Regulation of Soil Monitoring with the mandate to protect soils on the same legal basis as air and water.

In the context of what was mentioned above, the main challenge but also the opportunity lies in the orientation towards a low carbon economy by reducing greenhouse gas emissions but also meeting the objectives of rapid improvement of the economic situation, social cohesion, and receipt of international support. This will require improving the current situation and moving towards sustainable production, consumption, and lifestyle trends so that Kosovo*, as a future member of the EU, can contribute to European competitiveness and cohesion in the long term.

3.2.4. Sustainable measures and best practices already applied for the protection of agricultural land

It is evident that farmers often use inappropriate agrotechnical measures that reflect negative effects on fertility, low and unplanned agricultural productivity. Traditional agricultural production, in most cases, continues to be accepted by older generations.

Protection from physical degradation of the soil and the application of appropriate agrotechnical measures reflects the protection from physical degradation of the soil, which is done through the destruction of the soil structure and the destruction of the balance of the air-water regime in the soil.

Over the past twenty years, various seminars have been organized in Kosovo* by various international and local organizations as well as various NGOs to train farmers in the way of tillage and good agricultural practices. This has been done in order to reduce erosion processes and avoid the loss of soil humus (organic matter) and plant nutrients. Erosion is caused by improper agrotechnical measures, especially when cultivating land on a steep slope. Some of the measures farmers have started to implement to reduce or stop erosion processes include planting grass in orchards as a solution for adaptation of agricultural crops to the nature of the slope. On the other hand, the cultivation of the soil perpendicularly to the isohypses presents a much greater risk for acceleration of erosion and

carrying and washing away soil nutrients. Therefore, one of the focuses of the trainers was to apply ploughing along the isohypses (contour ploughing).

Burning of plant residues used to be practiced on a massive scale and is still practiced by some farmers. By burning plant residues, microflora and fauna are destroyed in the part of the arable soil layer. The microbiological process of organic matter decomposition is minimized, and this is directly reflected in soil fertility. This practice has begun to be significantly reduced after many debates with the farmers regarding the harm caused by this practice of destroying bad weeds. The regulation of riverbeds at a low level by the farmers themselves is a measure that enables the avoidance of the risk of possible floods and creates the possibility of sustainable development of planned agricultural production in the areas around small rivers.

Through formal and informal ways of irrigation in Kosovo*, 19,958 ha were irrigated during 2021. Through formal irrigation organized through irrigation companies, a total of 14,451 ha was irrigated, while through informal, unorganized and individual irrigation, and irrigation from different water sources such as rivers, wells, etc., 5,506 ha were irrigated. The tendency for farmers to irrigate surfaces in agricultural production has been increasing from year to year. Especially the application of drip irrigation, which is also included as a measure in the strategic documents of agriculture and rural development programmes of the Ministry of Agriculture, Forestry and Rural Development.



Picture 3.1. Applying drip irrigation on medical plants



Picture 3.2. The practice of burning plant residues has not yet been completely eliminated

3.2.5. Already adopted mechanisms and opportunities for effective adoption of adaptation measures for soil health protection

In November 2020, Kosovo* signed the Sofia Declaration on the Green Agenda for the Western Balkans (GAWB), thus adopting the strategy of the European Green Deal towards a modern, climate-neutral, resource-efficient and competitive economy. Among the agreed actions is the alignment with the EU Climate Law (once adopted), with a vision of achieving climate neutrality by 2050, and the implementation of clear measures designed to reduce greenhouse gas emissions by mainstreaming action on climate in all relevant sectoral policies.

Regarding air quality, ammonia (NH3) is the primary air pollutant. Agricultural activities are the dominant contributors to ammonia emissions. Kosovo* is not part of the Convention on Long-Range Transboundary Air-Pollution (CLRTAP) nor a signatory to the Gothenburg Protocol (for acidification, eutrophication and ground-level ozone). Therefore, Kosovo* has no legally binding targets for reducing ammonia emissions (compared to EU member states).

Kosovo* still needs intervention in policies to promote agricultural practices with the environment systematically. Looking at the EU Common Agricultural Policy, the mechanism is simple: Good Agricultural and Environmental Conditions (GAECs) are defined by each economy based on a set of standards, which include the protection of biodiversity, soil, and water, and related to any surface payments, including direct payments and agri-environmental compensations. GAECs are not intended to solicit farm investment but to stimulate farmers to adopt good practices. In this way, Kosovo* should first design a simplified set of GAEC and implement awareness-raising campaigns among farmers with the support of the public consultation system. In case of non-compliance, instead of fines for farmers, they should receive notices on how the KBPK would help to keep the natural resources of the farm in good condition, at least in the first years of the implementation of the system.

Kosovo* has a real potential to contribute to climate change mitigation through carbon sequestration measures such as the afforestation of agricultural land (also addressing the problem of soil erosion).

The primary measure of adaptation to climate change can be considered the rehabilitation and modernization of the irrigation and drainage system. However, the method currently requires significant investments in rehabilitating existing systems and constructing new irrigation systems. In the past two decades, there have been many project investments by the European Union and the World Bank in the rehabilitation of existing irrigation systems, while through the programme for agriculture and rural development within the Ministry of Agriculture, a special measure of annual grants is implemented for the construction of irrigation systems, especially systems drip irrigation in greenhouses, orchards and vineyards and online services for farmers.

Furthermore, public or private advisory systems do not promote good practices for climate change adaptation, such as using cover crops on the terrain where erosion occurs, minimum tillage, crop diversification, and plant rotation.

IPA funds are linked to many programmes (the establishment of vineyards and orchards, investments in the construction of systems for the storage of agricultural products, the purchase of mechanization, etc.) but are not linked to the permanent control of land with environmental conditions and there are still no agri-environmental measures.

Agriculture continues to have low access to general bank financing, with only 2.1% for 2021 (0.1 percentage points lower than the previous year). Thus, this is the sector in which financial institutions in Kosovo* were the least credited. In Microfinance Institutions (MFIs), the situation is different because the participation of agrocredits was 19.5% in 2021.

It is worth evaluating the economy's effectiveness in mitigating climate change through extensive management of large rangelands and low-input cropping systems, which can be considered more effective than high technologies and practices applied to the intensive agricultural systems of developed economies (Strategy on Agriculture and Rural Development 2022-2028). However, along with the expected development of agriculture, good practices and investments related to climate change are essential; otherwise, there is a high risk of missing the opportunity to ensure sustainable development of the economy and a close alignment with EU policies.

3.2.6. Analysis of the current institutional and legal setup for effective adaptation of soils to climate change

Since the United Nations institutions have not yet accepted Kosovo*, Kosovo* is not a party to international conventions and participates in negotiations only as an observer. However, compliance with international laws, including Multinational Environmental Agreements, continues to be very important for Kosovo*'s future as domestic strategy as well as in international relations.

In order to address climate change in this area, the Ministry of Environment and Spatial Planning has issued the following Administrative Instructions, which deal with specific segments in this area:

- Administrative Instruction of the Government of the Republic of Kosovo* No. 19/2013 for access to information on economic fuel consumption and CO2 emissions of new personal vehicles
- Administrative Instruction of the Government of the Republic of Kosovo* No. 20/2013 on the Implementation of Flexible Mechanisms for Clean Development
- Administrative Instruction of the Government of the Republic of Kosovo* No. 01/2016 on the Mechanism for Conveyance of Greenhouse Gas Emissions
- Administrative Instruction of the Government of the Republic of Kosovo* No. 09/2015 on the Conveyance of Greenhouse Gas Emissions
- Administrative Instruction of the Government of the Republic of Kosovo* No. 16/2013 on substances that damage the ozone layer and fluorinated greenhouse gases

In addition to the legislation, the Ministry of Environment and Spatial Planning (MESP) has developed the Greenhouse Gas Inventory for 2008, 2009 and 2015.

MESP has also prepared the Strategy on Climate Change 2019-2028 and the Action Plan for Climate Change 2019-2021. The Strategy on Climate Change 2019-2028 defines policies for reducing greenhouse gas (GHG) emissions and policies for adapting to climate change. Also, it presents an opportunity to find and define measures to reduce greenhouse gas emissions, and it presents an opportunity to see mitigation and adaptation measures that will promote sustainable development.

Institutions responsible for land monitoring are the Agricultural Institute of Kosovo*, which operates within the framework of the Ministry of Agriculture, Forestry and Rural Development, and the Hydrometeorological Institute of Kosovo*, which operates within the framework of the Ministry of Environment, Spatial Planning and Infrastructure.

One of the basic tasks of the Hydrometeorological Institute of Kosovo* is the organization and performance of measurements and monitoring of elements and phenomena: hydrological, meteorological, agrometeorological, and environmental components, such as air, water and soil from the aspect of quality.

The Hydrometeorological Institute of Kosovo*, which operates within the Ministry of Environment and Spatial Planning and Infrastructure, does not regularly monitor and assess soil pollution due to a lack of human capacities.

3.2.7. Existing soil data availability and quality, data constraints and data gaps

According to the current legislation in force, land protection issues are addressed through the following two ministries:

- Protection of agricultural land from pollution, erosion, regulation, continuous monitoring of the condition and all changes in agricultural land such as physical, chemical and biological properties are the responsibility of the Ministry of Agriculture, Forestry and Rural Development; whereas
- the creation of policies, legislation, strategies for environmental protection and monitoring of the state of the environment, which includes the soil component, is the responsibility of the Ministry of Environment, Spatial Planning and Infrastructure, regulated by the Law on Environmental Protection and other environmental laws in force.

The lack of basic data on agricultural lands is a chronic problem of the Ministry of Agriculture, Forestry and Rural Development (MAFRD). The only complete systematic study of soil profiles was done during the preparation of the pedological map in 1974, at a scale of 1:50,000, where 120 types and subtypes of soils were identified. Unfortunately, Kosovo* does not have these data entries since they were not transferred to Kosovo* by the research institute because of hostile politics between Kosovo* and Serbia. Therefore, instead of a genuine pedological map, only an atlas of the types and subtypes of investigated soils was inherited from this study without data on their chemical and physical properties, water content, etc.

On the other hand, to control the granting of subsidies and grants, MAFRD implements the Land Parcel Identification System (sLPIS), which includes the Land Parcel Identification System as the relevant software for the graphic identification of land use based on orthophotos.

The Hydrometeorological Institute of Kosovo* (HMIK), which operates within the Ministry of Environment and Spatial Planning (MESP), needs to regularly monitor and assess soil pollution due to a lack of human capacities. Monitoring is carried out when there is an environmental accident or through a project, as was the case with the Study of Agricultural Soil Pollution (SST) in Kosovo* project, where a detailed study of agricultural soil pollution was made in 17 municipalities.

Data on soil erosion are not collected systematically but are based on GIS analysis and modelling of other data, such as land use, climate, and topographic data.

Through the European Union's IPA Programme for Kosovo*, the project Further Support to Land Use – EULUP has been implemented, which has produced several digital data sets, related to spatial planning, natural resources sensitivity and risk assessment, land suitability, land degradation processes, etc. (Annex 3.2).

3.2.8. Conclusions with key recommendations and priorities referring to soil adaptation to climate change

In the context of examining the issue of climate change and its impact on the Earth's ecosystem, some measures are necessary.

- Create a national list of land degradation indicators and define criteria for determining areas sensitive to land degradation processes, especially from contamination and erosion.
- Create a system of sustainable and integrated land management and systematic monitoring of soil quality, especially from the aspect of the use of fertilizers and pesticides.
- Regulation of riverbeds is a measure that enables avoiding the risk of possible floods and creates the possibility of sustainable development by balancing the economic, social, and environmental aspects. Therefore, regulating riverbeds should be a primary and priority measure that all municipalities must apply at the central and local levels of governance.
- Greenhouse gas emissions are one of the most sensitive issues for soil protection from climate change, so the potential for reducing greenhouse gas emissions by applying better agricultural management practices designed to slow soil erosion rates should be reviewed, also to reduce the movement and leaching of nutrients from agricultural lands.
- The land monitoring system by legal authorities should be kept under observation, data on the state of land provided, and actions to maintain the functions of the land suggested.
- The dynamics of monitoring and assessing the condition and use of land in Kosovo* should be implemented according to EU policies and standards. This dynamic should prioritize the integrated approach to land use planning and management. This dynamic should focus on monitoring, documenting, and evaluating Kosovo*'s spatial pattern, extent, and land cover.
- Organic production is in the initial stages, while on the other hand, the market demand for these products is growing and should encourage farmers to switch to organic farming. In this direction, Kosovo* should create a functional accreditation system for organic agriculture inspections and certification so that farmers can switch to organic agriculture through appropriate compensation schemes.
- Introduce into practice the Integrated Soil Fertility Management (ISFM), which is defined as a set of agronomic practices relating to crops, mineral fertilizers, organic inputs and other components adapted to local conditions for different cropping systems, soil fertility status and socio-economic profiles, aimed at optimizing efficient agronomic use of the applied nutrients and thereby improving crop productivity and soil health management.

3.3. Status of water resources and their importance for agricultural production

3.3.1. Analysis of water resources in Kosovo* and their importance for agricultural production

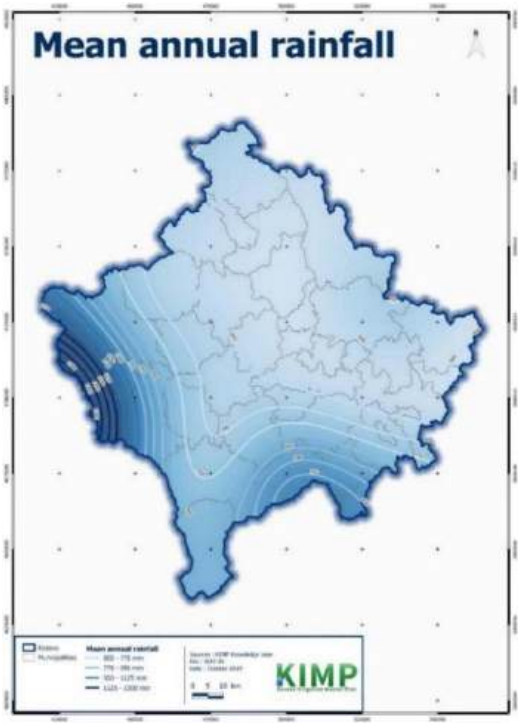


Figure 3.4 Average annual precipitation map

In hydrographical terms, Kosovo* is divided into four river basins: the Drini i Bardhë, Ibri, Morava e Binçës and Lepenci which then continue flowing into three seas: the Black Sea, the Aegean Sea and the Adriatic Sea. Long-term average annual flow of rivers and recharge of aquifers from endogenous precipitation in Kosovo* is round 1,900 m^3/capita/year[25]. Kosovo* is uniquely dependent on internal water resources with a very low dependency ratio. The only water that enters the economy other than in form of precipitation is the water that enters Gazivoda Lake from the Iber River. Internal renewable water resources in Kosovo* are 3.3 BCM/year, while external renewable water resources are only 0.3 BCM/year or only 9% of the total water resources in the economy. Long-term average annual precipitation in depth (mm/year) in Kosovo* is 768 mm/year or 8.38 BCM/year[26].

Bearing in mind that Kosovo* is dependent on internal water resources (89%) precipitation play key role particularly in agricultural production. The climate in Kosovo* is continental with cold and snowy winters and hot and dry summers. The annual average rainfall is 763 mm (840 mm in the Lepenc and Drini i Bardhë basins and 675mm in the Morava basin).

The total water consumption for all needs in Kosovo* is 344 MCM/year or 193 m^3/capita/year[27]. From the total water consumption amounts, drinking water takes the largest share with 178 MCM/year, followed by agriculture with round 140 MCM/year and industry with round 26 MCM/year[28]. From total abstracted water, 89% are from surface water bodies (rivers, lakes and accumulations) while 11% is abstracted from ground waters[29].

Groundwater and its reserves in Kosovo* have not been adequately explored except in the Drini I Bardhë River Basin through the Swedish International Development Cooperation Agency (SIDA) programme. In addition to the SIDA Programme, the European Commission implemented a project called Institutional Support to the Ministry of Environment, Spatial Planning and Infrastructure (MESPI) in the year 2009/2010. The EU project identified and delineated 14 groundwater bodies within the Drini River basin. Further, the EU Project has also provided information about the hydrogeological setting of the Drini River Basin. Groundwater in Kosovo* is mainly found in the rocks of various formations, that from the Palaeozoic to the Quaternary. Currently the use of Groundwater in Kosovo* is made mainly through wells and springs.

25 Kosovo* Irrigation Master Plan/KIMP (source: Aquastat, 2017, World Bank 2015)
26 Kosovo* Irrigation Master Plan/KIMP (source: Aquastat, 2017, World Bank database, Kosovo* Water Strategy, 2018)
27 Kosovo* Irrigation Master Plan/KIMP (source: *Aquastat, 2017, World Bank 2015*)
28 Kosovo* Irrigation Master Plan/KIMP (source: *Aquastat, 2017, World Bank 2015*)
29 Kosovo* Statistical Agency (Source: Kosovo* Census 2014)

3.3.2. Brief analysis of irrigation status in Kosovo*

Irrigation in Kosovo* are organized in two major ways, as formal irrigation within large irrigation schemes under the umbrella of the three Public Irrigation Companies and informal irrigation within small schemes managed privately or by Water User Associations (WUA). These two systems have coexisted for a very long time. Today, regardless of organizational forms, there are three irrigation techniques that are applied in Kosovo*, including surface irrigation on 53.5%, sprinkler irrigation on 31.4, and drip irrigation on 15% of total irrigated areas. Water sources used for irrigation are surface water bodies with 70% (rivers, streams, lakes) and around 30% groundwater bodies[30]. Today in Kosovo*, large-scale irrigation is organized within three public enterprises under the authority of the Ministry of Economic Development.

Table 3.1. Designed, irrigable and irrigated area within three public companies

Scheme	Irrigation techniques	Designed area (ha)	Irrigable area after 1999 (ha)	Irrigated in 2022 (ha)
Ibër-Lepenc	Sprinkler irrigation	20,000	11,000	1,800
Radoniqi-Dukagjini	Sprinkler and surface irrigation	13,600	11,100	5,100
Drini Bardhë	Surface irrigation	23,500	8,600	1,350
Total		57,100	30,700	8,250

Ibër Lepenc J.S.C. is a is a multifunctional enterprise that supplies water to industry, non-treated water to RWC Prishtinë and RWC Mitrovicë for potable water and water for irrigation to agriculture in 5 Kosovo* municipalities as well as hydraulic power for a power plant. The water source is Ujmani/ Gazivoda lake in the northern part of Kosovo*, with the capacity of 375 MCM.

Radoniqi-Dukagjini is an irrigation company covering the territory of three municipalities (Gjakovë, Rahovec and Prizren), with two working units, Radoniqi in Gjakovë and Dukagjini in Prizren. The water source for Radoniqi unit is Radoniqi lake (113 MCM) while Dukagjini unit divert water from the river Lumbardhi i Prizrenit/Prizrenska Bistrica. The Radoniqi scheme itself has a command area of 8,600 ha, of which 4,579 ha or 53% are irrigated every year. The Dukagjini scheme is located near Prizren and was built in the late 1960s. It consists of two sub-schemes, "R" and "D", totalling 5,000 ha. Due to uncontrolled urbanization, today only 2,500 ha in total can be irrigated in Dukagjini, out of which was irrigated 460 ha in 2022.

Drini i Bardhë is a very old scheme built in the 1960s under surface irrigation covering the territory of three municipalities (Istog, Pejë and Decani). The main system are concrete intakes with concrete open or buried canals, while the secondary canals are mostly open earth canals or partly AC pipes. The diversion of water in some parts is still done with primitive traps or weaves from tree branches.

However, a common problem for the three schemes is the development of urbanization, which strongly hampers the future of irrigation on substantial parts of the respective command area. In all three public irrigation systems, charges for irrigation services are per hectare, regardless of the amount of water used.

Farmers who irrigate outside the command area of Public Irrigation Companies using water from surface water bodies by direct diverting/diversion weirs from rivers or groundwaters using mobile fuel pumps with a capacity of up to 10 l/sec, which is more adequate for irrigation of vegetables and fruits. So, their command area is limited and depends on the proximity and capacity of water sources near the fields. There is no accurate data regarding the surfaces for the so-called informal irrigation,

30 Kosovo* Statistical Agency (source: *Agriculture Census 2014*)

but according to a survey made by the Ministry of Agriculture in 2005, these surfaces are about 8,225 ha, while according to the 2021 Green Report, these surfaces are 5,506 ha.

Table 3.2. Total, used and irrigated land in Kosovo*[31]

Regions	Total available land by holdings (ha)	Utilized land (ha)	% of utilized land in comparison with total available land	Irrigated land[32]	
				% From total available land	% From utilized land
Prishtinë	117,698.30	92,297.66	78.1	2.1	2.6
Mitrovicë	61,666.68	48,148.73	78.1	2.8	3.6
Pejë	67,025.48	56,626.37	84.5	7.2	8.6
Prizren	97,597.08	80,647.22	82.6	7.2	8.7
Ferizaj	48,109.16	38,772.92	80.6	2.3	2.9
Gjilan	59,782.40	49,960.30	83.6	4.0	6.1
Gjakovë	60,121.19	47,181.96	78.5	3.8	4.8
Total	**512,000.29**	**413,635.16**	**80.8**	**4.25**	**5.3**

Note: The above table has been adapted and modified by the expert for this report using data from the Agriculture Census 2014 and Green Report 2016.

According to the 2014 Agriculture Census, out of the total utilized agricultural land, 5.5% is irrigated (22,888 ha). The main crops that were irrigated were grain and green corn (6 236 ha), followed by meadows and pastures (5 547 ha) and vegetables (3 826 ha).

Referring to data from the Green Book in 2016, out of the total utilized agricultural land, 5.3% was irrigated (21,765 ha) or round 10% of cultivated/arable land (180,381 ha).

Table 3.3. Irrigation of agricultural land by regions in 2016[33]

	Source of water	Irrigated crops	Surface
Prishtinë	RIC Ibër-Lepenc, rivers, wells,	Maize, alfalfa, vegetables, fruits	2,440
Mitrovicë	RIC Ibër-Lepenc	Potato, cabbage, maize	1,720
Pejë	RIC Drini i Bardhë	Maize, fruits, vegetables	4,841
Prizren	RIC Radoniqi-Dukagjini, wells, rivers	Maize, vegetables, forage, fruits	7,004
Gjilan	Wells, rivers	Vegetables, potato, maize	1,109
Gjakovë	RIC Radoniq-Dukagjini, rivers, wells	Vegetables, maize, potato, fruits	2,378
Ferizaj	Rivers, wells	Maiza, fruits, vegetables, forage	2,273
Total			21,765

Note: The above table was modified and adapted for this report by the expert, while the data was taken from a table from the Ministry of Agriculture entitled: Irrigation of Agricultural Land by Municipalities in 2016, given in the Annex.

3.3.3. Drought risk assessment and crop water requirement

There have been many periods of short-term drought in Kosovo*, and a significantly dry year occurs once every six years on average. Kosovo* wastes much of its water resources, and has high levels of demand, and therefore water shortages are likely to increase in future especially in summer months. Many regional water companies that depend on river flows are especially vulnerable to drought.

31 Kosovo* Statistical Agency (source: Agriculture census 2014)
32 Ministry of Agriculture, Forestry and Rural Development (Source: Green Report 2016)
33 Source: MAFRD Green Report – 2016

A provisional drought strategy was prepared in 2007 by the Water Department within MESPI outlining various emergency measures associated with three levels of drought emergency, but this is useful for emergency situations only. In February 2011, the Kosovo* Water Task Force was supported by the Swiss Cooperation Office in Kosovo* to develop Kosovo* drought and flood risk management framework.

Droughts should be seen also from the perspective of climate change, which affects the increase in temperatures and changes in rainfall patterns and will affect both crop water demand and the availability of water for irrigation. Under such circumstances, the possibility of adopting more efficient irrigation techniques should be considered, such as drip irrigation with 85-95% efficiency, followed by sprinkler irrigation with 65-85% efficiency, which can reduce irrigation water consumption.

Predicted changes for precipitation and temperature at 2050-time horizon in Kosovo* area based on Service for Water Indicators in Climate Change Adaptation (SWICCA) calculated by the Kosovo* Irrigation Master Plan (KIMP) project team are presented in the following table.

Table 3.4. Predicted precipitation and temperature change at 2050-time horizon (SWICCA)

Month	Precipitation change (%)	Temperature increase (°C)
January	11.1	2.1
February	17.6	2.4
March	6.6	2.6
April	8.4	2.4
May	7.7	2.2
June	-4.8	2.5
July	-11.9	3.0
August	-9.4	2.7
September	-6.1	2.1
October	-10.3	2.1
November	11.8	1.9
December	7.6	1.5

According to this forecast presented in the above-mentioned table, it can be seen that there will be less rainfall in the June-October period, starting from 4.8% in June up to 11.9% in July, while the temperatures will increase from 1.5 to 3˚C in the same period. In the other part of the year (November-May), precipitation will increase from 7.6 % in December up to 17.6% in February, which may cause floods. Considering projections of higher temperatures, reduced precipitation, socio-economic development and insufficient storage capacities (560 MCM or only 321 m^3/inhabits)[34] may result in a shortage of water supply by 2050 in Kosovo*.

The irrigation rates that are applied today by irrigation companies in Kosovo* are based on irrigation programmes previously determined by the project design of irrigation schemes for specific crops or farmers' assessment and not on the basis of soil moisture measurements. Designed irrigation rate in Radoniqi irrigation scheme is 5,000 m^3/ha/year but the abstracted amount of the water from the Radoniqi lake is round 7,000-8,000 m^3/ha/year[35], including water losses.

34 Kosovo* Water Strategy
35 RIC "Radoniqi-Dukagjini"

The average designed irrigation rate in Ibër-Lepenc irrigation scheme is 3,200 m^3/ha/year[36], but the diverted amount of water from the lake for irrigation is round 6,500 m^3/ha/year, including losses from the infrastructure.

With the aim to improve water management and reduce water losses, World Bank in coordination with the Kosovo* Government is financing rehab and modernization of two irrigation schemes Radoniqi-Dukagjini and Ibër-Lepenc.

Reference evapotranspiration ET_0 in the largest part of the economy is over 860 mm/year. This poses the need for irrigation to meet water crop demands, especially during the June-August period when ET_0 values exceed 140 mm/month, while monthly average precipitation for this period is between 50-70 mm/month.

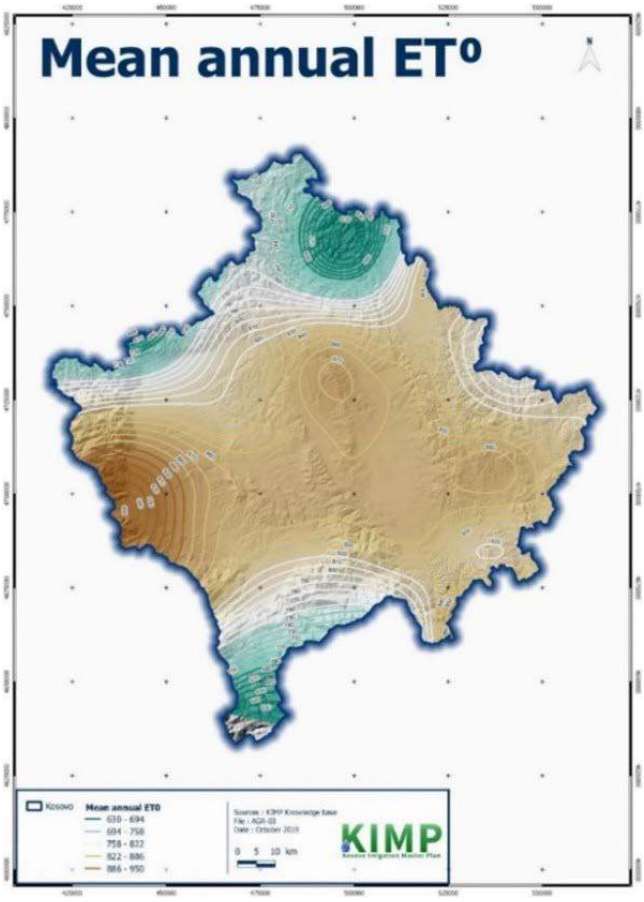


Figure 3.6. Average annual evapotranspiration

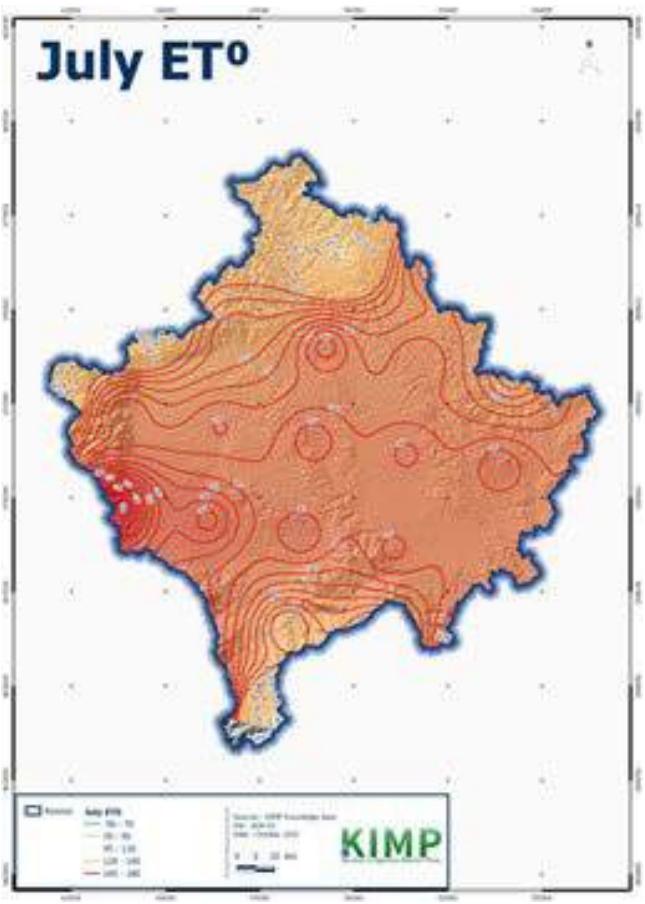


Figure 3.7. Evapotranspiration in July

With the aim to avoid floods of land along the streams within the command area of irrigation systems, open drainage canals were also built. The surfaces that were drained by the canals where completely buried in mud and debris as a result of floods during episodic rains, as well as their damage from gravel use from river beds, so it can be said that today they no longer exist.

36 HPC "Iber-Lepenci"

3.3.4. Overview of farmers' existing adaptive practices for proper water use under CC

After the war, the irrigation sector was supported by different projects for the rehabilitation of the irrigation infrastructure and capacity building related to best irrigation practices. One of these projects is the Kosovo* Irrigation Rehabilitation Project (KIRP II), funded by the EU, focusing on capacity building of all stakeholders, including MAFRD, municipalities, irrigation providers and farmers. For this purpose, in addition to the trainings organized, a detailed handbook was prepared for best irrigation practices with the aim of efficient water use and minimizing water losses. The ongoing Integrated Water Resource Management project funded by SDC supports different stakeholders in Kosovo* at the national, regional and local levels to establish an integrated water resource management approach. Among others, this project addresses issues such as pollution, rising demand for water for farming, industry and growing urban areas, and will help mitigate the impact of climate change. In addition to training, 90 farmers also received grants for modern irrigation equipment. Also, the Ministry of Agriculture provides several extension services for crop production, where the issue of irrigation best practice has been tackled too.

The question of how much this knowledge and adaptive practices for proper water use are applied by farmers is quite debatable within the command area of the public irrigation schemes as they are still charging their farmers per hectare instead of water amount used. While farmers who are using water outside public irrigation schemes divert water from surface water bodies or wells, they are using mainly drip irrigation, especially on commercialized farms.

Also, it should be emphasized that a large number of farmers are trained in the proper use of irrigation systems, drip fertigation programmes, mulch materials, UV nets, as well as other types of equipment for rational water use, its conservation and adaptation to climate change. Some results of the application of adaptive measures and best practices in Kosovo* are shown in the Annex to this report.







According to data from the Agriculture Census in 2014 from the total irrigated agricultural land, 7.5% or around 1,600 ha of drip irrigation is applied, but referring to the data gathered from agricultural input dealers during the last 10 years, they have sold equipment for drip irrigation and fertigation in the value of round 2.5 million EUR mainly to commercialized farms and farmers who have received grants or subsidies from MAFRD for the establishment of orchards or greenhouses (Measure 101, sub-measures 1a, 1b & 2). One of the preconditions for receiving these grants is the installation of drip irrigation systems. A set of this equipment is about 750 EUR/ha which means that about 3,300 ha or round 15% of the total irrigated area is irrigated using drip irrigation.

3.3.5. National strategies, documents and adaptation plans for proper water use under climate change

Kosovo* faces the same climate issues and challenges as anywhere else. With the aim to address climate change and challenges, in February 2019, the Government of Kosovo* issued a decision to draft the Strategy for Climate Change in Kosovo*. Climate Change Strategy 2019-2028 is consistent with the expected EU policy framework on climate and energy, aims to adapt to the ongoing and future impacts of climate change and to mitigate its causes. It prioritizes GHG emissions reduction through increased energy efficiency in all sectors and increment of energy generation from renewable sources, sustainable usage of natural resources to fulfil future obligations to the UNFCCC. Accelerated construction since 1999, combined with poorly regulated land use planning and lack of adherence to building codes, increases the rapidly growing population's exposure to hazards, like the one in April 2014. Due to new construction and infrastructure development, during the period of 2000-2018, the total urban area in Kosovo* grew by 57% (UNKT 2020)[37].

37 The United Nations Kosovo* Team (UNKT) comprised of UN entities, agencies, funds and affiliates with staff from Kosovo* and abroad

The total emissions of greenhouse gases in Kosovo*, reached 10 Mt CO_2eq in 2015. Compared to other economies in Europe, Kosovo* has relatively low emissions per inhabitant (5.5 t CO_2 equivalent per capita in 2015), while greenhouse gas emissions per unit of GDP (0.56 kg CO_2 equivalent per EUR during 2015) are higher. Emissions per capita are only slightly above the EU average (9.93 t), while emissions per unit of GDP are almost twice as high as the EU average (0.4 kg/EUR)[38]. Meanwhile, transport is responsible for the second largest share of greenhouse gas (GHG) emissions.

It is certain that agriculture is itself responsible for an estimated one-third of climate change effects. It is generally agreed that about 25% of carbon dioxide emissions are produced by agricultural sources, mainly deforestation, the use of fossil fuel-based fertilizers, and the burning of biomass. Although there is a lack of reliable data, some of the most significant contributors to GHG emissions in Kosovo* are agriculture, forestry and land use change.

Continuous socio-economic development, which implies greater food production, also affects the increase in the demand of water for crop irrigation. Therefore, this poses the need to introduce the concept of sustainable irrigation, where water consumption does not exceed local renewable water available in surface and ground waters, and hence does not impair freshwater ecosystems.

3.3.6. Institutional setup and the legislative framework for adaptation activities relevant to the sector

The current institutional framework for water management in Kosovo* involves a large number of Government institutions starting from the Kosovo* Assembly as the legislative body with Committees for agriculture, forestry, rural development, environment and spatial planning, and environment.

Competencies on water management in Kosovo* are divided among six ministries and local authorities as follows: Ministry of Environment, Spatial Planning and Infrastructure (MESPI) responsible for overall water management resources, Ministry of Agriculture, Forestry and Rural Development (MAFRD) responsible for irrigation, Ministry of Economy Development (MED) responsible for all public companies, Ministry of Finance, Labour and Transfers (MFLT), Ministry of Health (MH), the National Institute of Public Health (NIPH) and municipalities.

The Inter-Ministerial Council for Waters, chaired by the Prime Minister's Office, and the members of which are relevant ministries, is a decision-making body, which reviews systematic issues of water management, and proposes measures for development, use and protection of resources and the water system in Kosovo*.

The Water Services Regulatory Authority (WSRA), as an independent authority established by the Kosovo* Assembly is responsible to ensure the provision of quality, efficient and secure services on a non-discriminatory basis to all consumers in Kosovo*, taking into account the protection of the environment and public health.

One of the key players in the management of water resources are central and regional water companies. The Law on Publicly Owned Enterprises (No. 03/L-087) categorizes publicly owned enterprises involved in drinking and irrigation water management into three groups: central public enterprises, regional public enterprises and local public enterprises.

The legislative basis for Water Protection and Water Resource Management in Kosovo* is the Water Law No.04/L-147, from 29 April 2013. The competent authority for water management in Kosovo* is the Ministry of Environment, Spatial Planning and Infrastructure (MESPI), and is supported by the Kosovo* Environmental Protection Agency (KEPA), which monitors the state of the environment.

38 Kosovo* Climate Change Strategy

The legislative basis that is currently regulating the water and wastewater management sector in Kosovo* consists of the following primary and secondary legislation:

- Law No. 04/L-147 on Water, adopted by the AoK on 19 March 2013 promulgated by
- Presidential Decree No. DL-011-2013, dated 05 April 2013
- Law No. 2009/03-L-025 on Environmental Protection
- respective administrative instructions

Other relevant legislation:

- Law No. 04/L-125 on Health
- Law No. 02/L-9 on Irrigation of Agricultural Land and Law No. 03/L-198 amending and supplementing Law No.02/l-9 on Irrigation of Agricultural Land
- Law No. 03/L-040 on Local Self-Government
- Law No. 03/ L- 049 on Local Government Finance
- Law No. 03/L-041 on Administrative Municipal Boundaries
- Law No 2003/14 on Spatial Planning

3.3.7. Conclusions with key recommendations and priorities referring to proper water use and adaptation to climate

For crop irrigation, optimal water efficiency means minimizing losses due to evaporation, runoff or subsurface drainage while maximizing production.

As changing irrigation systems can be a costly undertaking, conservation efforts often concentrate on maximizing the efficiency of the existing system. This may include chiselling compacted soils, creating furrow dikes to prevent runoff, and using soil moisture and rainfall sensors to optimize irrigation schedules.

In order to follow world trends, automatic control of pressure is becoming common practice in pressurized hydro systems for water distribution all around the globe. Benefits are that with the reduction of pressure we reduce water losses and defects, and with that we reduce operating costs as well as water consumption and we increase the efficiency of the systems.

Recommendations and priorities

- Increase water storage capacities with the construction of multi-purpose dams
- Reduce water losses through rehabilitation and modernization of irrigation infrastructure
- Improve water management within irrigation companies by introducing Management Information System (MIS) and remote control through the implementation of SCADA
- Introduce volumetric charging and/or metering at individual or hydrant (or alternatively block) level and possible revisions in irrigation service delivery
- Optimize irrigation schedules and rates based on soil moisture measurements and cropping patterns;
- Increase surfaces with drip irrigation as much as possible
- Increase the capacities of farmers for best land use and irrigation practices
- Introduce crop varieties with less water requirements in cropping patterns

3.4. Crop production analysis linked to climate change in agriculture

3.4.1. Analysis of meteorological data availability and accessibility

Hydro meteorological Institute of Kosovo* builds and maintains the network of hydrological and meteorological stations. This institute conducts measurements and observations related to various elements and phenomena, including hydrological, meteorological, bio-meteorological, and hydro-biological aspects. Additionally, it monitors atmospheric electricity, air pollution, water quality, and precipitation.

All data within the report is taken from the annual bulletin for the years 2017–2022 from the website of the Hydrometeorological Institute of Kosovo* (HMIK).

In the past, the Hydrometeorological Institute of Kosovo* (HMIK) had a meteorological monitoring network that covered the entire territory of Kosovo* and met all the criteria in accordance with monitoring objectives and WMO regulations. However, during the war, this network was completely destroyed. Since 2000, efforts to restore and operate this network have been underway.

Today there are 4 meteorological stations with classical measurements, Prishtinë, Pejë, Ferizaj, Mitrovicë and 12 meteorological stations with automatic measurement and real-time data transfer to the central system for data collection and archiving. While the meteorological station network covers the entire territory of Kosovo*, there is a notable absence of a centralized data processing hub. Moreover, at certain stations, there is a lack of continuity in recording specific climate parameters, which presents challenges when calculating annual averages for these parameters.

At the Ferizaj monitoring station, located at the geographic latitude of 42°22’32.45” and the geographic longitude of 20°08’13.31”, with an altitude of 578 meters above sea level, the annual average temperature (T) between 0°C for the years 2017 to 2021 was 11.08°C. The minimum extreme temperature (T extreme 0°C) was-15.48°C, the maximum extreme temperature (T extreme 0°C) reached 35.06°C, the average annual rainfall between 2017 and 2021 was 755.92 mm, and the average number of rainy days during this period was 108 days.

At the Pejë monitoring station, located at the geographic latitude of 42°39’56.30” and the geographic longitude of 20°18’18.30”, with an altitude of 498 meters above sea level, the annual average temperature (T) between 0°C for the years 2017 to 2021 was 12.34°C. The minimum extreme temperature (T extreme 0°C) was -12.74°C, the maximum extreme temperature (T extreme 0°C) reached 35.02°C, the average annual rainfall between 2017 and 2021 was 907.0 mm, and the average number of rainy days during this period was 102 days.

At the Prishtinë monitoring station, located at the geographic latitude of 42°38’56.36” and the geographic longitude of 21°08’13.49”, with an altitude of 573 meters above sea level, the annual average temperature (T) between 0°C for the years 2017 to 2021 was 12°C. The minimum extreme temperature (T extreme 0°C) was -15.98°C, the maximum extreme temperature (T extreme 0°C) reached 36.38°C, the average annual rainfall between 2017 and 2021 was 675 mm, and the average number of rainy days during this period was 128 days.

Kosovo* is located in the Balkan region, which is prone to droughts. A major drought occurred as recently as 2008, early 2014 and most recently during the 2018/2019 hydrological year. Since 2015, the institute has established a drought monitoring programme based on the Precipitation Standardization Index (SPI), calculated from the amount of precipitation monitored in 26 monitoring locations.

The location of the meteorological, climatological and agrometeorological stations and the parameters monitored in the existing stations which were operational during 2020 are presented in the table below.

Table 3.5. Meteorological, climatological and agrometeorological stations

No.	Name of Station	Geographic latitude	Geographic Longitude	Altitude above sea level (m lmd)	River basin
1	Brezovicë	42° 13’ 18.10’’	21° 00’ 06.40’’	915	Lepenc
2	Dragash	42° 03’ 59.40’’	20° 38’ 55.10’’	1,047	Plavë
3	Ferizaj	42° 22’ 32.45’’	21° 08’ 13.31’’	578	Lepenc
4	Gjakovë	42° 25’ 32.00’’	20° 23’ 24.00’’	410	Drini i Bardhë
5	Istog	42° 46’ 43.50’’	20° 29’ 24.40’’	457	Drini i Bardhë
6	Junik	42° 29’ 02.90’’	20° 16’ 03.40’’	618	Drini i Bardhë
7	Kamenicë	42° 35’ 18.55’’	21° 34’ 13.78’’	474	Morava e Binçes
8	Malishevë	42° 28’ 29.20’’	20° 44’ 01.50’’	553	Drini i Bardhë
9	Mitrovicë	42° 53’ 37.60’’	20° 52’ 23.40’’	510	Ibri
10	Pejë	42° 39’ 56.30’’	20° 18’ 18.30’’	498	Drini i Bardhë
11	Podujevë	42° 56’ 01.86’’	21° 11’ 52.40’’	620	Ibri
12	Prishtinë	42° 38’ 56.36’’	21° 08’ 13.49’’	573	Ibri
13	Prizren	42° 14’ 51.04’’	20° 44’ 08.41’’	402	Drini i Bardhë
14	Tugjec	42° 41’ 13.20’’	21° 33’ 19.50’’	1,042	Morava e Binçes

3.4.2. Analysis of phenological monitoring

There is no dedicated institution for recording phenological data for plant crops in Kosovo*. Typically, descriptions are based on historical data from previous years with similar climatic conditions. A significant initiative began from 2017 to 2020 under the Italian project KosAgri. With their support, the VinSence platform was developed for monitoring grapevine phenological phases.

However, after the contract with the Italian project ended, the three agrometeorological stations ceased to operate, resulting in a limited database covering only three years.

Climatic conditions have always played and will continue to play a significant role in the development of agricultural crops. The duration of sunny days and the intensity of sunlight are crucial factors influencing the growth and maturation periods.

rains in May and June, these two varieties did not yet reach maturity and were harvested at that time.

3.4.3. Analysis of crop models used for estimating the crop response to the climate change

In Kosovo*, crop yield modelling takes various forms. For most agricultural crops, we conduct an analysis of the planted areas and the average yield of these crops. This data is reported and collected by the Department for Statistics and Economic Analysis, and it is published annually in the Green Report, which serves as the basis for five years. Currently in Kosovo*, modelling agricultural crops with CropWat, CropSys, and Aquacrop is not being utilized. In the near future, as a response to the adaptations in agriculture aimed at understanding the effects of climate change, Universities in Kosovo* will begin using data modelling.

A significant milestone has been achieved in the viticulture and winemaking sector with the

establishment of the electronic Vineyard Register and wine quality control. These systems ensure compliance with European Union regulations. Data on grape production, wine production, and stocks have been consistently reported for the past ten years. Crop modelling is starting to influence farmers' decision making. For instance, in vineyards, farmers have started taking measures to protect their crops from hail. Protective nets are now considered essential in certain viticulture areas.

3.4.4. Analysis of extreme weather events

Extreme weather events, including drought, flood, late frost, and hail affect many crop production areas in Kosovo*. The Environmental Protection Agency in Kosovo* is responsible for monitoring these phenomena and regularly provides information through its website and audio-visual tools about upcoming extreme events.

The Agency records and reports these events. In the Dukagjini Vineyard Region, which includes five vineyard areas (Rahoveci, Suhareka, Prizren, Malisheva, and Gjakovë), hailstorms are the most frequent occurrences.

Hailstorms were documented in several years: July 2013, July 2016, May 2017, June 2018, and May 2020. Additionally, spring frosts were recorded in April 2017.

Two traditional insurance products have been developed thus far, specifically covering hail damage for the following crops: apples and peppers. Hail insurance provides coverage against physical damage caused by hail, and in many cases, it also includes protection against certain diseases resulting from hail impact, whereas grapevine insurance covers damage caused by late spring frosts. So far, 300 ha of vineyards have been secured, which also includes protection against certain diseases resulting from hail impact.

Table 3.6. Damages reported by farmers in the period 2017-2021, in EUR

	2017	2018	2019	2020	2021
All losses (damages)	15,425,096	8,381,478	1,969,656	11,837,908	4,996,848
Losses from hail	1,972,730	6,457,937	1,198,947	3,448,707	3,085,539
Losses from hail (%)	**13**	**77**	**61**	**29**	**62**

Source: Evidence from the work of the Commission for Review of Claims for Compensation of Damages

Providing farmers with insurance policies presents a unique opportunity to promote agricultural development in the economy. It also enhances access to financial resources for all Kosovo* farmers and creates new avenues to overcome the daily risks they encounter. Kosovo*'s agricultural insurance system is strengthening its foundations by incorporating best international practices to design suitable products for local farmers.

3.4.5. Information on the most important crops sensitive to climate change, vulnerable regions and their combination

The most sensitive crops cultivated in the region include apples, plums, grapes, raspberries, blackberries, peppers, walnuts, cherries, sour cherries, pears, beans, and maize. These agricultural crops are highly sensitive to climate change, including spring frosts, extreme high temperatures, excessive rainfall, and hailstorms. Various initiatives have been launched to combat climate change and adapt to its effects. For instance, in viticulture, autonomous actions include the introduction of new grapevine varieties resistant to spring frosts and fungal diseases.

Climate change has indeed affected cultivated crops. Nowadays, it is challenging to find a plant that remains unaffected by these changes. The consequences of climate change are significant, resulting in reduced yields, diminished quality, and altered organoleptic properties.

Data has been collected on agricultural crops that are consistently affected by climate change, including vegetables, apples, plums, grapes, raspberries, blackberries, peppers, walnuts, cherries, sour cherries, pears, beans, and corn. In the Dukagjin District, hail is a frequent occurrence in vegetable crops and vineyards, making vineyard areas particularly vulnerable to the effects of climate change. Over the past several years, these regions have experienced recurring hailstorms and spring frosts.

Similarly, in the Kosovo* Plain (Kosovo* District), particularly in the cities of Podujevë and Vushtrri, we have cultivated two or more vulnerable crops. For example, in Podujevë, we combine raspberries with peppers, and in Vushtrri, we focus on the cultivation of potatoes combined with strawberry.

3.4.6. Information on practices used by the farmers to protect their crops from damages caused by weather variability (hot weather, drought, excessive water, hail, intensive sun, etc.)

In some vegetable farms, particularly greenhouses, farmers have been compelled to adapt to climate change, which brings hotter weather and intense sunlight. To mitigate the effects of excessive sun intensity, farmers apply greenhouse slaked lime to the interior roof.

Similarly, in vineyards, farmers use shading nets to protect the vines from intense sunlight and also for hail protection. However, due to the associated costs, many farmers are unable to implement this measure. In the support measures provided by the Ministry of Agriculture, Forestry and Rural Development (MAFRD), the state co-finances the application of shading nets for hail protection.

3.4.7. Information on climate change adaptation measures and practices already tested/ promoted in the economy or established in national documents related to climate change and agriculture

The Climate Change Strategy 2019-2028 and the Strategy on Agriculture and Rural Development 2022-2028 both address the impact of climate change on agricultural crops and food security. While well-adapted local conditions provide resilience in the face of extreme climatic conditions, they often do not result in high productivity. Good practices for climate change adaptation, including the use of cover crops, no-till or minimum tillage, crop diversification and rotation, among others, are not adequately promoted by public or private advisory systems. Direct payments are not tied to any environmental conditions, and there have been no agro-environmental measures undertaken or implemented.

In light of the factors discussed above, the effectiveness of Kosovo*'s approach to climate change mitigation and adaptation is notable. The economy employs large pastures under extensive management and low-input cropping systems, which, in some cases, can be considered more effective than advanced technologies and practices seen in intensive farming systems in other economies.

Furthermore, Kosovo* has demonstrated its commitment to environmental sustainability by signing the Sofia Declaration on the Green Agenda for the Western Balkans (GAWB) in November 2020. This aligns with the European Green Deal strategy, aimed at fostering a modern, climate-neutral, resource-efficient, and competitive economy.

Implementation of Climate-Smart Agriculture (CSA) measures transforms and reorients agricultural systems to mitigate greenhouse gas emissions (GHGs) and adapt to climate change, resulting in several benefits:

- Increased crop yields
- Enhanced profitability
- Improved loan repayment prospects
- Augmented economic development potential in the future

Appropriate measures that have been or can be implemented in the economy include:

- Solar energy systems on farms
- Anti-hail systems
- Drip and sprinkler irrigation
- Introduction of minimum tillage practices

The assessment of capacities and the use of renewable energy, particularly solar panels on farms and agricultural enterprises, has found significant investments. From 2014 to 2019, a total of 6,642,900 EUR were invested in 1,073 agricultural farms.

3.4.8. Information on the measures from the national agricultural policy and from national systems for support to agriculture that can be related to climate change adaptation

Agricultural policies and support schemes have consistently aimed to facilitate climate change adaptation in the agricultural sector. Under Measure 101, support positions have been established to encourage the use of protective nets for mitigating high solar intensity and protecting crops from hail, especially in orchards and vineyards.

Additionally, under support Measure 103, MAFRD has made the decision to install solar systems for renewable energy production. These measures directly contribute to increasing agricultural surfaces and yields that are resilient to climate change. As part of support measures, water saving through drip irrigation system is also promoted.

However, is it enough? No. To effectively address the challenges of climate change, Kosovo* must urgently draft new policy documents or amend the existing policy framework to integrate climate change mitigation and adaptation measures into the overall national development strategy. These policy revisions should be based on comprehensive scientific research that assesses the potential impacts of climate change on water resources in all four river basins in Kosovo*.

3.4.9. Brief analysis of the current infrastructure and systems for preventing and mitigating the negative effects of weather extremes on crop production

The Environmental Protection Agency in Kosovo* (EPAK)and the Hydrometeorological Institute of Kosovo* are responsible for the protection, monitoring, analysis, and forecasting of these phenomena. Kosovo*'s network of meteorological stations covers almost the entire territory; however, there is a lack of a central data processing centre. The Agency regularly provides information through its website and audio-visual tools regarding upcoming extreme events. The current system provides information on drought, frost, and hailstorm events; however, this information is only available on the Agency's website. There is currently no link between the Agency's website and the website of the Ministry of Agriculture, Forestry and Rural Development.

EPAK serves as the national authority responsible for all activities related to establishing and maintaining the National Inventory System, which is part of the environmental information system, and for preparing biennial updated reports. The Agency records and reports these events. The current imperative is to ensure the functionality of the agrometeorological station network to provide early warnings for extreme climatic conditions affecting agricultural crops, such as hailstorms or severe droughts accompanied by intense sunlight.

3.4.10. Policy, institutional setup and the legislative framework for adaption activities

The Ministry of Environment and Spatial Planning plays a central role in addressing climate change, while there is also a critical collaboration with the Ministry of Agriculture to address climate change adaptation in agricultural crops. In response, both ministries have adopted respective strategies. The Ministry of Environment and Spatial Planning has already drafted and approved the Climate Change Strategy 2019-2028, and the Ministry of Agriculture has approved the Strategy for Agriculture and Rural Development 2022-2028.

Currently, the Ministry of Agriculture is in the process of revising, amending, and enhancing its strategy to include a dedicated chapter on adaptations in agricultural crops as a response to climate change. Additionally, the final stage of developing the Climate Change Law is underway, with completed public consultations. This law will be complemented by administrative instructions that will define the operational mechanisms for addressing climate change.

3.4.11. Data availability and quality

Data related to climate change and potential adaptations in agriculture are in the early stages. Inter-ministerial mechanisms are not yet fully integrated. Once the Climate Change Law is approved, it will define the responsibilities and obligations for each operational mechanism.

Data on climate parameters in Kosovo* are currently available at 16 meteorological stations. This information is accessible through the website of the Hydrometeorological Institute of Kosovo*.

The data presented on HMIK website meets the criteria set by WMO regulations, including meteorological, climatological, agrometeorological, and precipitation stations, in line with monitoring objectives.

Data on temperature (average, minimum, maximum), precipitation, relative humidity, sunshine, wind speed, and transpiration evaporation are available in an annual bulletin format that one can use for analysis. However, there is no open access to meteorological data.

3.4.12. Conclusions with key recommendations and priorities referring to crop production and adaptation to climate change

The main conclusions and recommendations related to climate change and the possibilities of adaptation in agriculture are as follows:

- Ensure that all interested users have access to a comprehensive climate database, fostering a common platform for the six Western Balkan economies
- Establish a relevant institution tasked with maintaining a comprehensive database covering all phenological phases for agricultural crops
- Review the Agricultural Direct Payments plan and establish a connection between crop subsidies and climate change adaptation
- Promote adaptation practices in agriculture resulting from climate change through both public and private advisory services

Kosovo* is currently in the process of restructuring the agriculture and forestry sector, focusing on sustainable economic development aligned with European environmental standards and legislation. The government of Kosovo* is advocating for an integrated approach that seeks to strike a balance between economic growth, environmental protection and land use.

The Ministry of Environment and Spatial Planning (MESP) is the authority responsible for environmental policies and climate change. MESP has defined two primary objectives: Specific Objective 1: Designing and implementing climate change policies; and Specific Objective 2: Establishing the framework for the National Greenhouse Gas (GHG) Inventory System. The implementation of these two main objectives, along with other tasks derived from the National Strategy for Climate Change, will be a top priority.

3.5. Livestock farming analysis linked to climate change in agriculture

3.5.1. General context and livestock farming

Kosovo* is in the centre of the continental part of the Balkan Peninsula and is part of the group of Western Balkan economies. Its territory lies between 41°50'58" and 43°51'42" of north geographical latitudes and 20°01'30" and 21°48'02" of east geographical longitude, with a total area 10,905,25 km^2.

Kosovo* is a potential candidate economy for membership in the European Union, and with the signing of the Stabilization and Association Agreement, it aims at making further steps towards EU integration. The economy's policies on agriculture and rural development are gradually being aligned with the EU Common Agricultural Policy (CAP) in order for the agri-rural sector to be competitive in the region and the EU.

Even though Kosovo* has high-quality agricultural land, land fragmentation, old and insufficient agricultural equipment and machinery, poor agricultural infrastructure (i.e. irrigation systems, agricultural roads, etc.), expensive inputs, difficult access to finance is resulting in lower productivity per annual work unit in agriculture compared to the EU and neighbouring economies.

Dominated by small non-modernized farms and with open competition with EU economies and the region, the low competitiveness of agriculture in Kosovo* **is directly reflected in an open trade balance, especially with EU economies**[39]**.**

As a signatory to the Sofia Declaration in 2020, Kosovo* has pledged to play its part in making the continent carbon neutral by 2050, together with the European Union (EU), through mainstreaming a strict climate policy and reforming the energy and transport sectors. In 2021, Kosovo* agreed to implement the Green Agenda Action Plan, meaning that it will subscribe to putting sustainable development, resource efficiency, nature protection and climate action in the centre of all economic activities. In order to achieve this, the Ministry of Environment, Spatial Planning and Infrastructure (MESPI) is in need of technical and legal support in order to aid the successful implementation of the Kosovo* climate change agenda. The technical assistance required includes skills on greenhouse gas (GHG) emission accounting, with a focus on emissions from the agricultural sector, in order to coordinate and assist ongoing attempts to update the national GHG inventory.

The **cattle** stock in 2021 was 260,528 heads, which is a decrease of 861 heads or 0.3% compared to 2020. Dairy cows continue to have over 50% share in the total cattle stock, and this share in the last three years has been 51%.

In terms of slaughter, 116,204 heads were slaughtered in 2021, which is 156 heads more than in 2020. The value of the total production was 47.1 million EUR, while the import value is 75.5 million EUR. With this amount of production, the self-sufficiency rate is 43.9% and the per capita consumption is 25.5 kg. Dairy cows make up 50.7% of the total number of cattle and in 2021 the number of dairy cows was lower than in 2020 by 1.4%. Per capita consumption is estimated to be 171 kg of milk per year or about 0.47 kg per day, which is the amount consumed by one person, including dairy products.

39 Strategy on Agriculture and Rural Development 2022 – 2028

This designation is without prejudice on the positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

In 2021, the total stock of **sheep and goats** decreased by 0.1%, and divided by groups, sheep decreased by 0.4%, while goats increased by 1.6%. Within sheep, sheep for breeding have a share of 74.1%, while within goats, goats for breeding have a share of 74.0%.

The category of **pigs** constitutes only 8.6% of the total number of animals. In 2021, the number of pigs in Kosovo* increased by 4.4% compared to the previous year, while compared to the average for the previous four years, the increase was 13.4%.

Table 3.7. Number of livestock heads

Number of animals	2017	2018	2019	2020	2021	Difference 2021/2020 in %
Cattle	**259,729**	**258,662**	**257,733**	**261,389**	**260,528**	**-0.3**
Dairy cows	132,971	132,474	131,939	133,916	132,076	-1.4
Sheep and goats	**210,688**	**209,808**	**216,299**	**241,688**	**241,393**	**-0.1**
Sheep for breeding	136,810	139,312	145,248	159,067	156,666	-1.5
Goats for breeding	24,836	22,401	20,602	21,907	22,234	1.5
Pigs	41,086	40,164	40,533	45,394	47,384	4.4
Poultry	**2,811**	**2,538**	**2,665**	**2,782**	**2,788**	**0.2**
Broilers	398	407	321	384	346	-9.9

Source: KAS – Agricultural Household Survey (2017, 2018, 2019, 2020, 2021); Kosovo* Green Report 2022

In 2021, the total number of **poultry** increased by 0.2% compared to 2020. While the number of laying hens (94.8% of the number of poultry) in 2021 increased by 2.9%, the number of broilers decreased by 9.9%. Out of the total number of chickens, the majority are laying hens (75.5%), followed by broilers (13.1%) and the category of birds, roosters and other chickens (11.4%).

3.5.2. Analysis of meteorological data availability and accessibility

In the historical past, the Hydrometeorological Institute of Kosovo* had a meteorological network that covered the entire territory of Kosovo* and fulfilled all the criteria according to the regulations of the World Meteorological Organization (WMO), but this network was completely destroyed during the last war and since 2000 it has started to function again.

Currently there is a network of meteorological, climatological, agrometeorological, and rainfall stations. Climatological measurements at the monitoring locations are made at three time points: 7.00h, 14.00h and 21.00h, according to local time.

The data produced by HMIK are public as can be found on the website. Public access is only allowed for hydrometeorological yearbooks. The data are annual averages and are not available on a daily basis.

Initially, 4 meteorological stations with classical measurements were operationalized, Prishtinë, Pejë, Ferizaj and Mitrovicë, and then from 2014 and until now 12 meteorological stations with automatic measurement and transfer of data in real time to the central system for collection and archiving have been operationalized. Currently, there is a good coverage with the meteorological monitoring network and meets the criteria according to the monitoring objective and according to WMO regulations. The existing network should be expanded in the future.

Parameters monitored at measuring stations include the following:

- Insolation (h)
- Relative humidity – Rh %
- Amount of daily precipitation (mm)
- Wind speed and direction (m/s)
- Snow layer (cm)
- Air pressure(hPa)
- Temperature – Tmax (°C)
- Temperature – averageT (°C)
- Temperature – Tmin (°C)
- Cloudiness (0-10)

Prishtinë, Pejë and Ferizaj stations are complete with all the data and take for review humidity, whereas the Thermal Humidity Index (THI) is calculated in the monitoring locations but there is no accurate monitoring data on livestock farms related to THI and it is not used in livestock farms.

Production systems in the Kosovo*'s livestock sector are different and depend on the type and size of the farm as stated in the Livestock Law. Dairy cow farms with more than 10 heads keep them indoors, and taking into account the conditions in the economy, they are considered to be intensive systems. Animals for fattening are also kept under the same conditions. Dairy cows in farms smaller than 5 heads usually spend the summer days in pastures and in this case are not exposed to much heat stress. Most small ruminant producers are small farms with largely traditional animal husbandry practices with insufficient efforts invested in the development and modernization of farms, slow acceptance of technology, inadequate housing of animals, and usually low level of welfare. This sector has huge demand for investment in the modernization of stables. The production of laying hens and broilers is located in intensive farms equipped with ventilation systems and balanced feed.

Predictions for climate change are evident, in the future there will be an increase in temperatures on average up to 1°C. Based on these predictions, it is necessary to prepare the legal basis which would enable models for connection between large farms (as presented in the Livestock Law) with existing meteorological stations. The designated meteorological stations would report on changes in average temperatures and relative humidity. In this way, heat stress on all types of animals would be managed.

Table 3.8. Locations of meteorological stations

No.	Station name	Latitude	Longitude	Sea level (m)	River basin
1	Brezovicë	42° 13' 18,10''	21° 00' 06,40''	915	Lepenc
2	Dragash	42° 03' 44,50''	20° 38' 48,40''	1,060	Plave
3	Ferizaj	42° 22' 32,45''	21° 08' 13,31''	578	Lepenc
4	Junik	42° 29' 02,90''	20° 16' 03,40''	618	Drini i Bardhë
5	Mitrovicë	42° 53' 37,60''	20° 52' 23,40''	510	Ibri
6	Pejë	42° 39' 56,30''	20° 18' 18,30''	498	Drini i Bardhë
7	Podujevë	42° 56' 01,86''	21° 11' 52,40''	620	Ibri
8	Prishtinë	42° 38' 56,36''	21° 08' 13,49''	573	Ibri
9	Prizren	42° 14' 51,04''	20° 44' 08,41''	402	Drini i Bardhë
10	Istog	42° 46' 43,50''	20° 29' 24,40''	457	Drini i Bardhë
11	Gjakovë	42° 22' 32,00''	20° 23' 24,00''	410	Drini i Bardhë
12	Kamenica	42° 35' 18,55''	21° 34' 13,78''	474	Morva e Binçes
13	Malisheve	42° 28' 29,20''	20° 44' 01,50''	553	Drini i Bardhë
14	Tugjec	42° 41' 13,20''	21° 33' 19,50''	1,042	Morva e Binçes

Source: Hydrometeorological Institute of Kosovo* – Hydrometeorological Yearbook, 2020

The drafting of the Yearbook was done by analyzing the daily, monthly and annual data, collected from the monitoring network of meteorological, climatological and agrometeorological parameters, the rainfall network as well as from the hydrological monitoring network.

Referring to the Hydrometeorological Yearbook, the minimum and maximum temperatures are read at 9 p.m. and recorded for that day. The amount of daily precipitation refers to a period of 24 hours, from 7 o'clock of the previous day to 7 o'clock of the current day. Tmax represents the maximum monthly temperature values on a daily basis in °C, average air the temperature on a daily basis in °C, Tmin represents minimum monthly temperature value on a daily basis in °C, and tropical days the maximum daily air temperature ≥ 30 °C.

The data on air temperature in Kosovo* originating from the Hydrometeorological Institute of Kosovo* and from international institutions show that in Kosovo*, since 1900 until today there has been a movement of average annual temperatures with an increasing trend. Thus, the average annual temperature for the period 1930-1990 was 8.6°C, for the period 1990-2002 it was 9°C, while for the period 2003-2019, over 10°C. Data show that in Kosovo* since 1930 until now there has been a change in the amount of precipitation with a tendency to decrease the amount of precipitation. Thus, the average annual rainfall for the period 1930-1990 was 820 mm, while for the period 2001-2019, it was 674 mm.

Estimated from the average monthly values for the aforementioned region, temperatures usually begin to rise in June to reach a peak in July and August with continued trends in September. Kosovo* lies in the southern part of the middle geographical belt of the northern hemisphere. The main macro climatic factors, which influence the climate of Kosovo*, is the position of Kosovo* regarding land masses (Eurasia and Africa), water masses (Atlantic Ocean and Mediterranean Sea) and air masses (tropical and continental). The main local factors that influence the climate in Kosovo* are relief, waters, soil, and vegetation. The eastern part of Kosovo*, Kosovo* Plain, Llapi, Drenica and Ana-Morava Regions is colder than the western part (Dukagjini Plain).

Kosovo*s annual average temperature is 9.5°C. The hottest month is July (19.2°C) whereas the coldest month is January (-1.3°C). The highest average annual temperature is in Prizren (12°C), and the lowest in Podujevë (9°C). All forms of atmospheric precipitation are present in Kosovo*. They have the greatest importance: rain in the valleys and snow in the high mountains.

In the eastern part, precipitation reaches the average annual amount of 600 mm, while in the western part over 700mm. Snowfall occurs in the lower parts of Kosovo* within average duration of 26 days, while in the mountainous areas it is over 100 days.

Kosovo* is located in the Balkan region, which is prone to droughts. A severe drought has occurred recently in 2008, early 2014 and most recently during the 2018/2019 hydrological year. Since 2015, the institute has established the drought monitoring programme, which is based on the Standardized Precipitation Index (SPI). Rainfall calculation is done by monitoring centres, which are located in 26 locations.

3.5.3. Analysis of extreme weather events

A number of extreme weather disasters characterized 2021, including floods and wildfires. Extreme weather events are the new norm in the region and beyond, with Kosovo* also facing extreme weather. Referring to the Hydrometeorological Institute, the biggest floods in the last 10 years are considered those from the period 6-12 January 2021, with about 200 mm of rain or litres/m^2. During floods, among the most affected regions were the river systems of Drin i Bardhë, Morava e Binça, especially Kriva Reka and Sitnica. During this period, many properties and agricultural lands were flooded. Kosovo* is sensitive to floods, and they happen often. Flooding in Kosovo* in November 2007 affected more than 3,500 households, causing significant material damage. Almost all the municipalities of Kosovo* have been more or less affected by the risk of flooding, which manifests itself in the form of flooding after storms in mountainous areas, flooding after continuous rains in plain areas, and floods after melting snow, accompanied or not by bad weather. Recent floods in Kosovo* occurred in February 2006, January 2010, and April 2014.

Currently, we consider the factors that affect the intensity of risks from strong winds can include significant distance from the coast, relief with mountain ranges and forests covered with vegetation, which can significantly affect natural inhibition and reduce the intensity of winds, in particular in the fields that surround it. As for floods, they occur most often in winter, spring and autumn. Floods in Kosovo* are usually the result of atmospheric rains with large flows of water in rivers, causing considerable damage to infrastructure, private property, agriculture, etc. In the last year (2022), disaster caused by floods was recorded on a chicken farm. In this case, 125,000 heads were destroyed. The farm building was built near the river in the municipality of Skenderaj.

Kosovo* is an economy with a significant rural area, where during the summer season there may be longer periods of heat that are mainly manifested by shortages of atmospheric precipitation which can cause drought, with great water shortages[40]. Kosovo* has been hit by droughts several times during the last two decades, in 1993, 2000, 2007, and 2008 (Source: Strategy on Climate Change 2019-2028).

As a result of this natural disaster, agricultural lands and meadows were flooded and a small number of animals were killed. There is no doubt that extreme weather events have a negative impact on the development of the livestock sector. These negative effects can be seen in animal feed in terms of quantity and quality. In Kosovo*, there is no monitoring system for extreme weather events in the livestock sector, but the Ministry of Agriculture, Forestry and Rural Development has established a commission for monitoring natural disasters in general and in agriculture.

Also, for this report, it is worth mentioning the fires that have occurred and, in some cases, strong winds that have influenced the spread of fires. According to HMIK, during the last 10 years the most powerful winds with maximum speed have been recorded in meteorological stations such as: Ferizaj, Pristina, Pejë and the region of Istog. Damages have been recorded, among others, in agriculture and in livestock facilities. In the livestock sector, damages caused by strong winds have been mainly recorded in roof structures.

Regarding the biggest snowfall in the last 10 years, the Hydrometeorological Institute of Kosovo* announced that the year 2012 was the year with the most snowfall, specifically during the month of February. In Ferizaj during this period, 84 days of snow cover with a maximum thickness of 72 cm were recorded, followed by Pristina with 52 days of snow cover with a maximum thickness of 55 cm.

40 Source: Assessment of Risk From Natural Disasters and Other Disasters, Ministry of Internal Affairs, July 2016. Agency for Emergency Management.

3.5.4. Heat stress risk assessment for ruminants, pigs and poultry

One of the most obvious impacts is thermal stress on animals. High temperatures can cause considerable distress to livestock as their ability to regulate body temperature is limited. Regarding the use of THI in animal husbandry, it has not been used in Kosovo* until now. Problems caused by heat stress can be observed in ruminants, mainly cattle. Pigs and poultry are more resistant to extreme temperatures, but the impact on production reduction is present in all species. In order to avoid the reduction of milk yield as a result of high temperatures, the Ministry of Agriculture, Forestry and Rural Development (MAFRD) supports farmers in the construction of new barns with a free system, considering more advanced than the tie system, better production and reproduction. Poultry farms are well equipped with ventilation systems, sufficient water, vaccination programme and balanced feed. The Rural Development Programme 2014-2020, through the measure on investments in physical assets on the farm, supported a considerable number of milk and meat producers for the construction of new storage for manure and liquid manure. There is a traditional practice among sheep breeders of migration from lowlands to mountain pastures, mainly during the time of high temperatures, which is done in order to reduce heat stress and use sufficient grazing.

Since most farms have a natural ventilation system, it is necessary to think about establishing a regular system for monitoring the parameters.

3.5.5. Overview of farmers' existing adaptive practices for mitigating impacts of climate change

In general, livestock farms in Kosovo* do not have the minimum microclimatic conditions, especially ruminant farms. Within this perspective, there are efforts to improve animal breeding conditions, so a small number of farms have benefited from support in the construction of model stables that present practices in mitigating the impact of climate change and adaptation. Also, with the farmers' own initiatives on one hand and support granted by the Rural Development Programme on the other, it is considered that a step has been taken towards improving the conditions, but it is still considered insufficient.

Commercial dairy farms have a more advanced approach in terms of microclimate management, including the installation of a ventilation system, the use of more advanced feed, using quality hay, silage and concentrated feed, but no feed supplements are used, which are necessary in the conditions of extreme heat.

Breeders of small farms that mainly produce milk and dairy products for their own needs try to build and rebuild stables, paying attention to adapting to climate changes with natural ventilation, while not investing so much in food, most of the time they spend the summer season in pastures, while water supply is made from natural sources and other alternative sources.

In the production of eggs and broilers, farming systems and production technology are under controlled conditions and continuously improving. During the review of strategic documents, no measures were observed that affect the increase in livestock farming through adaptation to climate change. Adaptive practices to climate change still remain unaddressed and with little knowledge, such as adapted feeding techniques, biosecurity and breeding of resistant animals, etc.

3.5.6. Summary of national strategies and adaptation plans in the livestock sector

The 2019-2028 climate change strategy defines policies for reducing greenhouse gas (GH) emissions and adapting to climate change. Also, it presents an opportunity to define measures to reduce greenhouse gas emissions and adapt to climate change, which will promote sustainable development.

Although Kosovo* is not yet a party to and has not signed the United Nations Framework Convention on Climate Change (UNFCCC), it has the responsibility to respond to the requirements as one of the signatories of the Energy Community Treaty.

The Strategic Objectives for adaptation to climate change include the following:

- Development of new mechanisms and improvement of current ones in disaster risk reduction, in sectors of economic importance that are vulnerable to climate change;
- Raising capacities for adaptation of natural ecosystems;
- Raising the capacities of central and local partners, actors and stakeholders for the integration of climate change and adaptation issues in development processes.

Referring to this basic document related to climate change and adaptation, the approach to the livestock sector and livestock farming has not been addressed, while livestock is counted as the first sub-sector that generates about 600 thousand tons of CO_2 equivalent per year.

The Strategy on Agriculture and Rural Development 2022–2028, approved Decision of the Government of the Republic of Kosovo* No. 12/50 dated 23 December 2021, and Action Plan include the following budgeted actions: compensation for damage caused by natural disasters, agricultural insurance schemes including animals, support in mitigating and adapting to climate change, such as the use of renewable energy, prioritizing grants for farmers with investments in manure storage for manure management and the drafting of a Code of Good Agricultural Practices for the prevention and reduction of nitrate pollution caused by agriculture.

The Agriculture and Rural Development Programme 2023-2027, approved by the Decision of the Government No.15/151 dated 12 July 2023, responds to climate change by increasing the adaptive capacity of the agriculture sector. In agriculture, adaptation measures occur on a variety of spatial scales, including national, regional and farm levels.

Adaptation at farm level focuses on technical measures that change production patterns, methods, farm structures and strategies. Technical measures relate to changes in agricultural practices as a result of rising temperatures, for example drought-resistant crops, responsible and targeted use of pesticides, sustainable water use depending on the local circumstances, use of hail and frost protection, flood prevention, etc. Farm-level adaptation should address the specific needs of farms, including breeding livestock for greater tolerance and productivity; improving pasture and grazing management; improving animal rearing conditions; preventing existing and new diseases.

3.5.7. Overview of policy and institutional setup and legislative framework for adaptation activities relevant to the sector

The Ministry of Agriculture, Forestry and Rural Development (MAFDR) is the main institution that proposes and implements agricultural policies, proposes and drafts primary and secondary legislation in the area of its responsibility, manages the preservation of agro-diversity, agricultural lands, forests, farm animals, hunting, fish and food security.

Within the MAFRD, there are departments that are charged with specific tasks in the field of agriculture, forestry and rural development: the Department of Agricultural and Trade Policies, the Department of Rural Development Policies and the Department of Forestry. The Food and Veterinary Agency, the Forestry Agency of Kosovo* and the Agricultural Development Agency are also integral parts of MAFRD.

The Law on Agriculture and Rural Development (Official Gazette of the RK* No. 8 of 29 March 2023) regulates the drafting and implementation of national policies on agriculture and rural development. The objectives of this Law are to create a competitive agricultural and agri-food sector, to ensure a stable supply of safe food, protection of natural resources and the environment from the negative effects of agricultural production, which address the challenges of climate change, achieving sustainable use of natural resources and promoting production methods that preserve the environment. Based on this Law, the national Programme on Agriculture and Rural Development is drawn up, which includes the Rural Development Programme , the Direct Payments Programme and other public support measures for agriculture.

The objective of the Law No. 04/L-191 on Livestock (Official Gazette of the RK* No. 25 of 8 July 2013) is the protection, improvement and preservation of quality animal gene sources with the aim to entice farmers to increase animal production, to improve the quality of livestock products and to protect the animals' genetic variability. This Law determines the conditions and practice of rearing farm animals, it governs the methods and technology of rearing, conditions for establishment and approval of breeding programmes, change and preservation of animals' characteristics, preservation of genetic variability and indigenous breeds, professional and scientific service, genetic reserves, breeding enterprises, trading and marketing of breeding material.

The Law No.08/L- 120 on Food aims to define the general principles and requirement for food and feed, measures and procedures regarding food and feed, as well as to determine the competent authority for sale in the market. This Law applies to all stages of production, processing, and distribution of food and feed, except in primary production, preparation, storage and use of food in households which is not intended for sale in the market. Article 18 regulates the issue regarding requirements for feed safety.

The Law No. 02/L-10 on Animal Welfare (Official Gazette of the Provisional Institutions Of Self-Government in Kosovo*, Prishtinë: Year I, No. 5, 01 October 2006) regulates the keeping, care, housing, breeding, transportation and other issues related to animal care. The purpose of this Law is to establish a legal base for animal welfare to ensure physiological and social needs of animals.

The Veterinary Law (No. 21/2004) and other by-laws, stipulate that the Animal Health AND Welfare Directorate carries out official control of livestock farms according to a previously approved plan twice a year, in January-June and August-November. This control includes the 37 municipalities of Kosovo* with a total of 985 farms. These checks include all the information about animals. Official controls on chicken farms are carried out on farms for the production of eggs for consumption and farms for raising broilers. Controls are defined in UA 32/2008 for Salmonellosis Disease, UA 14/2005 for New Castle Disease and UA 24/2005 for Avian Influenza, and the application of the poultry immunization programme is also required.

The purpose of the **Law on Organic Agriculture** (04/L-085 No. 28 of 16 October 2012) is to create the basis for the sustainable development of organic production. The general objectives of this Law include the conservation and improvement of land, water, plants, animals and maintaining the balance between them, to contribute to biological diversity, to respect animal welfare standards.

Government support measures. Agriculture in general, and livestock in particular, is supported by rural development measures aimed at increasing the quality of production and competitiveness through investments in the physical assets of agricultural economies (M1), investments in physical assets in the processing and marketing of agricultural products (M3) and farm diversification and business development (M7). The measures aim to improve farm infrastructure. Meanwhile, in terms of climate, these measures aim to mitigate climate effects through investment in energy production from renewable sources.

3.5.8. Conclusions

During the research for the preparation of this study, the data requested to be analyzed has proven to be largely missing and has not been treated before.

- There is no accurate monitoring data on livestock farms related to the Thermal Humidity Index (THI) and it is not used on livestock farms.
- Based on the data on extreme weather events, livestock is a sector vulnerable to climate change.
- In general, livestock farms in Kosovo* do not have minimum microclimatic conditions, especially ruminant farms.
- There is a lack of political measures to help with climate change and adaptation regarding livestock.
- Information is not always in suitable formats for use, often its exchange between partners is ineffective.
- There is inadequate primary and secondary legal infrastructure related to climate change adaptation.

Recommendations

- In the future, it would be good to implement pilot projects that would monitor THI on individual farms.
- Information is not always in suitable formats for use, often its exchange between partners is ineffective.
- Meteorological and agricultural monitoring should be improved.
- Farmers should be supported in climate risk management.
- Legal framework should be completed climate change policies in the field of livestock unified.
- It is necessary to adapt the structure of incentive measures.
- Breeding conditions, ventilation, cooling systems and natural shadows in barns should be improved.
- The legal framework related to livestock climate change adaptation should be improved.
- Intersectoral cooperation should be deepened.
- Capacity building should be increased and all relevant levels and farmers included.
- Support from the EU with expertise in climate change with special accent on animal husbandry is needed.
- The level of advisory services on adaptation to climate change should be increased.

3.6. References

Agriculture Census Report 2014 (Kosovo*`s Statistical Agency).

Annual Performance Report for Water Services 2021 (Water Regulatory Authority).

Annual Reports from Irrigation Providers (Regional Irrigation Companies: Ibër-Lepenc, Radoniqi-Dukagjini and Drini I Bardhë).

Assembly of Republic of Kosovo* (2013): Law No. 04/L-174, on Spatial Planning, Prishtinë, Kosovo*.

Ciborowski, P. (2022): Greenhouse gas reduction potential of agricultural best management practice (Revision edition), Minnesota Pollution Control Agency, Saint Paul.

Climate Change Strategy and Action Plan 2019-2028 (Kosovo* Government Sept 2018).

Čustovic, H., Ljuša, M., Sitaula, B.B., (2015): Adaptacija na Klimatske Promjene u Sektoru Poljoprivrede, Poljoprivredno-prehrambeni fakultet Univerziteta u Sarajevu.

EULUP (2011): Project Number 2010/230-489, Further Support to Land Use – Eulup, Agricultural Land Suitability Classification, Technical Report No.3, Prishtinë, 2011.

Exploring the challenges of climate change and opportunities for the transition to a carbon-neutral economy September 2022 (Research, including a Public Pulse survey from UNDP in Kosovo*).

Faulkner, B. (2011): Kosovo* Drought Risk Management Framework – An Action Plan for Policy, Procedures and Coordination, Prishtinë, Kosovo*.

Faulkner, B. (2011): Kosovo* Flood Risk Management Framework – An Action Plan for Policy, Procedures and Coordination, Prishtinë, Kosovo*.

Government of Republic of Kosovo*/MESP (2018): Climate Change Strategy 2019- 2028, Action Plan on Climate Change 2019-202, Pristina, Kosovo*.

Green Agenda for the Western Balkans (Guidelines for the Implementation of the Green Agenda, Brussels, 6.10.2020).

Green Reports 2016 and 2021 (Ministry of Agriculture, Forestry and Rural Development).

https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=29356

https://ihmk-rks.net/?page=1,11&date=2017-00-00

https://ihmk-rks.net/?page=1,11&date=2018-00-00

https://ihmk-rks.net/?page=1,11&date=2019-00-00

https://ihmk-rks.net/?page=1,11&date=2020-00-00

https://ihmk-rks.net/?page=1,11&date=2021-00-00

https://ihmk-rks.net/?page=1,11&date=2022-00-00

https://www.mbpzhr- ks.net/repository/docs/STRATEGJIA_20222028_FINAL_ALB_Web_Noprint_final_PDF.pdf

https://www.mbpzhr-ks.net/repository/docs/Bujqesia_ne_numra_2021.pdf

https://www.mbpzhr-ks.net/repository/docs/Raporti_i_Gjelber_20221.pdf

Kosovo* Law on Water No.04/L-147.

Kosovo* Irrigation Master Plan (Ministry of Agriculture, Forestry and Rural Development 2020).

Kosovo* Agency of Statistics (2015): Agriculture census in the Republic of Kosovo* 2014, Final results, K.G.T, Prishtinë, Kosovo*.

Land Portal (2022): Land and Climate Change: https://landportal.org/issues/land-climate-change-brief

MAFRD - Ministry of Agriculture, Forestry and Rural Development (2012): Administrative Instruction No. 02/2012 on Classification of Suitability of Agriculture Land, Government of Kosovo*, Ministry of Agriculture, Forestry and Rural

Development Prishtinë, 2012.

MAFRD- Ministry of Agriculture, Forestry and Rural Development (2021): Strategy for Agriculture and Rural Development 2022 – 2028, Pristina, Kosovo*.

MAFRD; Green report 2022 (December 2022).

MAFRD; Kosovo* – Department for Vineyards and Wine from May – until September 2023.

MAFRD; Kosovo* Agriculture in Numbers 2022 (2022).

MAFRD; Strategy for Agriculture and Rural Development 2022-2028 (16 August 2022).

MESP; Ministry of Environment and Spatial Planning. Climate Change strategy 2019-2028 (19 February 2019).

Meteorological bulletins from 2017 – 2022, Hydrometeorological Institute of Kosovo*.

Ministria e Punëve të Brendshme – Agjencia e Menaxhimit Emergjent (2016): Strategjia për Zvogëlim të Rrezikut nga Fatkeqësitë dhe Plani i Veprimit 2016 – 2020, Prishtinë, Kosovo*.

Ministry of Agriculture, Forestry and Rural Development /MAFRD/ (2020), Green Report 2020, Pristina, Kosovo*.

Ministry of Agriculture, Forestry and Rural Development /MAFRD/ (2022), Green Report 2022, Pristina, Kosovo*.

National Water Strategy 2017-2036 (Ministry of Environment and Spatial Planning 2017).

Pejić, M. (2022): Utjecaj klime na svojstva tla, Fakultet Agrobiotehničkih Znanosti u Osijeku, Osijek.

Rajib Karmakar, Indranil Das, Debashis Dutta and Amitava Rakshit, 2016. Potential effects of climate change on soil properties: Areview.Sci.Int., 4: 51-73.

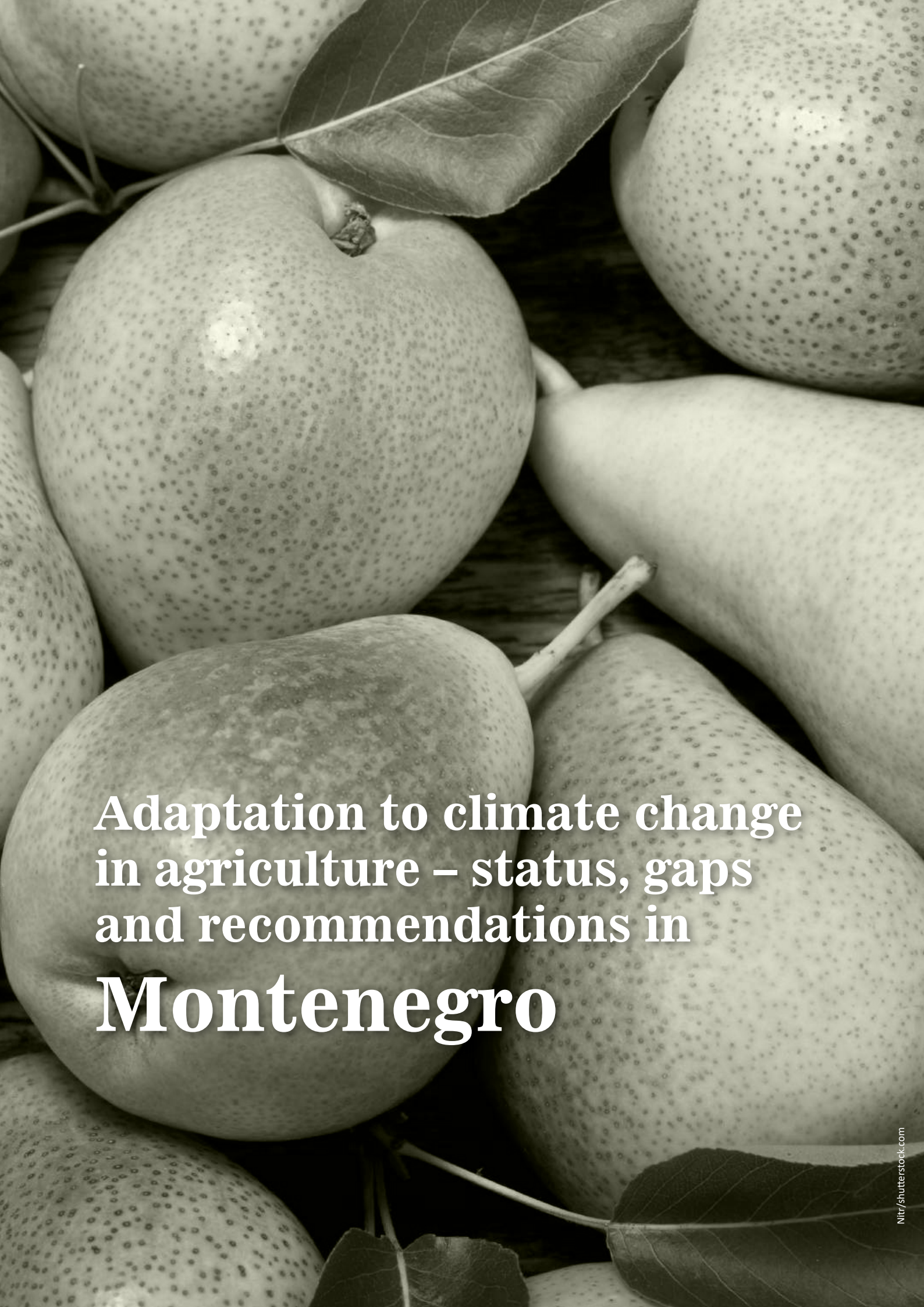
Water Security Outlook for Kosovo*, June 2018 (World Bank document).

Water Statistics in Kosovo* 2020-2021 (Kosovo*`s Statistical Agency).

Zogaj, B. (2022): PPP – Dorëshkrim mbi Zjaret Pyjore nga 2010-2014 dhe 2015-2020 https://www.wbif.eu/technicalassistancegrants//WB25-KOS-ENV-02#:~:text=The%20Preliminary%20Flood%20Risk%20Assessment,and%20538%20economically%20important%20areas.



Adaptation to climate change in agriculture – status, gaps and recommendations in Montenegro



Nitr/shutterstock.com

4. Adaptation to climate change in agriculture – status, gaps and recommendations in Montenegro

Mirsad Spahić [41], Mirko Knežević [42], Zoran Jovović [43], Božidarka Marković [44]

4.1. Status of economic, socio-economic and agricultural sector related to climate change

4.1.1. Macro-economic aspects on the national economy level

In Montenegro, the Gross Domestic Product (GDP) has had a tendency to grow in recent years, almost reaching 6 billion EUR, with the key sectors for growth being tourism and construction, and the real growth in 2022 6.4% (MONSTAT, 2023a). Inflation has been relatively stable over the past decade with low levels of increase, however, since the start of the COVID-19 pandemic, Russian aggression against Ukraine and instability in the agricultural market, inflation has reached 20% in the previous year, while the average (2021-2022) was 12.4%. Montenegro is facing public finance challenges, especially in relation to high public debt and budget deficit, and the government is trying to reduce the fiscal deficit and establish the sustainability of public finances. Key sectors in the Montenegrin economy are tourism, construction, energy and agriculture. Tourism plays an important role in attracting foreign investment and generating income, while the construction sector is closely related to the development of infrastructure and tourism. The unemployment rate in Montenegro is relatively high, but there is are challenges regarding the quality of jobs and seasonal employment. The Government of Montenegro is focused on strategies on the development of education and the creation of a favourable business environment in order to maintain sustainable growth and support competitiveness on the labour market.

Table 4.1. Key general statistics

	Units	2015	2016	2017	2018	2019	2020	2021	2022
GDP (at current prices)	mill. EUR	3,625	3,954	4,299	4,663	4,951	4186	4955	5924
Value added (at current prices)	mill. EUR	2,992	3,065	3,519	3,816	4,022	4193	4732	4769
Economic growth (real change in GDP)	%	3.4	2.9	4.7	5.1	4.1	-15.3	13.0	6.4
GDP per capita	EUR	5,826	6,354	6,908	7,495	7,959	6,737	8,002	9,598
Inflation	%	1.4	5.1	3.8	3.2	2.0	-0.2	4.7	12.4
Total employment	000	175.6	178	229.3	237.4	243.8	219.4	212.6	251.2
Unemployment rate	%	19.7	17.7	16.1	15.2	15.1	17.9	16.6	14.7
External trade balance	mill. EUR	-1,523	-1,736	-1,833	-1,985	-2,185	-1,739	-2,068	-2,834

41 Agricultural economics expert, Ministry of Agriculture, Forestry and Water Management of Montenegro (mirsad.spahic@mpsv.gov.me)
42 Soil and water expert, University of Montenegro, Biotechnical Faculty, Podgorica (mirkok210271@gmail.com)
43 Crop expert, University of Montenegro, Biotechnical Faculty, Podgorica (zoran.jovovic.btf@gmail.com)
44 Livestock expert, University of Montenegro, Biotechnical Faculty, Podgorica (bozidarkam@ucg.ac.me)

Montenegro has a serious problem with regional disparities, especially in the northern region. From the data on the number and business results of companies that have submitted financial statements, then on the number of employees, the number of pensioners and the number of unemployed people, it can be concluded that the northern region is significantly behind compared to the central and coastal regions. According to the recently adopted Final Report on the Implementation of the Regional Development Strategy of Montenegro for the period 2014-2020, regional disparities in Montenegro have not been eliminated, on the contrary, they are even more pronounced. Although Montenegro is a small economy, it has a relatively small population, with an average of 45 inhabitants per square kilometre. The economy has a diverse demographic structure, with a significant share of the elderly. As for the poverty rate, Montenegro has seen a gradual decrease over the past years. However, there is still a certain level of poverty, especially in rural areas and among less privileged population groups. According to the latest available data, the Gini coefficient is around 30. This indicates the presence of moderate inequality in the distribution of income in the economy. Montenegro has a rural component, although a significant part of the population is concentrated in urban centres. In Montenegro, according to the 2011 Census, about 62% live in urban areas, and the rest in rural areas (Government of Montenegro, 2020). During the past years, the migration of the population from the less developed parts of the northern region to the central and coastal regions, where living conditions are more favourable, has intensified. As a result of this migration, the pressure on resources in urban settlements has increased. A negative impact is also present in rural areas, especially mountainous ones, since a lot of land remains uncultivated and overgrown with weeds, bushes and trees. Also, 13.41% of the territory, i.e. 185,269.69 ha, is under protection. The areas of the national parks: Durmitor, Lake Skadar, Lovćen, Biogradska gora and Prokletije, cover 7.27% or 100,427 ha, while nature parks cover 79,583.10 ha or 5.76% of the territory of Montenegro (Government of Montenegro, 2020).

4.1.2. Macro-economic aspects on the agricultural sector level

In 2022, agriculture had a significant share in the Gross Domestic Product of Montenegro, in the amount of 6.0%. Although the share of agriculture in the total GDP has been decreasing in recent years due to the development of other sectors, it still represents an important segment of the economy, for the reason that the gross value of production has reached 625 million EUR (Monstat, 2023a).

The agricultural sector provides significant employment opportunities for the population, especially in rural areas. Farmers often rely on agriculture as the only source of income for their families. Products such as fruits, vegetables, meat and dairy products are placed on the domestic market, but can also be found on international markets. The development of agriculture can have a positive impact on the trade balance and the reduction of food imports, but the instability of the market for agricultural products has influenced even greater imports. Preliminary data from the FADN system show that the rise in prices has greatly affected the profits of agricultural producers whose production depends on imports, data showing that milk production is on the verge of sustainability despite high subsidies.

Taking into account that data on economic accounts in agriculture are not available, and that the census of agriculture is planned for 2024, decision-makers are faced with a lack of data from official statistics in terms of input for the adoption of agricultural policy.

4.1.3. Land use

According to the data of the Administration for Statistics – MONSTAT, the total available agricultural area in Montenegro was about 334 thousand hectares in 2016 (Monstat, 2017), which represents about 24% of the total territory of the economy, while the initial level of digitization of land use with

LPIS (2017) estimated that 418,800 ha were available. It should be taken into account that the initial level of LPIS was based on an old orthophoto (2017), and no quality validation of SIZEP had been carried out. The approximate area of unused agricultural land was therefore about 160,000 ha, which could potentially be available for food production. In the Spatial Development Plan of Montenegro (2007–2020), it is stated that the available agricultural land is 514,501 ha, which is 114,000 ha more than recorded during the initial establishment of LPIS, and this indicates a change in methodology, but also the conversion or abandonment of agricultural land. The information shows that it is necessary to conduct a more detailed analysis of the situation in the management of agricultural land, and to identify the solution for the problem of its conversion, in order to achieve more coordinated spatial planning and the implementation of agricultural policy (Ministry of Agriculture, Forestry and Water Management, 2023a). Agricultural land in Montenegro can be categorized into three main groups: arable land, perennial crops, and meadows and pastures. When looking at the structure of agricultural land used by farms (homesteads, arable land, orchards, vineyards, nurseries, and meadows and pastures), it can be seen that there were no significant changes in 2022 compared to 2010. The share of meadows and pastures in total agricultural land in 2022 amounted to 94.4% (where an increase in the average area per farm was recorded – mainly related to farms engaged in animal husbandry), while other categories of used agricultural land amounted to 5.6% and recorded a slight increase (Monstat, 2023b).

Various types of crops, such as vegetables, fruits and olives are grown on agricultural land in the central and southern regions. Medicinal plants and herbs are also grown. Agricultural land is used for livestock grazing. The main breeding forms in animal husbandry are cattle, sheep, goats and pigs. Many farmers have their own farms where they raise livestock for the production of meat, milk and dairy products. Montenegro is known for its rich wine-growing heritage. In the north of Montenegro, agricultural land is used for growing fruits such as apples, pears, plums, raspberries, strawberries and berries. Fruit growing has significant economic potential and contributes to local and export trade. There is a growing trend of organic agriculture in Montenegro. Many farmers are turning to organic farming of plants and livestock to meet the demand for healthy food and provide added value to their products.

It is important to note that the management of agricultural land in Montenegro is of vital importance for maintaining the balance between agricultural production, environmental protection and conservation of natural resources. The Government of Montenegro is taking measures to improve the management of agricultural land and support the sustainable development of agriculture. In recent years, focus has been on support when it comes to direct payments, so from year to year we have a larger number of measures, so that in addition to the basic direct payments that we have implemented so far, we have production-related payments in plant production, then payments for young farmers, additional payments for production on unused agricultural land, in order to relieve the exploitation of agricultural land that has been cultivated for several years. From 2023, they are starting to implement agro-ecological measures for private meadows and pastures. New schemes of direct payments in plant production have been introduced and funds for this purpose have increased significantly.

4.1.4. Brief agricultural sector overview

Agriculture is an important sector in the Montenegrin economy, contributing to the economy's GDP and employment of the rural population. Montenegro has a diverse climate and landscapes that enable different types of agricultural activities. The coast of the Adriatic Sea provides favourable

conditions for fruit growing, while the mountainous areas are suitable for cattle breeding. Agriculture in Montenegro is characterized by a large number of small farms, while the majority of farmers are family farms with small areas of land. This often leads to challenges in modernization and increasing productivity.

The agricultural sector in Montenegro faces challenges such as insufficient investment in infrastructure, a small number of young farmers and problems related to the market and placement of products. However, the government of Montenegro undertakes measures to support agriculture through subsidies, education and targeted support programmes. Montenegro is increasingly striving to develop sustainable agriculture, including organic production. The goal is to protect natural resources, biodiversity and improve the quality of agricultural products.

It is important to emphasize that the agricultural sector in Montenegro is constantly developing and that there is a need for further investment, modernization and support in order to realize the full potential of this sector. When it comes to the economic performance of agriculture, the relevance of statistical data is questionable: there is no available data on economic accounts in agriculture, the latest information on the workforce does not include the workforce in annual work units (AUW), the farm structure survey from 2016 shows that is the total amount of GRJ is 46,000, which means about GRJ 0.45 per household (Ministry of Agriculture, Forestry and Water Management, 2023a). Another problem is that most agricultural products are sold on the farm or used for personal consumption. As for employees, the need for labour in most Montenegrin farms is met by members of family farms, who are not paid for their work. Paid labour is primarily employed on larger farms owned by commercial enterprises. During the tourist season, the demand for food is very high. The decline in the volume of tourism in 2020 led to disruptions in the market of agricultural products, which affected the reduction of activities in the agricultural sector and led to a decrease in the number of persons employed in 2020.

Damage to agricultural crops, livestock and other resources is a regular companion of agricultural production, especially from weather damage to crops and damage caused by wild animals to livestock. Damages on a larger scale exceed the possibility of remediation by the producer and can seriously threaten the survival of farms, and thus the long-term sustainable development of agricultural production. The tendency in the new strategic period is to increase the number of users who provide agricultural production. Support for insurance against damage to agricultural crops, livestock and fire insurance can be up to 60% of the insurance policy.

At the end of June 2022, a severe storm accompanied by hail and rain hit Podgorica and surrounding towns and lasted approximately eight minutes. The amount of damage amounted to around 10 million EUR, and the most affected were grape plantations, watermelon crops and many greenhouses with vegetables were destroyed. The Government of Montenegro helped the company 13. Jul Plantaže with 1.5 million EUR so that it would not experience complete bankruptcy.

4.1.5. Farm structure key indicators and context

More recent data on the average age of farm owners in Montenegro are not readily available. However, it can be concluded that there is a tendency for the agricultural population to age, given that many young people are leaving rural areas and reorienting themselves to other sectors. Both men and women are involved in agriculture in Montenegro. Although agriculture has traditionally been considered a male sector, an increasing number of women are involved in agricultural production and rural activities. According to MONSTAT data (2016), there are 43,791 agricultural farms in Montenegro, and according to the Register of Agricultural Farms, 19,622 farms were recorded in September 2023,

2,974 of which owned by women, which represents 15.15% (Ministry of Agriculture, Forestry and Water Management, 2023b).

The average area of land per farm receiving support from the Ministry was 2.1 ha. According to current regulations, agricultural holdings that do not use support, as well as those that do not submit requests for the same according to IPARD measures, are not required to register in the register of agricultural holdings. The currently registered areas in the LPIS system represent about 3% of the total used agricultural areas. Agricultural farms in Montenegro are not specialized. About 80% of all farms are mixed farms, and only 8.0% of the total number of farms are the so-called specialized farms for breeding pigs and poultry. Only 2.9% are unclassified farms (e.g. family farms on homesteads) (Ministry of Agriculture, Forestry and Water Management, 2023a).

The majority of farms in Montenegro are family farms, which make up the vast majority of the total number of farms. However, there are also larger agricultural companies engaged in agricultural production. The size structure of farms in Montenegro is diverse. The range of farm sizes can be very different, from small areas cultivated by hand to larger industrial farms with modern machinery. There are different types of agricultural farms in Montenegro, such as arable farming, fruit growing, vegetable growing, animal husbandry, beekeeping, viticulture, etc. Depending on geographical and climatic conditions, certain types of farms may be prevail in certain regions.

There is variation in the level of education among farm owners in Montenegro. While some owners may only have primary-school education, others may have higher education or professional degrees in agriculture or related disciplines. In the Register of Agricultural Holdings, about 15% of the holdings are held by women (2023). The age structure of agricultural producers in Montenegro is quite diverse. There are farmers in different age groups, from young people who have just started their career in agriculture to older generations who have been active in the agricultural field for a long time. Younger generations of farmers are increasingly showing interest in agriculture and the modernization of agricultural activities. These young farmers usually have higher education and use new technology and methods in agricultural production. Many of them also practice organic farming.

On the other hand, there are also older farmers who have been involved in agricultural production for many years and have considerable experience. These farmers often prefer traditional working methods and pass down knowledge to younger generations. Some of them may not be so well versed in modern technologies, but they are still very hardworking and dedicated to their work. It is important to note that women are increasingly represented as farmers in Montenegro. They often play a key role in family farms and contribute to the community through their activity.

Table 4.2. Age structure

Age of farmers/beneficiaries registered*	2020	2021	2022	2023
Under 30	489	639	815	1,028
Over 30 up to 40	1,182	1,407	1,618	1,934
Over 40 up to 50	2,244	2,585	2,976	3,405
Over 50 up to 65	5,273	5,876	6,711	7,726
Over 65	4,240	4,673	5,208	5,926

*Note: Number of holdings in the Register of Agricultural Holdings

The land is mostly owned by private owners, but there is also land rental by other owners or land use through concessions by the state. There is still no information available on how much agricultural land is owned by the state. In order to utilize land areas, the Government of Montenegro, i.e. the

Commission for Valorization of State-Owned Agricultural Land, publishes calls to which it invites all interested producers to participate in tenders. The land from the public calls is leased exclusively for agricultural activity, and cannot be used for other purposes. The Ministry of Agriculture, Forestry and Water Management publishes a call for the lease of state agricultural land specifying which municipality it refers to. In its public invitation, it states that it is inviting registered agricultural producers, natural or legal persons, interested in leasing land with information on the plot and its area. Currently, only 330 ha are under lease. Also, the lack of updating of cadastral data on the use and class of individual plots, which can significantly deviate from the real situation on the ground, greatly slows down the entire procedure of leasing land.

4.1.6. The legislative framework and institutional setup linked to the socio-economic aspects of climate change

The Ministry of Agriculture, Forestry and Water Management as an umbrella institution manages policies on agriculture and rural development, forestry, fisheries and water management. The structure of the Ministry is in accordance with the requirements of the EC on the division of policy creation and implementation. The Ministry is the responsible institution for coordinating activities, implementing and monitoring strategies. The managing body for rural development in the operational structure of IPARD is the Directorate for Rural Development, while the Directorate for Payments is the accredited IPARD Agency.

In Montenegro, there is a Ministry of Ecology, Spatial Planning and Urbanism, which is in charge of coordinating environmental protection policy, including climate change management. There is also an Environmental Protection Agency, which provides professional support, supervision and control over the implementation of environmental protection measures.

Montenegro has also established a high-level Council that focuses on issues of sustainable development, gathers representatives of several institutions, and is chaired by the President of Montenegro. The Council was formed in 2008 by the Government, which has achieved a shift in inter-institutional coordination and cooperation. The 2013 reform strengthened the Council's mandate in the area of climate change, as a strategic priority of the Government in achieving a low-carbon society. In 2016, the Council became the National Council for Sustainable Development, Climate Change and Integrated Coastal Management (Government of Montenegro, 2020).

The legislative framework and institutional arrangement related to the socio-economic aspects of climate change in Montenegro are significant for facing the challenges related to climate change. First of all, it means respecting the international convention, and on the other hand, preserving the environment and minimizing the impact on the economy. In Montenegro, there are a number of laws related to climate change and its socio-economic aspects. Montenegro has adopted the National Strategy on Sustainable Development until 2030, which aims to integrate socio-economic aspects of climate change in all sectors. Montenegro, which is significantly oriented towards tourism, declared as an ecological economy, must pay special attention to the valorization of green growth and circular economy, integrating demographic, social, natural and economic aspects of economic development, as stated in the National Development Strategy of Montenegro until 2030, with which the UN universal Sustainable Development Goals were translated into the national context (Government of Montenegro, 2020). There are also action plans that include concrete measures for adapting to climate change and mitigating its impacts, such as the Action Plan on the Implementation of Measures for the Use of Renewable Energy Sources and Energy Efficiency Measures in the Transport Sector, the Action Plan on Helping to Accelerate the Transition to a Circular Economy, the Action Plan for the Development and

Greater Use of District Heating and/or Cooling and High-Efficiency Cogeneration in Montenegro, the Action Plan on Energy Efficiency, and others. Montenegro uses different sources of financing to deal with socio-economic aspects of climate change. This includes domestic budget funds, international donors, EU funds and other sources. Montenegro is active in international cooperation regarding climate change. The economy participates in UN negotiations on climate change, as well as regional initiatives within the Western Balkans.

It is important to note that continuous monitoring and updating of the legislative framework and institutional arrangement is necessary in order to effectively respond to the growing challenges of climate change. Montenegro strives to improve capacities, establish monitoring and evaluation systems, and act jointly with other economies and stakeholders in the fight against climate change.

4.1.7. Literature review on climate change linked to socio-economic aspects

A small number of studies investigate the impact of climate change on different sectors in Montenegro, such as tourism, agriculture, water resources, and energy. Some studies analyze the social and economic consequences of these changes and provide recommendations for adaptation.

In the study on climate changes and their impact on the economies of the region (Abramovic et al., 2016), the authors point out contemporary changes and global warming caused by human activities as topics that attract a lot of attention at all levels of society, as well as the interest of scientists for more detailed research. The impact of climate change depends on the rate of changes, exposure and sensitivity of the ecological and socio-economic systems, as well as the society's ability to adapt to these changes. It is estimated that the most damage will be brought to developing economies, because they are not ready for such changes. This promotes the use of renewable and clean energy, as well as actions of economies on the international level, with the ultimate aim of suppressing the harmful effects of climate change. The connection between climate change and sustainable growth is highlighted in many international frameworks that have been developed so far, and the main reason for their creation is the fight against climate change (Abramović et al, 2016).

A study on the impact of climate change on key macroeconomic indicators in Montenegro describes how climate change represents a major challenge that, with its complexity and unpredictable dynamics, shapes the opportunities and possibilities of the modern age. Climate factors directly affect important and critical economic resources, such as water, agricultural products and human health. Changes in the climate can also affect production in the fields of manufacturing, energy, transport and other services. We are witnessing increasingly frequent climatic extremes and disasters such as droughts, fires, floods, which modern scientific research links to global warming (Ivanović, 2023).

On the other hand, a study on the influence of flooding on the main parameters of potato productivity describes the consequences of global climate change as considerably felt in Montenegro. The most significant indicators of these changes are: increased frequency and severity of floods and droughts, significant increase in air temperature, increase in surface temperature and sea level, more intense occurrence of forest fires, stormy winds, etc. In recent years, agricultural producers in Montenegro have suffered enormous damage to agricultural crops, livestock, buildings, and other resources. A significant part of these losses is related to floods. Floods, as a natural phenomenon, significantly complicate the production of potatoes in Montenegro, and sometimes they completely destroy it. Bearing in mind the size of the areas under this plant, it is quite clear that these damages, especially those caused by catastrophic floods, are enormous. Due to low investment, this branch of plant production shows increasing sensitivity to climate variability and extreme weather conditions, which leads to large yield fluctuations and instability of production results (Jovović et al., (2021).

Socio-economic conditions are described in the study titled the Economic impacts of climate change in Montenegro: a first look on how climate change, in any case, affects the quantity and quality of the environment that people use for the production of goods and services, i.e. for lack of a better term, "to enjoy life". In this way, the aforementioned physical influences penetrate the markets of goods and services, as well as everyday life. In markets, climate change affects the production and market prices of goods and services in sectors directly affected by climate change. In modern economies, markets are interconnected by inter-industry flows of goods and services, as well as the funds received in exchange for those goods and services. These inter-industry flows act as a conveyor belt for the transmission of climate change impacts, potentially spreading them throughout the economy (Callaway et al., 2010).

By submitting the Third National Report (TNC), Montenegro has once again fulfilled its international obligations in accordance with the UNFCCC. This report contains the results of the new GHG inventories for 2016 and 2017, the recalculation of earlier time series from 1990, as well as a general description of the measures formulated, established and implemented by Montenegro in order to plan the reduction of GHG emissions. Also, the report contains the climate profile of Montenegro, highlighting the sectors and regions that are most susceptible to the effects of climate change, as well as an analysis of potential adaptation measures. This report summarizes information on processes related, among other things, to capacity building at the national level and promotion of investment and financing mechanisms.

4.1.8. Agricultural policies linked to climate change

The National Strategy on Climate Change until 2030 is a key instrument in the field of public policy on climate change management in Montenegro, and it prescribes the Government's obligation to act against climate change in an integrated and multisectoral manner, respecting international obligations under the UNFCCC. The strategy sets a vision that by 2030, Montenegro will be able to adapt to negative effects and promote sustainable development with a low carbon content. The strategy is largely focused on harmonization with the EU legislative framework in the field of climate change. As part of the strategy, Montenegro's Intended Nationally Determined Contributions (NDC) for reducing greenhouse gas (GHG) emissions was also adopted. With this document, Montenegro undertook to reduce GHG emissions by 30% by 2030 compared to the base year of 1990.

In 2019, Montenegro adopted the Law on Protection from the Negative Effects of Climate Change (Ministry of Agriculture, Forestry and Water Management, 2023a). The aim of this Law is to protect against the negative effects of climate change, reduce greenhouse gas emissions and protect the ozone layer. This brings Montenegro even closer to the acquis of the EU in the field of climate change. The main national body responsible for environmental protection and climate change policy is the Ministry of Ecology, Spatial Planning and Urbanism.

Priorities for the next period, according to the Strategy on the Development of Agriculture and Rural Areas 2023-2028, will include the following steps:

- Development of measure M4 within IPARD III (including Organic production, Preservation of indigenous genetic resources in agriculture and Sustainable use of mountain pastures) and its implementation through the IACS system.
- The obligations of the green agreement are the inclusion of 25% of the used agricultural land in organic production by 2030, which would mean 64,487 ha. IPARD III draft (M4) envisages 23,250 ha covered by obligations for the management of habitats, genetic resources, landscape and permanent pastures and meadows, which means the need to include an additional 41,137 ha by 2030.

- Creation of a programme of obligations (or within eco-schemes) that will contribute to determining the amount of use of mineral fertilizers and pesticides in order to potentially reduce the use by 50%, and reduce sales of antimicrobial agents for animal breeding by 50% by 2030.
- Development of a measure that will contribute to the reduction of nutrient losses by at least 50% by 2030 (within the eco-scheme or with an obligation, including the planting of legumes).
- Developing a programme that will contribute to the reduction of GHG by 35% (compared to 1990), preventing forest fires and investing in forestry (starting with planning and implementation M11 – forestry measures within IPARD III) and the development and implementation of support measures for organic production and climate measures for agro-environmental protection (IPARD III, measure M4).
- Development of an additional programme of measures with obligations (or without obligations) with higher standards than GAEC and SMR, such as integrated management of harmful organisms and development of guides for their application.
- Development of a programme of measures with obligations and their pilot implementation through the IACS system (until EU accession).
- Adjusting the budget in accordance with the approved strategic plan of the Common Agricultural Policy and full implementation – 35% of the budget for rural development allocated for the programme of agro-ecological, climate measures to support organic production with multi-year obligations (AEC – Organic Programme) at the time of accession.

Agriculture is one of the sectors most affected by climate change, because agricultural products directly depend on climate factors. Agriculture faces the great challenge of adapting to the expected effects of climate change. Montenegro belongs to one of the regions in the world where pronounced negative impacts of climate change on population health, economic development and availability of natural resources, food production, etc. are expected, despite the fact that, as a developing economy, it does not have a significant share in global atmospheric GHG pollution. On the contrary, due to a relatively high proportion of forest and vegetation areas, it contributes to the stabilization of carbon dioxide levels in the atmosphere. The effects of climate change can negatively affect soil fertility by reducing soil organic matter and increasing the risk of soil erosion due to higher temperatures and more frequent drought and rainfall.

The effects of climate change can negatively affect soil fertility by reducing soil organic matter and increasing the risk of soil erosion due to higher temperatures and more frequent droughts and rainfall.

Montenegro is particularly exposed and sensitive to climatic hazards such as droughts, floods, forest fires and heat waves. Climate projections show that these climate extremes will become more frequent and pronounced in the future. The most vulnerable sectors are water management, forestry and agriculture. In terms of geographic vulnerability, the coast is particularly threatened by rising sea levels and decreasing rainfall. Montenegro is aware of the urgent need to address the impact of climate change by promoting effective adaptation measures in the main vulnerable sectors. In the water sector, the water balance is decreasing in all the basins of Montenegro. The decrease in the amount of precipitation and snow will drastically affect the availability of surface water. Adaptation measures are aimed at applying an integrated approach to the management of water resources and systems, and strengthening intersectoral planning and activities.

Smart agriculture is the most effective solution for the use of resources with the maximum utilization of production capacity and the application of the precision model, which implies the introduction of innovative technologies and practices in agricultural production, as well as the use of smart technologies in the fight against climate change. The Ministry of Agriculture, Forestry

and Water Supply has several support measures aimed at new technologies in agriculture, which include the introduction of innovative equipment, services and applications. The introduction of innovative technologies and practices will lead to better productivity, increased yields and stronger competitiveness of products on the market. At the same time, it will contribute to better adaptation to climate change, environmental protection and biodiversity preservation, and ultimately contribute to the implementation of the EU Green Plan. More precise use of inputs such as pesticides and fertilizers is important for environmental protection and increased production efficiency. Also, the management of waste and by-products arising from agricultural production is one of the important segments of sustainable agriculture with a role of environmental protection, and their implementation becomes imperative in sustainable agro-ecological systems.

Considering the importance of the agricultural sector for the Montenegrin economy, together with organic agriculture, this sector should be one of the priorities for resource efficiency. The potential for greening the agricultural sector is found in fiscal measures to support organic production, the so-called greening of subsidies, application of new technological solutions and encouragement of innovation.

4.1.9. Existing data availability and quality for analysis of climate change socio-economic issues

The availability and quality of data for the analysis of the socio-economic issues of climate change in Montenegro varies depending on the specific area and aspects of research. In general, there are available data that allow for the analysis of socio-economic issues related to climate change, but there are also some limitations and gaps in these data.

Data limitations usually come from insufficient data collection and updating at the state level. In some cases, the lack of data may be the result of weak administrative capacities in monitoring and collecting data on the socio-economic aspects of climate change. This may result in incomplete or outdated information. Also, there may be data gaps due to the lack of an integrated approach to data collection. Data on specific socio-economic issues, such as poverty, employment or marginalized communities, may be fragmented or unavailable due to a lack of coordination among relevant institutions.

As for the indicators for evaluating and monitoring the effectiveness of climate change policy in Montenegro, there is an effort to develop them. However, there are challenges in determining and applying appropriate indicators. It is important to establish a robust framework for policy monitoring and evaluation to ensure their effectiveness. To include establishing clear objectives, defining relevant indicators and mechanisms for data collection.

In addition to limitations and gaps in data availability, Montenegro has recognized the importance of collecting and analyzing socio-economic data related to climate change. In cooperation with relevant institutions and experts, continuous efforts are made to improve the availability and quality of data and to develop a policy monitoring and evaluation system in this area. For example, years ago, a socioeconomic study was conducted in the marine fisheries sector, which contained a series of questions about the impact of climate change on the income of fishermen.

4.1.10. Conclusions with key recommendations and priorities referring to the socio-economic aspects of climate change

Montenegro is particularly exposed and vulnerable to climatic hazards such as droughts, floods, forest fires, and heat waves. Climate projections show that these climate extremes will become more frequent and pronounced in the future. After analyzing the socio-economic aspects of climate change in Montenegro, the following key issues, conclusions and recommendations are highlighted:

1. Untapped productive potential: There is potential to increase productivity in sectors such as agriculture, tourism and renewable energy. Investing in research and development, innovation and the application of new technologies is recommended to take advantage of these opportunities and increase the adaptive capacity of the sector and the socio-economic component.
2. (In)efficient agri-food chains: There is a need to improve infrastructure, logistics capacities and market access to ensure the efficiency of agri-food chains. Supporting small agricultural producers, diversifying production and local market chains can decrease the vulnerability caused by the structural deficiencies in the sector.
3. State of farm income and competitiveness: It is necessary to improve the income of farmers through a fairer distribution of profits in the agricultural sector. Also, it is important to invest in the development of rural areas in order to increase the competitiveness of agricultural products on the market.
4. Productivity and profitability: Improving knowledge, education and technical support to farmers can help increase productivity and profitability. It is recommended to provide access to financial and technical resources, as well as networking of agricultural operators to exchange best practices, especially in the area of climate change adaptation.
5. Structural situation and development: It is necessary to pay attention to regional disparities in rural areas and ensure balanced development. Improving land policies and supporting small farms and agricultural enterprises can contribute to the balance of development and sustainability of agricultural systems.
6. Profile of agricultural operators: It is important to understand the different profiles of agricultural operators in order to provide targeted support, providing access to education, financial resources and agricultural information. This includes young farmers, women in agriculture and farmers in marginalized communities.
7. Impact of climate change: It is necessary to adapt and mitigate the impact of climate change on agriculture through sustainable management of natural resources, protection of biodiversity and reduction of greenhouse gas emissions.

Taking into account these issues and priorities, key recommendations are aimed at strengthening capacities, improving the availability of financial and technical resources, developing adaptation strategies and mitigating climate change, and promoting cooperation between sectors and stakeholders in order to achieve sustainable socio-economic results in Montenegro. On the other hand, the development of the agricultural sector can provide an incentive for rural development and diversification of the economy. Investments in infrastructure, education, research and agricultural development can create new opportunities for rural areas and reduce population migration to cities. The agricultural sector plays an important role in the preservation of natural resources and the environment. The development of sustainable agriculture can contribute to biodiversity protection, sustainable land use and water resource management.

4.2. Status of soils linked to climate change in agriculture

4.2.1. Brief estimation of the exposure and sensitivity of soils to climate change and its influence on overall soil health

Montenegro's soil health is directly influenced by changes in temperature and humidity, which are essential for soil quality maintenance. Climate change indirectly affects soil health by impacting vegetation, a primary source of organic matter for soil.

Montenegro faces two types of floods, sustained rainfall-induced and meteorological flash floods. Vulnerable regions include the edges of Skadar Lake, Morača River's lower reaches, Bojana River Basin, Polimlje, Ćehotina River valley, and Ibar River in Rožaje. Frequent floods impact areas like Nikšić, Cetinje, Bjelopavlići plain, Ulcinj, Kotor, Lim and Ibar Rivers, Ćehotina River, Tara River upstream of Crni pod, Bukovica River, and Tušinja River upstream of Šavnik. Notably, the 2010 flood resulted in 44 million EUR in damages, affecting 30,000 hectares of agricultural land. Alluvial soil, Swampy-gley and Eutric brown soils are vulnerable, with erosion, pH fluctuations, crop yield loss, and livestock evacuation challenges.

Montenegro employs a standardized precipitation index (SPI), remote sensing, Drought Watch, and a reporter network for drought monitoring. Since the 1990s, the economy has seen more frequent droughts, with significant events in 2003-2011, particularly the 2011 drought in the Zeta-Bjelopavlići region. Heatwaves, like the one in 2012, have intensified the issue. These droughts disrupted agriculture, causing losses, reduced yields, and impacting water levels in rivers and power plants. Eutric brown soil and limestone-dolomitic black soil are highly susceptible to drought, leading to pH changes, reduced moisture, and limited irrigation. This results in soil compaction, poor root growth, reduced crop yields, and a decline in organic matter content.

Montenegro's forests have faced numerous climate-induced fires from 2005 to 2015, with about 800 large fires causing damage to over 18,000 ha of forests and 800,000 m^3 of wood. The worst season was in 2017, with 124 fires covering over 51,661 ha, significantly more than in 2016. Many of these affected areas have limestone-dolomitic black soil (Calcomelanosols), and the intense heat from fires can sterilize the soil, making it less suitable for agriculture.

Montenegro's hilly and mountainous terrain, covering 94% of its land, faces significant erosion challenges due to high precipitation levels and human activities like improper land use. Comprehensive erosion research is lacking, but around 300 registered torrential basins, spanning 460,000 ha, accumulate about 6 million cubic meters of sediment yearly. Additionally, areas like Andrijevo, Žuti Krš, Bakovića Gorge, and others, collect about 4,982,000 cubic meters of sediment per year. Erosion is the most prevalent in the Montenegrin Littoral (45%) and the Polimlje region (44%). The Waterpower Principles Act of 2000 classifies erosion categories, with 47.5% of Montenegro's total land area categorized as excessive (1.3%), intensive (9.8%), and medium erosion (36.4%). Erosion poses a significant threat to the integrity of Limestone-dolomitic black soil (Calcomelanosols), Colluvial soil, and Red soil (Terra Rossa). Landslides, common in high mountainous terrains and steep valleys, mainly have local consequences, with some potentially catastrophic events in deep canyons.

Montenegro faces a considerable risk of landslides at various locations. Areas such as the southwest slopes of Rumija, Sutorman, Lovćen, Orjen, and Vrmac are geologically susceptible to larger landslides. These terrains, characterized by flysch plastic and impermeable rocks overlying thick, rigid, well-

petrified rock masses, experience increased instability during rainy periods, including earthquakes. Large block landslides, including Vladimir, Ratac, Seoca, and Savina, have posed significant challenges due to their extensive surface and depth.

4.2.2. Overview of the producers' adaptive capacities relevant for sustainable use of soils

Between 2009 and 2022, Montenegro witnessed significant changes in its agricultural land use (different methodology). The total agricultural land in use decreased from 515,740 hectares in 2009 to 253,671.4 hectares in 2022. Despite the abundance of land resources, they were fragmented across a large number of family farms (48,870 total agricultural holdings) in 2010. Notably, parcels of land under 0.5 hectares constituted 31.6% of total agricultural land. Over half of farms (54.1%) cultivated land ranging from 0.10 hectares to 1 hectare. Astonishingly, 73% of family farms owned less than 2 hectares, while only 0.9% of family farms possessed over 100 hectares, covering 38% of the total utilized agricultural land. At the time, Montenegro had 48,870 agricultural holdings, with 48,824 being family agricultural holdings (2010). The combined economic value of these holdings was 25,817,765.2 EUR, averaging 2,574.54 EUR per agricultural holding. The agricultural sector employed 98,949 individuals, with 98,341 of them working on family agricultural holdings. The age distribution in farming reveals that 23,198 individuals aged 65 and older (23.58% of the labour force) were actively engaged in farming. On the other hand, 6,717 young individuals (aged up to 24) constituted 6.83% of the labour force. In terms of education levels, 33,180 individuals had at least four years of other secondary education (33.74% of the labour force), while those with post-secondary or high education in agriculture amounted to 1,446 individuals (1.47% of the labour force).

The state of mechanization in Montenegro's agriculture shows specific needs for modernization and upgrading of the machinery, particularly concerning older tractors, harvesters, and trucks. Two-wheel tractors are common, but many are over 10 years old. Four-wheel tractors are more prevalent, but many are older, especially those over 20 years. Insecticides are the most commonly used plant protection products, while biopesticides see the least usage. Herbicides, fungicides, insecticides, and mineral fertilizers are employed in varying quantities and on different land areas. Approximately 10.78% of agricultural land benefits from irrigation practices, mainly utilizing underground and surface water sources. Vineyards are the dominant category with the highest proportion of irrigated land. Traditional land cultivation techniques are still prevalent, with challenges related to parcel size and terrain limiting the adoption of more advanced practices. However, there is growing adoption of alternative practices in sectors like orchards and vineyards, such as cover crops, promoting soil health and sustainability. In Montenegro, lifelong learning programmes and vocational courses are available to equip agricultural experts with the latest information on sustainable soil management. Local farmers are offered specialized training courses focusing on soil health, erosion prevention and sustainable practices.

Montenegro has initiated a programme to valorize agricultural land, emphasizing land acquisition and agricultural operations. The success of these initiatives depends on the adaptability of producers.

4.2.3. Outline of the existing gaps and challenges to meet the newly adopted EU strategic and legal documents on soil and adaptation

The EU underscores the importance of research, innovation, sustainable soil management, and fostering collaboration among stakeholders in Montenegro. One primary challenge is the reluctance of land managers, policy makers, and farmers to adopt new technologies. This reluctance is driven by uncertainties about the benefits of these technologies, concerns about their cost, and a lack of clear financial incentives, subsidies, and grants. Additionally, there is a shortage of adequate training programmes and capacity-building initiatives, which are vital to enhance the willingness to embrace new agricultural technologies. Proper training and support can equip these stakeholders with the knowledge and skills needed to make the most of these innovations, increasing their adoption. Another obstacle is the communication gap that exists between policy makers and academia and scientific institutions. This gap restricts the flow of information and expertise, preventing policy makers from accessing the latest research findings and scientific insights crucial for evidence-based policy development. Simultaneously, researchers may struggle to grasp the priorities and needs of decision makers. Bridging this communication gap is essential to ensure that policies are informed by scientific knowledge and that research is aligned with relevant issues. Insufficient financial resources also pose a significant challenge. Without adequate funding, research and development efforts are hindered, study scales are limited, and the implementation of innovative solutions becomes difficult. Sufficient funding is a crucial factor for academia and scientific institutions to conduct high-quality research and contribute effectively to policy discussions. Additionally, in both Montenegro and the EU, soil monitoring is a pressing concern. Challenges in this area include verifying the accuracy of land monitoring data due to an insufficient number of samples and the need for independent validation. To address this, it is imperative to establish quality control measures for data collection. EU documents recommend the development and use of digital and remote sensors, apps, and handheld samplers to assess soil quality. Furthermore, ongoing innovation in soil monitoring techniques, such as remote sensing, geospatial analysis, and advanced sensor technologies, is needed to enhance data collection efficiency and accuracy. The EU Soil Strategy also encourages the identification of contaminated sites and the creation of an inventory and register of these sites to plan for their remediation. Additionally, it promotes a "TEST YOUR SOIL FOR FREE" initiative, aiming to provide crucial information about soil characteristics, such as pH, bulk density, soil organic matter, and nutrient balance. This information can help land users adopt best management practices. One valuable practice recommended by the EU Soil Strategy, which Montenegro currently lacks, is the introduction of a certificate of soil health to be provided during land transactions, ensuring that buyers are adequately informed about the condition of the soil they are acquiring.

4.2.4. Outline of sustainable measures and best practices already applied for the protection of agricultural land

In Montenegro, there is a growing awareness of the importance of soil protection and sustainable land use practices. Efforts to combat soil threats and promote sustainable agriculture are reflected in strategic documents such as the Strategy for the development of agriculture and rural areas 2023-2028. One significant initiative supported by the Instrument of Pre-accession Assistance Fund for Rural Development (IPARD) is the Agri-environment-climate and organic farming programme. This programme encompasses various agro-ecological and adaptive sub-measures aimed at soil protection and improvement. Some of these measures include:

- Cover crops have gained popularity among apple and vine producers in Montenegro. They are implemented to protect the soil surface from the impact of rainfall, reduce surface runoff, and prevent soil erosion.
- The Ministry of Agriculture, Forestry and Water Management in Montenegro is planning to instal platforms for precision agriculture equipped with sensors to measure meteorological and soil parameters at various locations in the economy. This technology enables data-driven decision-making for optimizing agricultural practices.
- Weather stations are installed at multiple locations to provide essential meteorological and soil data for agricultural planning and irrigation management.
- Implementation of soil laboratory testing schemes aids nutrient assessment and optimized fertilizer use.
- Cultivation practices including crop rotation.

4.2.5. Overview of the already adopted mechanisms and opportunities for effective adoption of adaptation measures for soil health protection

State support for agricultural development in Montenegro primarily relies on the Agrobudget, a comprehensive framework that encompasses various non-refundable incentives funded by the national budget. These incentives are designed to promote the growth of agriculture and rural areas and are implemented by the Ministry of Agriculture, Forestry and Water Management These funds were predominantly allocated to subsidies for milk, crops, livestock farming, and similar sectors. However, since the adoption in 2006, the Agrobudget has been aligned with the fundamental pillars of agricultural policy, which encompass market-price policies, rural development initiatives, and professional services within the agricultural sector.

Montenegro has engaged in fruitful partnerships with international organizations such as the World Bank, facilitated by its collaboration with the Ministry of Agriculture, Forestry and Water Management (MAFWM). Building on the World Bank's experience with the MIDAS I project, the European Union (EU) granted two IPA-funded projects in 2012 and 2013, which were executed by the World Bank.

These projects provided Montenegrin farmers and agribusinesses with opportunities to access grants resembling the EU's IPARD programme. Additionally, these initiatives bolstered the administrative capacity of national IPARD authorities. The total cost of the IPA 2012 and 2013 projects amounted to 10.5 million EUR, with Trust Fund I contributing 3.2 million EUR and Trust Fund II contributing 7.3 million EUR. Trust Fund II allocated 5.3 million EUR to grant schemes and 2 million EUR to the Land Parcel Identification System (LPIS) project. The Government of Montenegro contribution stood at 2,125,000 EUR. These projects facilitated the development of software, hardware, and digital orthophoto maps for Montenegro between 2016 and 2017.

4.2.6. Analysis of the current institutional and legal setup for effective adaptation of soils to climate change

Through the project Strengthening the Capacity of Montenegro in the Field of Integrating Climate Change Risks into the Planning Process and Preparation of the National Climate Change Adaptation Plan (2020-2024), implemented by the UNDP Office in Montenegro with the support of the Green Climate Fund, it is planned that Montenegro strengthens its institutional framework, expands the technical capacities of those responsible and involved in planning adaptation to climate change, improves the database needed for effective decision-making and defines a resource mobilization

strategy. Identified priority sectors in the process of adapting to climate change in Montenegro are agriculture, water, health, and tourism.

Montenegro has specific laws and institutions that address land and environmental management:

- The Law on Agricultural Land defines measures to protect agricultural land and improve its properties.
- The Law on Forests emphasizes sustainable forest management.
- The Code of Good Agricultural Practice offers measures for sustainable land management, including fertilizer application and storage recommendations.
- The Ministry of Agriculture, Forestry and Water Management is responsible for agriculture, water, and forestry policies.
- The Department for Plant Production manages perennial plantation registers and monitors plant production.
- The Department for Land Policy, Quality Schemes and Organic Production oversees policies and quality standards.
- The Forest Administration manages forest land and prepares annual forest management plans.
- The Ministry of Ecology, Spatial Planning and Urbanism oversees land protection, including the drafting of the Law on Land Protection.
- The Department for Air, Water and Soil in the Directorate for Ecology shapes environmental policies.
- The Environmental Protection Agency conducts environmental monitoring, including soil testing.
- The Institute of Hydrometeorology and Seismology monitors weather, climate, and provides climatological data.
- The Ministry of Interior, Sector for Emergency Management, handles disaster management.
- The Biotechnical Faculty, University of Montenegro is involved in agricultural research and education.

4.2.7. Highlight the existing soil data availability and quality. State if there are data constraints and data gaps

Montenegro has taken significant steps to evaluate and document its soil data, aimed at facilitating sustainable land management practices. A comprehensive soil mapping project was carried out by the Biotechnical Faculty in Montenegro, formerly known as the Agriculture Institute, spanning from 1958 to 1988. This ambitious initiative involved meticulous soil mapping at a 1:50,000 scale and drew on the study of two thousand soil profiles. The culmination of this endeavour is documented in the Soil Atlas, which contains detailed maps at the same scale, along with the publication Soil of the Montenegro Mountains, authored by Fustić and Đuretić in 2000.

Various laboratory methods have been employed to amass pedological data, encompassing both mechanical and chemical properties. Over nearly three decades, data from several thousand soil profiles were meticulously collected and manually recorded in six notebooks. This exhaustive effort resulted in digitizing approximately 7,666 profiles, constituting about 16,151 profile layers. Among these, approximately 4,986 profiles include mechanical property data, about 6,692 entail chemical property data, and roughly 4,030 encompass both mechanical and chemical property data. Additionally, around 3,536 profiles, comprising of approximately 6,555 horizons (with each profile featuring one or more horizons corresponding to distinct soil layers), have been georeferenced with geographical coordinates.

Through this data digitization and georeferencing process, it becomes feasible to construct a digital pedological map integrated with an extensive database. This integration allows for the interpolation and spatial representation of physical and chemical soil attributes. It enables the creation of thematic maps relating to soil texture (e.g., coarse sand, fine sand, silt, and clay) as well as crucial chemical properties (e.g., available phosphorus and potassium, soil pH, organic matter, and total carbonates).

Montenegro conducts annual soil condition monitoring, including testing for hazardous and harmful substances in soil, with funding provided by the state. The results of this monitoring are documented in the Annual Information on the state of the environment in Montenegro, prepared by the Environmental Protection Agency. However, it is important to acknowledge that monitoring potential soil pollution faces challenges due to the absence of an appropriate legal framework. The existing Law on Agricultural Land exclusively regulates agricultural land, leaving other land use categories like industrial areas, playgrounds, parks, residential zones, etc., without legally prescribed maximum allowable concentrations of hazardous and harmful substances.

4.2.8. Conclusions with key recommendations and priorities referring to soil adaptation to climate change

Montenegro's agricultural sector has the potential to adopt sustainable soil management practices, building on existing knowledge and capacities. However, several limitations such as limited access to up-to-date information, financial constraints, and inadequate infrastructure need to be addressed to encourage the widespread adoption of new technologies and sustainable practices.

To support farmers in Montenegro on their path toward sustainable soil use, it is crucial for stakeholders, including government agencies, research institutions, and agricultural organizations, to collaborate in providing access to resources, knowledge dissemination and policy support. The collaboration will enhance the adaptive capacities of producers and farms, ensuring the sustainable use of soils in Montenegro.

State support for agricultural development in Montenegro primarily relies on the Agrobudget, a comprehensive framework that encompasses various non-refundable incentives funded by the national budget.

It is necessary to strengthen the institutions responsible for soil protection through the strengthening of existing administrative capacities and organization of training programmes. Establishment of the Association for the Soil Research of Montenegro, which would have close cooperation with state institutions and local communities in the early stages of planning certain activities and would be involved in the decision-making process.

When it comes to soil data availability and quality, it is imperative to emphasize that the entire territory of Montenegro is not yet comprehensively covered with soil profiles. Ongoing mapping efforts continue to address these gaps, albeit certain regions or specific soil types may still lack adequate soil data coverage. Achieving a complete geographic distribution and soil property data coverage across Montenegro remains a goal.

Analyzing the gaps in soil function assessment and soil attribute data is crucial for comprehensive soil management. Initiatives are in progress to bridge these data disparities, ultimately leading to a more accurate understanding of soil health and functionality.

While strides have been made to assess and monitor soil degradation, comprehensive data is still needed to effectively tackle this issue. Initiatives like the Standardized Soil Profile Data are underway

to enhance global soil data coverage and quality, contributing to global mapping and modelling efforts.

Key Recommendations and Priorities:

Technology adoption:

- Encourage and incentivize farmers to adopt new agricultural technologies.
- Develop clear financial incentives, subsidies and grants for technology adoption.

Capacity building:

- Enhance training programmes and capacity-building initiatives for stakeholders.
- Bridge the communication gap between policy makers and the academia.

Financial resources:

- Allocate sufficient funding for research and development in soil management.
- Support initiatives for soil monitoring using digital and remote sensing technologies.

Legislation and regulation:

- Develop a comprehensive legal framework for monitoring and regulating soil pollution in all land use categories.
- Align existing laws with EU strategic and legal documents on soil protection.

Promote sustainable practices:

- Expand and support programmes like the Agri-environment-climate and organic farming initiative.
- Encourage the adoption of sustainable practices such as cover crops, precision agriculture, and soil testing.

International collaboration:

- Strengthen collaboration with international organizations for knowledge exchange and financial support.
- Leverage existing partnerships to enhance agricultural development and soil management.

Awareness and education:

- Implement awareness campaigns on the impact of climate change on soil health.
- Develop educational programmes at the community level to promote sustainable soil practices.

Land use planning:

- Incorporate climate resilience into land use planning and zoning regulations.
- Consider climate change projections when designating vulnerable areas.

Continuous monitoring and evaluation:

- Establish a robust system for continuous monitoring and evaluation of soil health initiatives.
- Regularly update and adapt strategies based on feedback and changing climatic conditions.

4.3. Status of water resources linked to climate change in agriculture

4.3.1. Analysis of water resources in the economy and their importance for agricultural production

Montenegro, characterized by its rich water resources, boasts an impressive annual runoff of 624 m^3/s, equivalent to 19.67 billion m^3. This abundance places Montenegro within the top 4% globally in terms of average runoff. Notably, a substantial 95% of this runoff is sourced from inland waters, underlining the economy's reliance on its domestic water bodies.

Examining the basins, the Adriatic basin, covering 6,268 km^2, stands out despite its smaller size compared to the Danube basin (7,545 km2). The Adriatic basin yields approximately 11.35 x 10^9 m^3/year, a remarkable 50% more than the Danube basin's output of 7.4 x 10^9 m^3/year. The average water content in the Adriatic basin is about 59.5 litres per second per square kilometre, surpassing the Danube basin's 31 litres per second per square kilometre.

The underground water potential in Montenegro is estimated at around 14,000 litres per second. The underground runoff module varies significantly across regions, ranging from 16 to over 70 litres per second per square kilometre. This variability is particularly evident in the karst terrains of the Lim and Ćehotina basins, part of the inner Dinarides.

In terms of population distribution and water supply, over 63% of Montenegro's inhabitants reside in urban areas, with an impressive 99% having access to public water supply. In rural areas, all three types of water supply systems, namely public, private, and individual, are well represented.

Despite this apparent wealth of water, Montenegro faces challenges. Approximately 35% of its territory grapples with a chronic lack of water, necessitating costly hydrotechnical interventions. Additionally, around 10% of the economy is faced with the issue of seasonal excess water.

Montenegro's annual precipitation is characterized by significant regional variations, ranging from about 800 mm in the north to a staggering 5,000 mm in the southwest. On the slopes of Mt. Orjen, in the village of Crkvice (940 m above sea level), precipitation may even reach 7,000 mm. The average annual number of days with precipitation is around 115 – 130 on the coast, or up to 172 in the north. On average, the wettest months have 13-17, and the driest 4-10 rainy days. The number of days with heavier daily precipitation (over 10 mm) ranges from 25 (Pljevlja) to 59 (Kolašin). However, the highest number of days with heavy rainfall occurs in Cetinje and amounts to 74 days. The unpredictability of precipitation patterns, coupled with the severity and frequency of droughts, poses risks to water availability.

The threat extends to the economy's land resources, with about 24,519 hectares at risk due to excess water. Of this, 14,924 hectares are in the Adriatic Sea basin, and 9,595 hectares are in the Danube basin. The existing drainage infrastructure in Montenegro is modest, and melioration efforts are particularly crucial in areas such as the Bjelopavlići plain.

While Montenegro is blessed with substantial water resources, the sustainability and effective management of these resources are critical. Addressing the challenges of chronic water scarcity, excess water, and uneven precipitation patterns requires a comprehensive approach to safeguard both water security and soil fertility.

4.3.2. Brief analysis of the irrigation status in the economy

In Montenegro, the focal point of current irrigation endeavours centres on Ćemovsko polje, a region meticulously managed by Plantaže Podgorica, where vineyards and orchards benefit from a balanced combination of sprinkler and drip irrigation systems. Below Ćemovsko polje, there is a source of drinking water of excellent quality, which is drawn from 23 wells by pumps with power of 90 l/sec. Additionally, the Grahovska River source hosts a reservoir, with a volumetric capacity of 1,000,000 m^3, designed to irrigate 400 ha; however, its partially constructed system requires extensive reconstruction efforts.

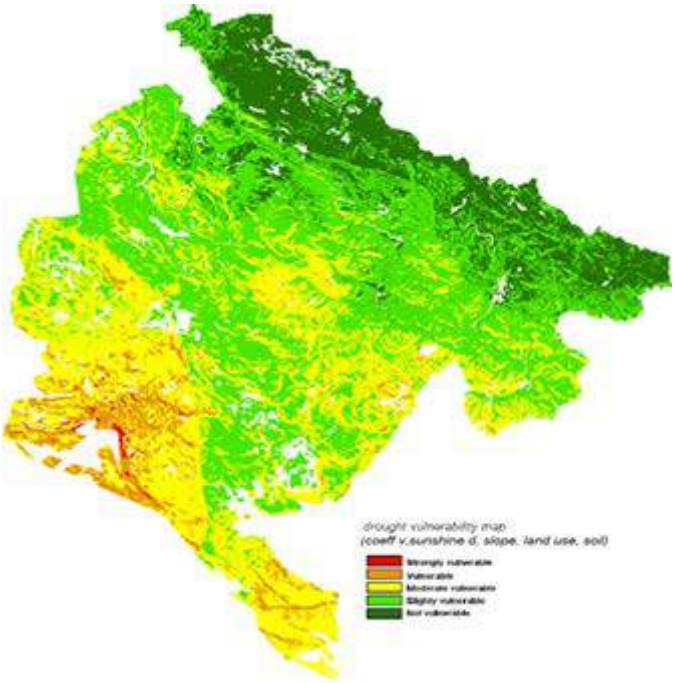
The overarching Water Management Strategy for Montenegro targets 74,090 ha of land for irrigation, envisioning an ambitious plan to cover 80% of this land by 2025 and reach full coverage by 2035. The anticipated annual water demand for this initiative ranges between 250 and 320 million m^3.

Delving further into specific regions, the plan for the coastal melioration zone along the Adriatic Sea, inclusive of the hinterland along the southern shore of Lake Skadar, includes an irrigation system covering 14,420 ha by 2025. The primary water sources for this region include the Bojana River, Lake Skadar and underground reservoirs, with an estimated annual water demand of about 70 million m^3. Moving to the central melioration area, spanning municipalities such as Podgorica, Danilovgrad, Nikšić, Cetinje, and partly Kotor, the objective is to cover 38,260 ha with irrigation by 2025. This expansive plan relies on diverse water sources, including Ćemovsko polje, Bjelopavlička ravnica, surface streams, direct abstraction, and the construction of reservoirs along the Zeta and Morača rivers. The northeastern melioration area, characterized by narrow river valleys, is subdivided into three constituent reclamation areas: Lim, Tara, and Ćehotina. The proposed irrigation scheme aims to cover 6,745 ha by 2025, primarily focusing on arable and fruit crops, with an additional 7,650 ha slated for coverage by 2035. Surface flows, reservoirs along the Lim, Tara, and Ćehotina rivers, as well as local springs, contribute to meeting the seasonal water needs.

The successful implementation of these irrigation plans necessitates a concurrent focus on regulatory frameworks to address evolving economic dynamics, particularly changes in land ownership and the inherent challenges of parcel fragmentation.

4.3.3. Drought risk assessment and crop water requirement

Monitoring of drought is carried out using IHMS, calculating the SPI index at different time intervals (30 days, 60 days, month, season, year, etc.), monthly SPI and monthly display of FVC and LAI indices related to vegetation status, and these were calculated from data obtained through the LANDSAF satellite (Map 4.1).



Map 4.1. Map of vulnerability of agricultural areas to drought

Source: IHMS, http://meteo.co.me/page.php?id=48

The climatic conditions in Montenegro give rise to two distinct phases in the soil water regime throughout the year: (1) a period of excess water from October to May, characterized by abundant rainfall, and (2) a subsequent period of water deficit during the growing season due to insufficient precipitation.

Regulating the water regime becomes crucial to mitigate the adverse effects of both excess and deficiency of water in the soil. The management of soil water conditions can be significantly addressed by implementing drainage and irrigation techniques in indoor areas and shielding them from external water influences. This approach not only eliminates negative effects but also establishes favourable soil conditions for essential agrotechnical activities, fostering high and stable agricultural production.

Experience gained from arranging soil regimes in areas designated for intensive plant production underscores the importance of employing horizontal pipe drainage. The economic impact of investing in drainage systems is manifold, extending beyond increased yields to ensure efficient soil drainage. In irrigation settings, drainage plays a pivotal role in controlling underground water levels, mitigating the risk of secondary salinization and preventing soil over wetting resulting from unexpected showers on recently irrigated surfaces.

4.3.4. Overview of farmers' existing adaptive practices for proper water use under climate change

In Montenegro, the agricultural sector plays a vital role, heavily relying on irrigation to ensure consistent crop yields, sustaining the livelihoods of many farmers. This essential practice extends to the cultivation of diverse crops, including fruits, vegetables, and grains. Rivers, lakes, reservoirs, and groundwater serve as primary sources of water for irrigation, with numerous farmers employing small-scale irrigation systems connected to local water bodies. As of now, approximately 10.78% of utilized agricultural land, totalling 5,204.2 hectares, is under irrigation. This area is distributed among 12,518 agricultural holdings in the economy, with an average irrigated area per holding standing at 0.42 hectares. Vineyards take the lead in terms of irrigated land, covering a substantial 96.24% of the total grapevine cultivation area. In contrast, perennial meadows and pastures have the least irrigated area, constituting only 0.11% of the total meadows and pastureland.

Farmers in Montenegro are adopting various adaptive practices to ensure proper water use and improve irrigation efficiency in crop production, especially in the context of climate change (Annex 4.1).

- Farmers use data from soil moisture sensors and weather forecasts to schedule irrigation based on the specific needs of their crops, reducing over-irrigation.
- Collecting and storing rainwater for irrigation during dry periods helps conserve freshwater resources.
- The use of mulch on the soil surface reduces evaporation, conserving soil moisture and improving water-use efficiency.
- Combining irrigation with the application of fertilizers through the irrigation system allows for efficient nutrient delivery to plants.
- Using UV-resistant nets can protect crops from excessive solar radiation and reduce water loss through transpiration.

The historical development of irrigation in Montenegro began in the post-World War II era, with notable progress in the 1970s and 1980s. Unfortunately, the redistribution of land post nationalization led to the fragmentation of parcels, resulting in the abandonment of large-scale irrigation systems. Currently, the sole operational irrigation system is managed by the Plantaže company in the Ćemovsko Polje area. Vestiges of modern systems exist in the Tivatsko Polje and Grahovsko Polje areas, though they are not in use.

Table 4.3. ETP and irrigation water requirement, applied irrigation techniques and irrigation regime by group of crops

	ETP by season (mm)	Irrigation water requirements by season (mm)	Applied irrigation techniques	Irrigation efficiency	Irrigation application rate (mm)	Number of applications during the season
Maize	720,4	345.2	Sprinkler	60-70%	50-60	6-7
Wheat	454,9	30.5	-	-	-	-
Fodder crops – alfalfa	736,0	279.0	Sprinkler	60-70%	50	6
Vegetables – tomato	726,1	388.8	Drip irrigation	70-90 %	15	25
Orchards	718,9	263.8	Drip irrigation	70-90 %	20	13
Vineyards	472,6	133.2	Drip irrigation	70-90 %	15	9

Statistics reveal that approximately 20% of arable land in Montenegro is irrigated, with actively irrigated agricultural land accounting for 6%. As outlined in strategic plans, the goal is to extend irrigation coverage to over 74,000 hectares by 2035, encompassing around 25% of agricultural land. The role of irrigation is crucial in facilitating intensive crop cultivation, and efforts are underway to both expand irrigation coverage and enhance the quality of existing methods and systems. It is important to note that the outcomes of irrigation projects are inherently long-term, requiring sustained efforts. Analyzing the various irrigation methods, sprinkler irrigation and localized irrigation emerge as the most cost-effective in Montenegro. The focus is on sprinkler irrigation systems, estimated to cost between 1,100 and 1,900 EUR per hectare, depending on the specific configuration. The Montenegrin government has acknowledged the significance of irrigation for agricultural development and has implemented measures to support farmers, including financial incentives, subsidies for irrigation equipment, and technical assistance.

The Montenegrin government has recognized the importance of irrigation for agricultural development and has implemented various measures to support farmers. These measures include financial incentives, subsidies for irrigation equipment, and technical assistance.

- IPA 2014 – Capacity building for the implementation of the Water Framework Directive in Montenegro. The total amount is 1.9 million EUR. Results: improvement of water quality standards, improvement of information on water resources and definition of models for sustainable water management in accordance with European Union standards.
- IPA 2016 – Support to the implementation and monitoring of water management. The total amount is 2.4 million EUR. This project will implement other water directives, which are not part of the IPA 2014 project, which is essential for the quality establishment of water management systems in accordance with EU water directives and implementation of all obligations in the water sector as part of Chapter 27.

4.3.5. Summary of national strategies and adaptation plans for water use in agriculture, including reports, R&D, projects and communications of the international CC (adaptation) framework (UNFCCC)

The agricultural sector is very vulnerable to climate change due to its dependence on specific temperature conditions and water availability, and is exposed to climatic disasters such as droughts and floods. The water sector shows a decrease in the water balance in all river basins in Montenegro. A decrease in the amount of rain and snow will drastically affect the availability of surface water. Adaptation measures should focus on the application of an integrated approach in the management of water resources and systems and the strengthening of intersectoral planning and activities. List of documents:

- Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks
- Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control
- Law on Waters (Official Gazette of Montenegro, No. 32/11, 47/11 48/15, 52/16, 02/17, 80/17, 84/18)
- Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood
- Risk Management Plan (Official Gazette of Montenegro", No. 69/15)
- Nation Plan of Protection and Rescue from Flooding, December 2019
- Water Management Strategy, 2017
- Preliminary flood risk assessment for the Danube River Basin

Changes in the water balance are becoming an increasingly pronounced problem for economies prone to drought, such as Montenegro. Therefore, it is necessary to develop appropriate capacities for stable irrigation through support for investments in water supply (wells, reservoirs, etc.). Building micro-reservoirs can be a viable strategy to cope with fires and water shortages in livestock and crop production. These small-scale water storage systems can play a crucial role in water conservation, improving agricultural resilience, and mitigating the impact of droughts. During droughts, micro-reservoirs can serve as a critical water source for livestock and irrigation, reducing the dependency on traditional water supplies and helping maintain agricultural productivity. Building micro-reservoirs can be an investment, and securing funding for the construction and maintenance may require collaboration between governments, agricultural organizations, and private stakeholders. It is necessary to conduct educational programmes and training sessions to raise awareness about water conservation practices and the importance of using water resources judiciously. Financial support or incentives to encourage farmers to adopt water-efficient technologies and practices, are needed. This can help overcome initial investment barriers and promote widespread adoption.

Establishing adequate monitoring of the quantitative and qualitative status of water is crucial for effective water resource management. This monitoring helps identify potential issues, potential risk of floods and droughts, track changes over time, and inform decision-makers. There are still parameters that are not monitored adequately due to lack of financial resources, lack of equipment and trained staff. Groundwater monitoring needs to be improved, and data collected from those stations needs verification and quality control in order to be used for analysis and distribution.

Water Management Strategy 2017-2035 prescribes the construction of irrigation systems that would cover 80% by 2025, or 100% by 2035, of the total available land suitable for irrigation. According to the Water Management Strategy, land suitable for irrigation is estimated at 74,090 ha. On the territory of Montenegro, 24,519 ha of land is set aside, which is threatened by the presence of excess water of various origins, which needs to be drained. So far, drainage works are modest.

4.3.6. Overview of the policy and institutional setup, and legislative framework for adaptation activities relevant to the sector in the economy

Montenegro, as a signatory to the Declaration on the Green Agenda aligned with the European Green Plan, commits to climate change measures, pollution prevention, and sustainable development in areas like energy, transport, circular economy, biodiversity, and agriculture.

The Law on Waters is a fundamental legal framework (Article 51) mandating entities using water for irrigation to install devices, monitor water quantity and quality, and ensure technical accuracy. Water for crop irrigation must meet prescribed quality standards (Article 61), determined by the Ministry of Agriculture, Forestry and Water Management.

The Water Management Strategy 2017-2035 outlines long-term water management directions, addressing flood risk assessments in the Danube and Adriatic basins.

The Water Framework Directive and Nitrate Directive implementation involves by-laws, including regulations on water quality for irrigation.

Under the Code of Good Agricultural Practice, periodic control of irrigation water is essential to avoid soil salt accumulation, with consultation recommended for specific issues.

In the administrative realm, the Ministry of Agriculture, Forestry, and Water Management plays a pivotal role. It spearheads the establishment of water policy, endeavours to harmonize national

legislation with EU standards, and proposes the adoption of laws and strategic documents. Crucially, the Water Administration, as the primary executive authority, oversees the issuance of water permits for both surface and groundwater use. Owners or users of irrigation facilities bear the responsibility of managing and maintaining these systems, with proportional costs according to usage.

The Ministry of Ecology, Spatial Planning and Urbanism reports on environmental quality, while the Environmental Protection Agency monitors the overall environmental status.

The Institute for Hydrometeorology and Seismology monitors water quantity and quality, forecasting floods, and adheres to the Water Framework Directive. The Ministry of Interior, specifically the Directorate for Emergency Situations, manages emergency responses, including flood protection and rescue measures.

4.3.7. Existing data availability and quality

The IHMS is responsible for monitoring the quantitative and qualitative state of surface and ground waters, and has a multi-decade series of data on water quality and quantity. However, some data are not in electronic format and require quality control in order to be used for analytical purposes.

Water quality datasets, spanning over 50 years, primarily comprise of physical-chemical, microbiological, and saprobiological data. While the IHMS surface water quality network is robust, covering 36 sampling profiles, 11 measuring points on lakes, 16 coastal sampling points, and 9 groundwater locations, further expansion is needed, particularly in tributaries and smaller watercourses, focusing on the coastal region. Integration of biological and hydromorphological indicators, as well as priority substances, aligning with Water Framework Directive (WFD) requirements, is imperative. In addition to the existing network for groundwater monitoring, in the second half of 2019, the first phase of the groundwater monitoring network was established, which includes existing boreholes, new boreholes and water sources and which will be part of the future monitoring system. The installed equipment measures water level, water temperature, and at a certain number of locations, conductivity. Data collected from those stations need verification and quality control in order to be used for analysis and distribution.

Given that data on water (including the coastal sea) can be found in several institutions in Montenegro, it is necessary to revise, standardize and enter them into a single water database. Unifying all available data, checking their quality and compatibility, and translating available historical and metadata into electronic forms is required. Needs and challenges:

- Adequate maintenance of the established network of stations
- Employment of professional staff (chemists, technicians, hydrogeologists)
- Additional training of existing personnel
- Establishment of the Department for Groundwater
- Provision of adequate financial resources for the implementation of water monitoring, in accordance with the requirements of WFD
- Improvement of laboratory equipment for water quality

4.3.8. Conclusions with key recommendations and priorities referring to proper water use and climate change adaptation

Montenegro faces pressing challenges related to water use and adapting to climate change in agriculture. The existing irrigation infrastructure is inadequate and deteriorating, resulting in underutilization of water resources. The economy is vulnerable to climate change impacts, including increased temperatures, altered precipitation patterns, and more frequent droughts, which pose significant threats to agricultural productivity. However, improved water management has the potential to substantially enhance agricultural output, reduce imports, and contribute to economic growth. It is crucial to note that unregulated water use can lead to adverse environmental consequences, such as over-extraction of water resources, habitat degradation, and compromized water quality. Only 14,441 (5.7%) hectares of agricultural land in Montenegro are used for plant production (fruits, vegetables and vineyards). Currently, the total irrigated area is 2,466 ha (16% of the area for plant production) and mainly refers to vineyards, fruits and vegetables, which are located in the surroundings of Podgorica, mainly in the area of **Ćemovsko** polje. Bearing in mind the limited area of land for plant production and the amount of water available for irrigation, there is a need to increase the use of water for irrigation, whereby ensuring its sustainable management. Changes in the water balance are becoming an increasing problem for drought-prone economies like Montenegro, which is why it is necessary to build adequate capacities for stable irrigation by encouraging investments in water supply (wells, reservoirs, etc.). Implementing sustainable water use practices in agriculture can be a complex endeavour, often met with several challenges. Firstly, there may be a lack of awareness and knowledge among farmers regarding the benefits and techniques associated with sustainable water use practices. Additionally, the transition to sustainable methods often requires upfront investments, which can be a financial barrier for many farmers, particularly in resource-constrained regions. Inadequate irrigation infrastructure and restricted water availability further complicate the implementation of sustainable practices. Limited access to reliable water sources can also constrain the adoption of efficient irrigation techniques. Regulatory challenges, such as inconsistent or unclear policies related to water use and irrigation practices, can create uncertainty for farmers. Lastly, limited access to financing or credit for investments in water-saving technologies can be a significant obstacle for farmers looking to make sustainable changes in their agricultural practices.

Key recommendations and priorities:

- Invest in the modernization and expansion of irrigation systems, emphasizing efficient and sustainable techniques, like sprinkler and localized irrigation.
- Promote water-saving practices, such as drip fertigation, soil moisture conservation, and efficient irrigation scheduling to optimize water use.
- Encourage research and development in climate-resilient crop varieties and farming practices that require less water.
- Develop and implement comprehensive water management policies and legislation that address agricultural water use and climate adaptation.
- Provide training and support to farmers to adopt water-efficient practices and technologies.
- Establish robust monitoring systems to track water use and climate impacts, aiding informed decision-making.
- Raise awareness among farmers, local communities, and government officials about the importance of water conservation and climate-responsive planning.

4.4. Crop production analysis linked to climate change in agriculture

4.4.1. Analysis of meteorological data availability and accessibility

Montenegro is a economy rich in diversities and climate is also one of them. Based on a large number of climatic factors Montenegro is divided into 6 climatic regions:

Climatic region 1 includes the coastline and the coastal part at an altitude of about 500-600 m a.s.l. (Ulcinj, Bar, Budva, Kotor, Tivat and Herceg Novi). This region has a maritime type of climate, moderately hot and dry summers and mild winters, the cold part of the year is rainy.

Climatic region 2 covers mountainous hinterland of the Adriatic and southwest of Montenegro (Cetinje, Grahovo, Crkvice and Vrbanj). This region represents the border area between land and sea and is characterized by a modified maritime-continental climate, with minor admixtures of mountain climate.

Climatic region 3 refers to the central part of the Zetskobjelopavlić plain up to about 500-600 m a.s.l. (Podgorica, Danilovgrad, Zeta, Tuzi and Virpazar). This region has a continental type of climate, significantly modified by the maritime influence.

Climatic region 4 includes western part of Montenegro and central part from 500 to 1000 m a.s.l. (Nikšić, Šavnik, Plužine, Krstac, Vilusi and Velimlje). This climatic region has a rather homogeneous continental climate, significantly modified by the maritime type and with minor modifications by the mountain type.

Climatic region 5 consist of northern lowlands at 600-1000 m a.s.l. (Berane, Bijelo Polje, Pljevlja, Andrijevica and Plav). This climatic region has a continental type of climate with moderately warm summers and cold winters.

Climatic region 6 represent mountainous northern and central part of Montenegro from 1000 m a.s.l. and more (Žabljak, Kolašin, Rožaje and Mojkovac)· This climatic region includes mostly mountainous areas above 1000-1200 m a.s.l. It is characterized by a continental mountain climate, modified by the Mediterranean influence.

Systematic meteorological measurements and observations in Montenegro began in 1949. The Institute for Hydrometeorology and Seismology is a reference institution with full responsibility for making and presenting weather and water forecasts, issuing warnings and announcements for extraordinary and dangerous meteorological and hydrological phenomena. The number of measuring stations is not constant and changes from time to time. Monitoring of meteorological indicators in 2022 takes place at 33 measuring stations throughout Montenegro. Of this number, 9 are meteorological (main), 12 climatological and 12 rainfall stations. At meteorological stations, measurements and observations are made every hour, at climatological stations 3 times a day (7, 14, 21 hours) and at rainfall stations once a day – at 7 a.m. (local time). In addition to the above, there are two airport stations, but they are not part of the national network of meteorological stations.

The Institute has meteorological stations in all Montenegrin municipalities, but the level of equipment of the stations and the method of reporting from the stations are not the same. Only in 9 municipalities there are automatic meteorological stations that send data via GPRS directly to the IT centre in Podgorica (capital) and have the possibility of direct presentation on the website. It is much easier to work with such stations, the data is more up-to-date and arrives in the IT centre in real-time. Data

availability for most measuring stations is from 1950, except for some that were established later.

Current – daily data are available in real time for everyone. Historical data (month, year and multi-year averages) are stored in databases and are available on request. For the academic community, experts, researchers and work of public interest they are free, but for commercial purposes, they must be paid for. The entire money obtained in this way goes to the state budget. The price of meteorological data depends on the extent of commercialization and is determined by relevant authorities (more in Annex 1).

4.4.2. Analysis of the most common agrometeorological indices available and used in the national context

The parameters most frequently used in agrometeorology in Montenegro are air temperature (average daily temperature, maximum and minimum daily temperature), amount of precipitation (total, maximum daily rainfall), precipitation intensity, rainy and dry periods during the year, number of rainy days, number of days with strong precipitation, relative air humidity, air pressure, number of tropical days, duration of warm tropical waves, snow, average annual number of frosty days, cloudiness, extreme unfavourable weather conditions such as flooding, strong winds, hail, etc.

Analysis of climatic anomalies, expressed through differences in values of climatic parameters between climate normal (1961-1990) and the ten-year period from 2013 to 2022, shows that the climate in Montenegro is rapidly changing. There is an increasing frequency of extreme rainfall and floods, extreme air temperatures and drought. Constant increase in average annual air temperature is happening on the entire territory of Montenegro (from 1.24°C in climatic regions 1 and 2 to 2.26°C in climatic region 5). With the increase in temperature, the number of tropical days (from 2.9 in climatic region 6 to 66.1 days in climatic region 3) and the duration of tropical waves also increase. At the same time as the temperature rises, the average annual number of frosty days decreases. This reduction is the most pronounced in climatic region 3 (modified maritime climate) and climatic region 6 (mountain climate area) – 52% and 26%, respectively.

Analysis of the amount of precipitation did not reveal significant changes. However, a slight increase was recorded in all climate regions (from 0.64% in region 1 to 5.83% in region 3). Analysis of the amount of precipitation did not reveal significant changes. However, a slight increase was recorded in all climate regions (from 0.64% in region 1 to 5.83% in region 3). Although the amount of precipitation has remained at approximately the same level, there are significant changes in the precipitation regime – pronounced rainy and dry periods during the year. In addition, there was a decrease in the number of days with heavy precipitation and an increase in the amount of precipitation in that period. All this points to the possible occurrence of extremely unfavourable weather conditions such as floods.

In addition to the above, there are 27 climate indices in use that combine two or more parameters (drought index, heat index, cooling index, etc). From the aspect of plant production, the drought index (SPI) is of great importance due to its connection with productive soil moisture reserves and surface and underground water levels. It provides information on the state of moisture in the soil and the state of plant stress, especially during the growing season. It can be calculated for different time intervals (e.g. 30 days, 60 days, season, year, etc.). It represents the probability of the realization of a drought and is used to analyze the beginning, duration and intensity of a drought. To monitor the SPI index, its values are calculated for 30 days, 60 days, 90 days, 120 days, 150 days, 180 days, 270 days and 360 days back from the current date (more in Annex 2).

4.4.3. Analysis of phenological monitoring

Phenological observations have been systematically carried out since 1951. The Institute for hydrometeorology and seismology has a phenological database with data classified into seven categories: fruit trees, vitis, forest trees, field crops, plant diseases and pests, bees and general field activities. The number of plants in each group, as well as the monitored parameters, depend on the characteristics of the climate region in which the given phenological station is located, but also on the development of agricultural production in it. Phenology can significantly contribute to a better understanding of climate change, but also of plant production in general. Knowing the timing of phenological events and their variability provides valuable data for planning, organizing and timely execution of certain agrotechnical measures that require precise information about the dates of certain phases of crop development. Data obtained by phenological observations represent the basis for studying the influence of weather and climate on the development of plants. Currently, seven meteorological stations are active.

As a result of global warming, the length of the growing season has increased in all climate regions. When it comes to cryophilic crops, they increase ranges from 21 days in climatic regions 2 and 4 to 30 days in climatic region 3. Climatic region 1 has the longest growing season – 365 days, and climatic region 6 the shortest – 206 days. Vegetation in spring starts earlier by 7 (climatic region 2) to 30 days (climatic region 3), and ends later in autumn by 12 (climatic region 4) to 17 days (climatic region 5). An increase in the growing season was also registered with thermophilic crops, from 10 days in climate region 2 to 45 days in climate region 3. Climatic regions 3 and 2 have the longest season for this group of crops – 283 and 285 days, and climatic region 6 has the shortest season with 135 days. Vegetation in spring starts earlier by 5 (climatic region 2) to 32 days (climatic region 3), and ends later in autumn by 4 (climatic region 4) to 13 days (climatic region 3).

In addition to phenological observations, soil measurements are also carried out at 11 agrometeorological stations at seven depths: 2, 5, 10, 20, 30, 50 and 100 cm (more in Annex 3).

Crop modelling is still not used in Montenegro.

4.4.4. Analysis of extreme weather events

Based on comparative analysis of the most important meteorological parameters, it can be concluded that the number of very cold days in Montenegro is decreasing, the number of very hot days is increasing, as well as the duration of heat waves.

The number of days without rain is increasing, as is the intensity of precipitation. Reduction in the number of days with strong precipitation and increase in the amount of precipitation during that period indicates an increase in precipitation intensity, as well as the occurrence of extreme unfavourable weather conditions. All this leads to sudden changes in air temperature, sudden changes in the precipitation regime, as well as changes in the type of precipitation. In some seasons, rapid growth of snowfall occurs, followed by years without snow. All of this fits into the global picture of climate change in Montenegro.

Extreme weather conditions have been a frequent occurrence in the last twenty years in Montenegro. Taking into account the size of the threatened area, the intensity and duration, as well as the amount of damage caused to agricultural production, the following stand out as the most important: floods (Nikšić, 2010, Tuzi, 2012, Plav, Kolašin, Bijelo Polje and Podgorica, 2023), low temperatures and strong north-eastern wind (Bar and Ulcinj, 2017), stormy wind (Tuzi, 2019), wet snow and freezing rain (Bijelo Polje, 2021), hail (Podgorica, 2022), drought (entire territory of Montenegro, 2022), high temperature and heat waves (entire territory of Montenegro, 2015, 2017, 2020, and 2021) (Annex 4.2).

4.4.5. Information on the most important crops sensitive to climate change, vulnerable regions and their combination

Dominant crops on arable land are potatoes, corn, wheat, barley, alfalfa, and clover. Among the fruit species, vines, plums, tangerines, apples and olives are mostly grown. In recent years, spring frosts have been causing increasing damage to lemon, cherry, apricot, and peach plantations in southern regions and almost all fruit species in continental areas. Drought and high temperatures are regular occurrences in ware and seed potato production, causing significant yield reductions. In the central and northern areas of the economy, genetic resources of field, vegetable and fruit species are grown on a smaller scale. They are mostly used in organic production and their cultivation is not related to their resistance to climate change. In general, rainfed agriculture in Montenegro is under increasing pressure from climate change. The most common damages to these crops are the result of high temperatures, long heat waves, drought, excessive amount of water, late spring frosts, hail, strong winds, etc.

Each climate region in Montenegro is vulnerable to climate change in a specific way due to its exposure to climate hazards. In climatic region 1 (area of Mediterranean climate), lemon is undoubtedly the most vulnerable to climate change. Due to its pronounced sensitivity to low temperatures, it suffers frequent consequences from spring frosts. In climate region 3 (an area with continental climate, significantly modified by maritime influence) problems with spring frosts are most felt by cherry, apricot and peach. In this region, extreme rainfall at the beginning of the growing season is also a threat. This problem is particularly pronounced in the production of early potatoes, where an excessive amount of water causes significant yield losses and a significant increase in production costs (planting delay, crop failure and increased crop protection costs). In regions 4 and 5 (both have a continental climate), late spring frosts cause significant damages to plantations of almost all fruit species. Due to the high prevalence of flat surfaces, most field crops in these regions suffer from abundant spring rainfall. The production of ware and seed potatoes is particularly risky in high mountain areas (climate regions 4, 5 and 6, continental and mountain climate). Due to the late planting caused by heavy spring rainfall, newly emerged potato plants are threatened by high temperatures. In these regions, potato plants regularly have problems with late spring and early autumn frosts.

4.4.6. Information on practices used by the farmers to protect their crops from damages caused by weather variability (hot weather, drought, excessive water, hail, intensive sun, etc.)

Previous experience shows that the greatest impact of climate change on agriculture will be realized through water. For these reasons, farmers in their production increasingly practice irrigation because only in such conditions they have a secure income. Today, 16% of the total area for crop production (mainly vineyards) in Montenegro is irrigated, with a constant trend of growth. In recent years, the use of water-soluble fertilizers, which dissolve easily in water and enable immediate uptake of nutrients by plant roots, even in the conditions of the lower soil moisture content, has also been increasing. In order to protect plants from low temperatures at the beginning of the growing season, more and more farmers are using greenhouses and other forms of protected structures. In addition, they can produce a large number of crops in a protected area in the period when in the period when it is not possible in the open field. In the production of highly profitable crops, a small number of producers, during the winter months, use different ways of heating the protected area. Producers who do not have the conditions to heat the greenhouse use agrotextile as a measure of protection against low temperatures. In the open field, the use of agrotextiles is becoming more and more popular as well. In mountainous areas, potato producers increasingly practice later planting because young

plants can more easily tolerate high summer temperatures and drought. In this way, the phases of intensive vegetative growth and tuber growth are shifted to the end of summer, when, along with lower temperatures, there is usually more precipitation. For this purpose, they use mid-late season varieties. Due to the important damage caused by hail to the production of fruit and grapevine, use of anti-hail nets is becoming more and more popular, especially in intensive plantings. In the production of vegetables, especially species sensitive to strong insolation, the use of shading nets is increasing.

4.4.7. Information on climate change adaptation measures and practices already tested/ promoted in the economy

The national strategy in the field of climate change until 2030 is a key policy instrument for climate change management in Montenegro. In addition, other documents related to protection against the negative impacts of climate change were adopted: Strategy of agriculture and rural areas development 2023–2028, Strategy for low-carbon development of Montenegro, Adaptation plan to climate change in Montenegro, Law on protection against negative impacts of climate change, etc. The preparation of the National Climate Change Adaptation Plan (NAP) is underway. The priority of the plan are water, health, tourism and agriculture, as the four most important and most vulnerable sectors in terms of adapting to climate change.

The National Strategy on Climate Change until 2030 has a vision for Montenegro to adapt to negative effects and establish sustainable development with a low carbon content by 2030. With this document, Montenegro undertook to reduce greenhouse gas emissions by 30% by 2030 compared to the base year of 1990.

The Strategy for the Development of Agriculture and Rural Areas 2023-2028 predicts the establishment of eco-scheme programmes aimed at sustainable management of resources and adaptation of agriculture to climate change. Through rural development policy measures, significant support is provided for sustainable development and efficient management of natural resources, development of organic production, management of manure on farms, reduction of dependence on chemicals and transformation of small farms in order to strengthen their competitiveness and resistance to climate change.

The impact of climate change on agriculture is increasingly pronounced, so the fear that it could quickly reach dramatic proportions is quite justified. Given that Montenegrin agriculture is very vulnerable to climate change, it is necessary to urgently take measures to adapt it. In addition to the activities aimed at mitigating climate change in the coming period, more attention should be focused on the development and establishment of effective systems of adaptation. In order to oppose more efficiently the upcoming changes, producers need much stronger state support because they alone lack capacities. Meaningful public policy will enable farmers to improve their production systems and to adjust the structure of their farms. Well-designed rural development measures can significantly contribute to mitigating the risks of climate change. The future of crop production in Montenegro is directly dependent on water resources. Irrigated area must be significantly increased, but also it should be provided greater availability and efficiency of water use.

Organic production has a less negative impact on climate change and the environment, and therefore more serious work should be done to spread it. This type of sustainable agricultural production is better adapted to climate change, so in unfavourable years, higher yields are obtained compared to conventional production.

The effects of climate change can be mitigated by choosing drought-resistant crops and varieties.

When choosing varieties, plant genetic resources should also be taken into account because some old varieties and populations, due to their adaptability to local production conditions, show a certain resistance to high temperatures and drought. The importance of the selection and timely application of fertilizers in conditions of climate change is becoming greater. By correctly choosing the type of fertilizer, time and method of application, plants will better adapt to the changed conditions of moisture and temperature that occur due to climate change.

4.4.8. Information on the measures from the national agricultural policy, and from national systems for support to agriculture that can be related to climate change adaptation

Direct support to producers for climate change adaptation in this field of agriculture is reflected in a large number of measures implemented within the agricultural budget and the IPARD programme. The aim of these measures is to reduce the sensitivity of the agricultural sector to climate change, as well as to improve production efficiency, productivity growth and competitiveness of the sector. These funds support investments for procurement of irrigation systems, sprinkler systems, water tanks, heating equipment in protected structures, nets, anti-hail nets, greenhouses, plastic foils for greenhouses, nets for shading, agrotextiles, as well as for drilling wells, building clears, etc.

Among the measures that increase the resilience of the plant production sector, it is important to mention support for the application of innovative technologies and practices, support for the application of smart technologies to combat climate change, support for the preservation and sustainable use of endangered autochthonous species, support for production insurance, support for farmer education and many others.

4.4.9. Infrastructure and systems for preventing and mitigating the negative effects of weather extremes on crop production, data availability and quality

In Montenegro, there is no infrastructure for protection, monitoring, analysis, and forecasting of the impact of weather phenomena and weather extremes on crop production.

Official data on the impact of climate change on crop production, damage caused to cultivated crops and agricultural infrastructure, as well as measures taken to mitigate these impacts are very scarce. There are no databases that aggregate such information.

4.4.10. Conclusions with key recommendations and priorities referring to crop production and adaptation to climate change

In addition to activities to mitigate climate change in the future, more attention will be focused on the development of effective systems of adaptation. Water shortages, floods, extreme weather events, as well as shifting of growing seasons will have a growing impact on agricultural production. Therefore, farmers will have to intensively adapt to the new climatic conditions. As agriculture is directly dependent on natural ecosystems and processes in it, it is that preservation of natural resources that can significantly mitigate adverse impacts of climate change. Models of large-scale agricultural production are not the right answer to the challenges of changing climate and increased demand for food. For these reasons, small-scale food production, due to greater concerns about the environment, will become more and more important in the future.

Among the most important measures that should be prioritized in the future, the following stand out:

- Given that the trend of rising temperatures and changes in the precipitation regime is expected to continue in the future, it is quite certain that irrigation will represent one of the key mechanisms for adaptation and mitigation. Therefore, irrigated areas must be significantly increased, but also greater availability and efficiency of water use ensured.
- Invest in appropriate agricultural innovations, which will include work on the creation of new varieties that will be tolerant to drought, high temperatures, diseases and other stressful situations.
- Soil erosion is a serious threat to agriculture, which can be accelerated by climate change. That is why agricultural areas should be kept under plant cover for as long as possible, preferably in the winter months, fertilized regularly with organic fertilizers and unnecessarily deep and excessive tillage avoided.
- Stronger investments in organic production considering low utilization and pollution of agricultural land.
- Adaptation of farmers to the conditions that are expected to occur in the future, which may mean abandoning the cultivation of certain crops and introducing some new ones into production.
- Support to farmers who practice acceptable agroecological measures.
- Finding solutions to rationalize consumption and increase the efficiency of energy use in agriculture.
- Strengthening public awareness, knowledge and skills of agricultural administration, advisory services and farmers in all areas related to climate change mitigation and adaptation.
- State support for risk management through insurance schemes.
- Establish climate, crop databases, and provide quick and easy access.

4.5. Livestock farming analysis linked to climate change in agriculture

4.5.1. Short overview of the livestock sector in Montenegro

Livestock farming in Montenegro is a very important sector of agriculture, as it contributes to approximately 50% of the total value of agricultural production. Its importance is particularly reflected in the fact that less productive areas such as pastures and meadows, which dominate the overall agricultural land structure (around 95%), are utilized through the rearing of ruminants (cattle, sheep and goats).

In the period from 2010 to 2022, the population of cattle, sheep and horses decreased by 15 to 20%, while the population of pigs, goats, and poultry grew by 15 to 25%, and the number of beehives increased in the same period by almost 70% (Table 4.4).

Cattle breeding is the most important sector of livestock farming. The dual-purpose production of milk and meat dominates. Typical dairy farms, with e.g. 20 or more dairy cows, with intensive farming system, are predominantly located in the area of municipalities Nikšić, Podgorica and Danilovgrad, near the main dairy processing facilities. However, most cattle farms, especially those in the northern region, apply a semi-intensive or semi-extensive farming system, which implies use of grazing during the vegetation season and rearing in barns during winter and feeding with fodder and concentrated feed.

Sheep production is almost entirely based on the use of available resources of meadows and pastures. It is characterized by a semi-extensive/intensive way of production, mostly based on rearing local sheep breeds with traditional seasonal moving of flocks to the high mountain pastures.

Table 4.4. Status of the Montenegrin livestock sector, 2010 - 2022

Item	2010	2016		2022	
Livestock	**No. of heads**	**No. of heads**	**No. of farms**	**No. of heads**	**Livestock units**
Cattle	95,963	89,269	21,939	71,166	61,959
Sheep	198,165	191,992	5,514	165,918	16,008
Goats	23660	31,458	3,200	29,032	3,859
Pigs	11,205	55,840	13,607	24,329	7,0566
Horses	4,828	3,947	2,775	3,618	2,341
Poultry	506,520	835,705	17,067	569,752	13,161
Beehives	42,237	67,705		71,597	
Total					**104,384**

Source: Monstat – Statistical yearbooks

Goat breeding is a very important sector in the karst area of the central and south Regions. Half of the total poultry production is intensive production as commercial farms of laying hens or broilers, while pig production is mostly organized on small family farms, usually with five to 10 sows, which could also be considered intensive production.

Almost all forages (hay and silage) for feeding ruminants are produced on cultivated grasslands and natural meadows. However, this production is very variable from year to year, due to frequent fluctuation in climatic conditions, the lack or impossibility of establishing an irrigation system, etc. The quality and nutritional value of the produced forage often varies. All concentrate feeds are imported

for feeding both ruminants and non-ruminants (poultry and pigs).

The free movement of people and animals, as well as pronounced climate change, have contributed to the emergence of some infectious diseases in domestic animals, which has caused major negative socio-economic consequences. Thus, three particularly dangerous infectious diseases of animals appeared in Montenegro in the last decade: lumpy skin disease in cattle, blue tongue disease (in sheep) and the permanent potential danger of the African swine fever.

4.5.2. Analysis of meteorological data availability and accessibility

Systematic meteorological measurements and observations in Montenegro were established in 1949. The Institute for Hydrometeorology and Seismology (IHMS) is the responsible institution for the meteorological data in Montenegro which are gathered daily from 9 main meteorological (synoptic) stations: Bar, Cetinje, Ulcinj, Herceg Novi, Podgorica, Nikšić, Kolašin, Pljevlja and Žabljak, as well as 2 airport stations (not part of the national network of meteorological stations). Daily precipitation data contains data from 36 measuring stations (main climatological, ordinary climatological and precipitation stations). Nine automatic meteorological stations have been in use since 2004.

At the main meteorological stations and a smaller number of climatological stations, measurements and observations are made every hour and data are sent for international exchange. At a larger number of climatological stations, measurements and observations are made 3 times a day at 7, 14, 21 hours, while at rainfall stations, measurements and observations are made at 7 o'clock (local time). Meteorological data are reported annually by the Yearbook, which can be found at https://www.meteo.co.me/page.php?keyword=reports.

Generally, the climate in Montenegro is very diverse. There are several climatic zones: Mediterranean in the coastal and lowland area around Skadar lake; continental climate in river basins and valleys, and alpine climate in mountainous areas of the economy. According to long-term meteorological analysis reported in the National Report on the Environmental Status in Montenegro (https://wapi.gov.me/download/3b8af3ba-368b-45a9-8180-d48fb62c8e90?version=1.0), the growth trend of air temperature is evident in the second half of the 20th century in most of the territory of Montenegro. Extreme heat has been appearing more often since 1998, especially during August. The average temperature has increased by 1.68 °C in the last ten years. The air temperature in the period June-August has increased by 1.9 to 2.35 °C, especially in the area around Podgorica, where the average summer temperature in last ten years has been 26.9 °C. This region is characterized by warm tropical waves and a prolonged period of sunny and warm weather with stable conditions.

In general, the maximal temperature (Tmax) has been increased in the last ten years by 2.13 °C and minimal (Tmin) by 1.50 °C. In the large part of Montenegro, which has a pronounced continental climate, the average quarterly temperatures in winter periods (December-February) are below freezing. In mountainous areas, the average quarterly temperature during spring varies around 3°C, while in the mid-continental regions it is around 8°C, and in the southern regions around 14°C. The average annual precipitation in the area of Montenegro is very heterogeneous, with exceptional accented rainy and less rainy regions.

Table 4.5. Average monthly values of meteorological parameters for the period 2013-2022 and the differences with the referent climatic period (RCP) 1961-1990

P10 (2013-2022)	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Annual
Temp. average °C	1.55	4.25	6.23	10.46	14.64	19.43	21.87	21.74	16.65	11.77	7.99	3.39	11.68
Precipit., l/m2	266.8	235.0	236.1	138.5	131.3	92.5	68.6	63.3	152.9	161.2	302.8	255.7	2104.8
Rel. Humid. % *	80.62	79.93	75.06	72.77	75.36	72.27	66.52	67.63	74.73	79.62	83.62	81.60	75.76
Tmax, °C	6.42	9.48	11.90	16.49	20.63	25.64	28.84	29.36	23.58	18.83	13.61	8.57	17.77
Tmin, °C	-2.31	0.03	1.49	4.79	8.86	13.10	14.97	15.12	11.13	6.71	3.85	-0.57	6.44
(P10-RCP*)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Temp. average °C	1.06	2.22	1.21	1.53	0.95	2.42	2.36	2.71	1.25	1.10	2.00	1.28	1.68
Precipit.. l/m2	10.96	15.39	22.84	-22.25	13.93	-0.32	6.60	-27.99	8.20	-17.22	2.37	-2.14	1.61
Rel. Humid. %	1.33	2.79	0.49	-1.05	1.60	-1.03	-1.45	-1.38	-0.15	1.79	2.42	0.29	0.44
Tmax. °C	1.22	2.71	1.70	2.26	1.29	2.81	2.89	3.38	1.32	1.67	2.42	2.00	2.13
Tmin. °C	1.12	2.07	1.03	0.92	0.92	2.02	1.90	2.35	1.28	0.98	1.98	1.18	1.50

Source: IHMS; *RCP – referent climatic period 1961-1990

The wettest areas have almost 6 times the amount the average annual precipitation compared to the least rainy areas. It has the highest average annual amount of rain southwestern part, in the area of Orjen mountain, with annual precipitation of 3,000-5,000 mm.

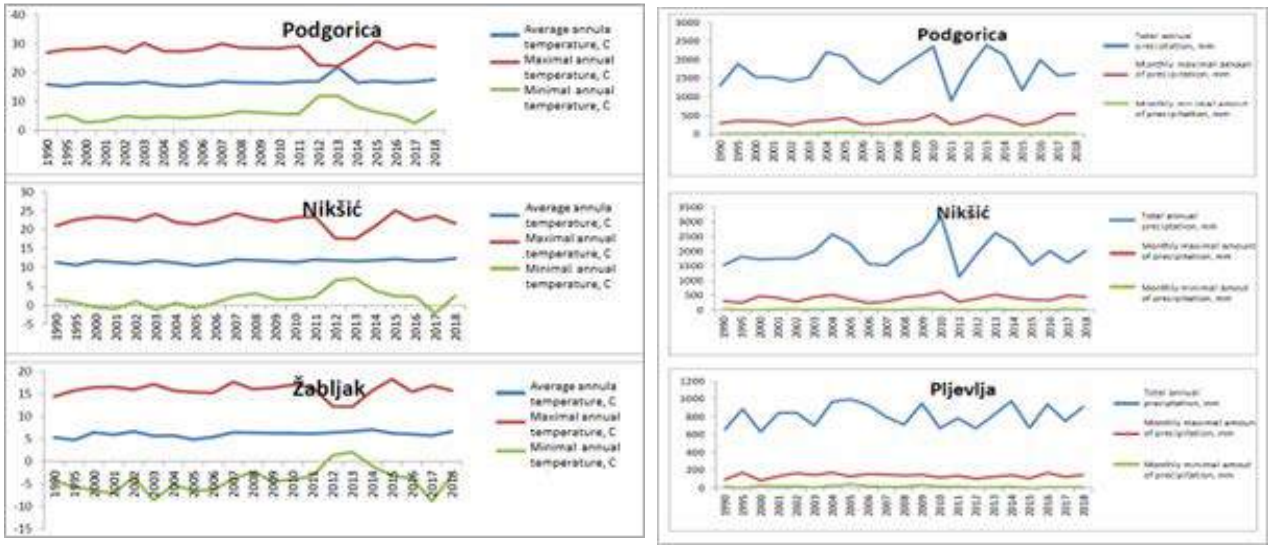


Figure 4.1. Average and total maximum and minimum annual temperatures, and annual precipitations in the three regions of MNE

Source: National Report on the Environmental Status in Montenegro

The least amount of precipitation was in northeastern and extreme northern parts, between 700 and 1000 mm. An increase of the annual precipitation is on average 1.61 l/m^2, however, it is an evident high growth of precipitation in the period January-March and high decrease of precipitation in April, August and October.

4.5.3. Analysis of extreme weather events

Occurrence and duration of different extreme weather events that have directly or indirectly affected livestock farming have been recorded by IHMS (Table 4.6). Since natural meadows and pastures are predominant in the total utilized agricultural areas of Montenegro and mainly used for grazing and production of forage for winter feeding of ruminants, occurrences of heat waves and droughts have had a strong influence on yields (reduced) and quality (content of cellulose and hemicellulose) of grass for grazing and hay or silage. As a result, there have been hay shortages, which has caused import of concentrated feed, even hay. This has led to a decrease in the profitability of production, even to a decrease in the population size of some livestock species. In those situations there is a need for urgent government intervention in providing additional subsidies for farmers. The negative impacts of extreme drought and strong heat waves on animal husbandry were particularly pronounced in 2011 and 2021. Floods, especially in the central region, cause a disruption in the supply of animal feed and limit the use of some agricultural areas. On the other hand, large pasture and meadow areas in Montenegro are characterized by being waterless (without natural springs or watercourses). Hence, long droughts and heat waves cause rapid emptying of rainwater reserves and problems in livestock watering. Fully respecting these problems, the Ministry of Agriculture, Forestry and Water Management has provided financial support for the construction of about 50 water reservoirs in the last 10 years (open water reservoirs) with a capacity of over 1,000 m^3.

Table 4.6. The occurrence of heat waves and floods, 2010-2022

Year	Heat wave and drought	Year	Floods and flash floods / high snow
2011	The drought of 2011 became a social and economic challenge	2010	January, November and December – floods in wide area around Skadar lake
2012	Heat waves in June, July and August (the hottest summer with temperature records)		Floods in the area of Nikšić and Danilovgrad
2015	July 12th – 31st		The north of Montenegro flooded by landslides
2017	July 30th – August 11th	2012	January and February – very high snow precipitation – state of emergency was declared in Montenegro
2020	July 20th – August 3rd		
2021	Long term drought with heat waves: June 1st – 30th and July 21st – Aug.2nd	2018	March 2018 – Floods in the Skadar Lake region Nikšić – Danilovgrad areas were under water
2022	Heat waves: June 19th – July 6th, July 15th – August 10th		

Source: IHMS

According to the official meteorological data in the mountainous area of the northern and central regions (Žabljak, Kolašin, Rožaje and Mojkovac), there is a strong heat change during August in terms of the maximum daily temperature. In the last 10 years, the number of summer days has significantly increased (days with temperatures at 25°C or more) at altitudes about 1,500 m above sea level. In the period 1961-1990, there were only 12% of days in August in these areas with temperatures at 25°C or more, however, in the period 2013-2022, for even 35% of days in August, the temperature reached and exceeded 25°C.

IHMS provides systematic monitoring and records of extreme weather events. However, there is no permanently established monitoring of the impact of extreme weather conditions on animal husbandry, only the occurrence of some extreme weather events is noted and ad hoc measures are taken to mitigate the negative impacts on animal husbandry.

The Institute for Hydrometeorology and Seismology (IHMS) has been monitoring some agrometeorological parameters (soil temperature and phenology parameters) since 1951. The Department of Applied Meteorology has a phenology database (Access database) with data collected from 19 phenology stations. That database contains data classified into seven main categories: fruit growing, vines, field crops, forest trees, plant diseases and pests, beekeeping, and general fieldwork. The beginning and the end of grass cutting and hay (forage) preparation are fully related to livestock farming.

For three years, IHMS has had a Department of Applied Meteorology and Climate Change that performs work in the field of climate change and projections, including climate variability, extreme climate and weather events, vulnerability assessment and adaptation according to the standards of the Intergovernmental Panel on Climate Change (IPCC).

They provide monitoring and assessment of extreme weather and climate events, their changes and variability; drought monitoring; preparation of seasonal forecasts: winter and summer season and reporting to the World Meteorological Organization on the state of climate reviewed changes, variability, as well as extreme weather and climate events.

4.5.4. Heat stress risk assessment for ruminants, pigs and poultry

Heat stress is one the most stressful and expensive events for farm animals with negative consequences for animal health, productivity and product quality. The Temperature Humidity Index (THI) is the most important environmental parameter influencing farm animal productivity and welfare. THI depends on ambient temperature and relative humidity. When animals are exposed to temperatures that are higher than their comfort zone (16-25°C), they experience heat stress. Value of the THI varies between different species of livestock, within the same species and between different age categories of animals. Cows suffer a lot of heat stress with serious consequences on their productivity and the quality of their products. This happens because a large part of the energy derived from feed is used to maintain a constant body temperature and is therefore not used for other activities (milk production, growth, pregnancy, fattening, etc.).

Although a significant number of dairy farms are located in the central and southern regions of Montenegro, where they are under the influence of the warm Mediterranean climate, there is still no systematic monitoring of THI on dairy and beef cattle farms in Montenegro. There has even been no preliminary study for experimental purposes measuring THI values and their impact on production and animal welfare during heat waves. Some preliminary analysis of THI based on meteo data of average monthly temperature and relative humidity (although only daily data relevant) indicate high levels of THI in the area of Podgorica, Danilovgrad, even Nikšić.

There is a small number of farms of dairy cows and dairy goats in Montenegro that have a ventilation system, apart from natural air circulation. Only commercial laying hen farms are equipped with appropriate ventilation systems. To mitigate the consequences of high THI and the occurrence of heat stress, it is necessary to establish regular monitoring of these parameters on farms as soon as possible.

4.5.5. Farmers' existing adaptive practices for mitigating impacts of climate change

The construction of new barns has in the last 10 years been supported by different funds (MIDAS, IPARD and the national Agro-budget), many new barns are much better equipped, mostly with better possibilities for natural air circulation (bigger open area – window space), some of them have some type of ventilation system, especially barns built in regions with very hot summers (Podgorica and Danilovgrad or the coastal area).

One of very good examples is the farm of dairy cows Iković in Bjelopavlići – Danilovgrad. Seven years ago, this farmer built a new barn with a capacity of up to 90 milking cows. The barn was constructed for a free system of keeping cows, manure cleaning and watering are automated, and a milking robot was installed, as well as a ventilation system in the barn. In addition, this farm has a mechanism for cooling, which works based on spraying (de-wetting) the animals with cold water. Due to the application of cooling and ventilation systems, as well as the increased frequency of milking during the day (on average 2.7 milking per cow in 24 hours), this farm has not had major fluctuations in production during summer heat in recent years.

The common practice of dairy cattle breeders in the region of Podgorica and Danilovgrad, where there is high THI during the three summer months, is that cows stay outside in shadow, not only during day but during night as well. One of the adaptation practices, applied during the spring and summer seasons, is feeding animals (cows) with highly digestible feed, with less cellulose/hemicellulose, such as fresh grass.

Table 4.7. List of impacts and adaptation measures that can be implemented and possible limitations of climate change

Impacts of climate change on livestock farming (indirect and direct)	Adaptation measures
Shorter grass vegetation season and reduced forage and crop production	Provide fodder reserves Cultivation of pastures for grazing and improving grazing management
Drought	Land irrigation for silage production, alfaalfa hay, etc.
Flooding	Monitoring and controlling animal health
New diseases	Supplementary feeds, barn protection from insects
Heat stress	Equipping barns with ventilation and cooling systems
Low productivity and unavailability of land for livestock	More adaptive livestock breeds – local breeds or robust breeds

A frequent practice of most sheep breeders and some cattle breeders in Montenegro is the seasonal moving of flocks of sheep and herds of cattle from the lowlands to mountain pastures (usually grom June to October). This practice reduces the impact of heat stress and provides animals with enough feed (graze) on the mountain pastures. Bigger pig farms (small number in Montenegro) usually have some ventilation system in the barn, while all commercial poultry farms are equipped with appropriate temperature regulation systems and have to apply rules on good agricultural practices and regulations on animal welfare for laying hens and broiler fattening.

4.5.6. National strategies and adaptation plans in the livestock sector, including reports, projects and communications under the international CC framework (UNFCCC)

The National Strategy on Climate Change until 2030 is a key instrument in the field of public policy on climate change management in Montenegro. It prescribes the Government's obligation to act against climate change in an integrated and multisectoral manner, respecting its international obligations under the UNFCCC. The strategy sets a vision that Montenegro will be able to adapt to the negative impacts of climate change and promote sustainable, low-carbon development by 2030.

The Environmental Protection Agency (EPA) provides monitoring and prepares the Report on the State of the Environment (SoER), according to international practices and standards. The last SoER was prepared for the period 2017-2020 with an action plan of improvement 2022-2025. State of the Environment Reports are based on the indicator approach to the issue of environmental protection in a concise, simple, understandable, and comparable way that shows the current status and trends of changes in the environment. In these strategic documents, climate change and its impacts on the agricultural sector are considered in general, while the livestock sector is not analyzed and observed in detail.

National Report No. 3 states that agriculture in Montenegro is a source of methane (CH_4) and nitrous oxide (N_2O), which comes from the livestock and fertilizer use. The National GHG Inventory shows that these two gases are the most prevalent in agriculture, while CO_2 emissions are negligible. This sector accounts for approximately 10% of the total emissions (11.5% in 2017). As mitigation scenarios, the management is suggested by manure and manure applied to land, or the impact on indirect N_2O reduction application of mineral fertilizer.

The Strategy on the Development of Agriculture and Rural Areas (2022-2028) analyzes in more depth the effects of climate change on agriculture, water resources, soil, and forest, as well as future prospects. Sustainable management of natural resources is defined as one of the strategic goals and proposed operational aims:

a) Contribute to mitigation of the impact of climate change by reducing emissions of greenhouses gases and improving their carbon sequestration

b) Support sustainable development and efficient management of natural resources such as water, land and air, including reducing dependence on chemicals

c) Contribute to prevent the process of loss of biodiversity

There are no strategic documents that treat livestock farming and farm animals.

4.5.7. Overview of the political and institutional setup and the legislative framework for adaptation activities relevant to the sector

The Ministry of Agriculture, Forestry and Water Management (MAFWM), as an umbrella institution, proposes laws and other regulations, proposes system solutions in agriculture, defines agricultural policy and undertakes measures for its implementation. MAFWM is responsible for the management and use of agricultural (natural) resources, use and protection of water resources; protection from adverse effects of water; protection of water against pollution; water supply in rural communities; conservation and management of agro-biodiversity and forests; hunting; food safety; and application of modern technology in agriculture.

Within MAFWM, responsible for the specific area of agriculture and rural development, there are five directorates: Directorate for Agriculture, Directorate for Rural Development, Directorate for Water Management, Directorate for Forestry, Hunting and Wood Industry, and Directorate for Payments.

Law on Agriculture and Rural Development (Official Gazette of Montenegro, No. 56/09, 18/2011, 34/14, 01/15, and 51/2017) regulates the development of agriculture and rural areas, the objectives and measures of agricultural policy, the incentives in agriculture and the preconditions for their realization, the rights and obligations of beneficiaries of subsidies, supplementary activities in agriculture, agriculture and other issues of importance for the development of agriculture and rural areas. Measures for sustainable management of agricultural resources are defined through the promotion of agricultural programmes that are compatible with the principles of environmental protection – agro-ecological measures and the conservation and sustainable use of agricultural genetic resources (Article 16).

The Law on Organic Farming (Official Gazette of Montenegro, No. 56/13) defines the main objectives of organic farming:

1) Establishment of a sustainable agriculture management system that respects natural systems and cycles and maintains and improves the quality of land and water, plant and animal health and their balance; contributes to a high level of biodiversity; rationally uses energy and natural resources (water, soil, organic matter, and air); respects animal welfare standards and in particular meets the specific needs of animals about their species.

2) Production of different types of food and agricultural products using non-harmful procedures for the environment, human, plant, and animal health.

Law on Livestock (Official Gazette of Montenegro, No. 72/2010, 48/2015) regulates the manner and preconditions for rearing domestic animals, the way of adopting and implementing breeding programmes, the preservation of genetic variability, the marketing of animal feed and genetic material, the rights and obligations of livestock farmers and other issues relevant to livestock breeding. The funds for preserving genetic resources of domestic animals are provided for in the Budget of Montenegro (Article 33).

The Veterinary Law (Official Gazette of Montenegro, No. 30/12 and 48/15) regulates the conditions and manner of carrying out veterinary activities, animal health protection, measures of veterinary public health, veterinary protection of the environment, as well as other issues of importance for performing veterinary activities.

Law of Animal Welfare, among other things, regulates the obligations of animal keepers, who are obliged to provide the animals with food and water according to their physiological needs; care and health care; accommodation in a facility with enough light, heat and space; space hygiene; and protection from weather conditions and natural enemies. According to this Law, animals that are temporarily or permanently not housed in barns must be protected from unfavourable weather conditions and other health hazards.

4.5.8. Policy measures

The agricultural policy in Montenegrin agriculture is implemented within a scope of a legal document called the Decree on regulation of conditions and implementation dynamics of agricultural policy measures. This Decree (Agrobudget) is prepared and adopted annually.

Rural Development Measures (Axis 1). Policy for improving the competitiveness of agriculture with ten different supporting measures for the development of different sectors of agriculture. One of the main reasons of the low competitiveness of Montenegrin agriculture is low productivity, caused by insufficient supplies of advanced mechanization and equipment.

The IPARD programme aims to achieve national and EU standards in the field of environmental protection, better use of natural resources; and public health, animal and plant health, animal welfare, and work safety. The **IPARD III programme** on the development of agriculture and rural areas of Montenegro, within the frame of Measure 1, provides supports for the construction or reconstruction of barns for animals according to standards; procurement of machinery and equipment, including computer hardware and software for the production process; non-production investments to achieve agro-ecological goals, etc.

Axis 2. Measures for sustainable management of natural resources are agro-environmental measures which include:

- Preservation of autochthonous genetic resources in agriculture (varieties and breeds)
- Organic production, sustainable use of mountain pastures and
- Support to improvement of manure management – in terms of the construction of capacity for storage solid and liquid manure to reduce GHG emissions and prevent negative impacts on the environment (water and land pollution), which is a measure of climate change mitigation.

4.5.9. Conclusions with key recommendations for livestock adaptation to climate change

Montenegro is particularly exposed and vulnerable to climatic hazards such as droughts, floods, forest fires, and heat waves. According to the Montenegro Third National Communication on Climate Change (2020), climate projections show that these climate extremes will become more frequent and pronounced in the future. The results of climate projections indicate that by 2040, the annual temperature in the entire economy will rise from 1.5 to 2°C, and by 2070, the average annual temperature will rise to 3°C. A decrease in the average annual amount of rainfall is expected, especially during the summer months, as well as an increase in precipitation in the winter months in some parts of the economy. Significant changes are expected in the amount of snow, which will decrease.

The agricultural sector is very sensitive to climate change due to its dependence on certain temperature conditions and water availability and is also exposed to climatic hazards such as droughts and floods. A large part of the agricultural land is located in the plains, which makes it especially vulnerable to flooding.

Drought can have multiple negative effects on the economy, the environment and people's health. Droughts are expected in the future, will be more intense, with a decrease in precipitation and an increase in temperatures, especially in summer and autumn which will further threaten the supply of livestock with feed. Changes in the water balance are becoming an increasing problem for economies prone to droughts, such as Montenegro. Due to this, it is necessary to encourage investment in the improvement of water supply (wells, reservoirs, etc.), especially in areas with high risk of droughts and fires. An increase in the frequency and intensity of droughts as a consequence of climate change is expected, as well as risk of fire, especially in the southern forest areas, which extend along the coast and in karst areas, which directly affect livestock farming in this area, especially small ruminants rearing.

Recommendations:

- To establish systematic monitoring and records of effects and losses in the livestock sector caused by extreme weather events.
- In the central region where there are bigger dairy farms, to provide on-farm monitoring of heat wave parameters as a pilot project on 100 dairy cow farms with 20 or more cows each (THI and heat stress on farm animals).
- Livestock adaptation to climate change (actions and measures) must be integrated in all strategic documents, mitigation action plans, national reports, etc.
- Research and development of new technologies (to better understand the impact of climate change on livestock, develop and adopt diets with nutrients and increased feed digestibility, develop genotypes, protect animal health and welfare).
- Strengthening the capacity of the scientific community in the area of adaptation of the livestock sector to climate change (projects, papers, books, recommendations).
- Transfer knowledge through continuous training and education of farmers and agricultural extension services about the effects of climate change on livestock.

4.6. References

Abramović, V., Jacimović, D., Jocović, M. (2016). Klimatske promjene i njihov uticaj na zemlje regiona. Ekonomske ideje i praksa.

Agencija za zaštitu životne sredine (2021) Izvještaj o stanju životne sredine u Crnoj Gori na bazi indikatora (2017-2020).

Bavec, M., Kovačević, D., Jovović, Z., Zejak, D., & Mirecki, N. (2014). Agriculture and climate change. Center for Agrarian Development, Bijelo Polje.

Burić, M., Fuštić, B., & Bulajić, P. (2017). Soil Atlas of Montenegro. Montenegrin Academy Of Sciences And Arts.

Callaway, J. M., Kašćelan, S., Markovic, M. (2010). Ekonomski uticaji klimatskih promjena u Crnoj Gori: prvi pogled.

Chamber Of Commerce Of Montenegro. (2023). Upravljanje zemljištem, nedostaci i preporuke. Mirko Knežević, March 2023.

Crna Gora Ministarstvo Poljoprivrede, Šumarstva i Vodoprivrede. (2023). Strategija Razvoja Poljoprivrede i Ruralnih Područja 2023-2028 Nacrt.

Flat Project. (2018). Analysis of Flood And Landslide Risks For Montenegro (With An Emphasis On The Catchment Area Of Bojana River And Skadar Lake). Podgorica, November 2018. https://Flat-Project.Org/Doc/Me/Analysis.Pdf

Flat Project. (2018). Analysis of Flood And Landslide Risks For Montenegro (With An Emphasis On The Catchment Area Of Bojana River And Skadar Lake). Podgorica, November 2018. https://Flat-Project.Org/Doc/Me/Analysis.Pdf

Government Of Montenegro. (2022). The Second Voluntary National Review: Montenegro And Sustainable Development Goals 2016–2021. June 2022.

International Found for Agricultural Development: Adaptation Framework Thematic Brief: Livestock. fad.org/documents/38714170/42258938/

Ivanović, M. (2023). Uticaj klimatskih promjena na ključne makroekonomske pokazatelje u Crnoj Gori, Centralna banka Crne Gore, Podgorica.

Jovovic, Z., Andjelokovic, V., Przulj, N., & Mandic, D. (2020). Untapped Genetic Diversity of Wild Relatives for Crop Improvement. In Salgotra, R.K. and Zargar, S.M. (Eds): Rediscovery of Genetic and Genomic Resources for Future Food Security, Springer, 25-65.

Jovović, Z., Broćić, Z., Velimirović, A., Dolijanović, Ž., & Komnenić, A. (2021). The influence of flooding on the main parameters of potato productivity. Acta Hortic., Proc. VIII South-Eastern Europe Symposium on Vegetables and Potatoes, No 1320, 133-138 (ISSN 0567-7572 print and ISSN 2406-6168 electronic).

Jovovic, Z., Micev, B., & Velimirovic, A. (2016). Impact of climate change on potato production in Montenegro and options to mitigate the adverse effects. Acad. J. Environ. Sci. 4(3): 047-054, West Yorkshire, England.

Jovović, Z., Pržulj, N., Anđelković, V., Mandić, & D. (2020). The importance of preserving biodiversity in the sustainable use of plant genetic resources. In: Pržulj, N., Trkulja, V. (editors) From genetics and external environment to food. Academy of Sciences and Arts of the Republic of Srpska, Banja Luka, Monograph XLI: 35-90.

Jovović, Z., Velimirović, A., Bućković, M., Dolijanović, Ž., & Komnenić, A. (2022). Irrigation- A Key Point In Adapting Potato Production To Climate Change. International Congress and Workshop on Agricultural Structures and Irrigation, 12-15 May 2022, Diyarbakır, Turkiye, 403-410.

K. Wegner, C. Lambertz, G. Daş, G. Reiner and M. Gauly (2014) Climatic effects on sow fertility and piglet survival under influence of a moderate climate. Animal, doi:10.1017/S1751731114001219.

Knežević M (2008). Planiranje i projektovanje sistema za odvodnjavanje i navodnjavanje u Bjelopavlićkoj ravnici. Doktorska disertacija, Univerzitet u Beogradu, Poljoprivredni fakultet Beograd-Zemun.

Knežević, M. (2022). Environmental Trends In Montenegro: Land Degradation Neutrality. 1st Interim Regional Expert Advisory Working Group Meeting On Soil, Bar, Montenegro.

Micev, B. (2002). Minimum air temperature in the cold part of the year in the area of Skadar Lake. Research work, Podgorica.

Micev, B. (2010). Expert analysis of rainfall during the floods in November-December 2010 Podgorica.

Micev, B. (2014). Climate change and flooding. First National Platform for Disaster Risk Reduction, Podgorica.

Micev, B. (2015). Report on climate anomalies during summer 2015. Podgorica.

Micev, B. (2015). Weather flooding. II National Platform for Disaster Risk Reduction, Podgorica.

Micev, B., Buric, M., & Mitrovic, L. (2012). Atlas of Climate Montenegro. Montenegrin Academy of Sciences and Arts, Podgorica.

Ministarstvo Ekologije, Prostornog i Urbanističkog Planiranja. (2021). National Programme Of Priority Activities In The Field Of Climate Change Mitigation And Adaptation To The Framework Of Cooperation With The Green Climate Fund 2021–2023 Draft. January 2021.

Ministarstvo ekologije, prostornog planiranja i urbanizma (2021) Izvještaj o sprovođenju nacionalne strategije u oblasti klimatskih promjena do 2030. Godine, izvještajni period septembar 2018. – septembar 2021. godine.

Ministarstvo održivog razvoja i turizma (2015): Rezime nacionalne strategije u oblasti klimatskih promjena do 2030. godine. Podgorica.

Ministarstvo Poljoprivrede i Ruralnog Razvoja. (2017). Strategija upravljanja vodama Crne Gore. Podgorica, June 2017.

Ministarstvo poljoprivrede, šumarstva i vodoprivrede (2022): Program razvoja poljoprivrede i ruralnih područja Crne Gore u okviru IPARD III (2021-2027).

Ministarstvo poljoprivrede, šumarstva i vodoprivrede (2023) Strategija razvoja poljoprivrede i ruralnih područja 2023–2028. Podgorica 2023.

Ministarstvo unutrašnjih poslova Direktorat za zaštitu i spašavanje. (2021). Procjena rizika od katastrofa Crne Gore. December 2021.

Ministarstvo Unutrašnjih Poslova Direktorat Za Zaštitu I Spašavanje. (2021). Procjena rizika od katastrofa Crne Gore. December 2021.

Ministry of Agriculture and Rural Development. (2017). Plan izgradnje irigacionih sistema u Crnoj Gori. Podgorica, March 2017.

Ministry of Agriculture, Forestry and Water Management (2023a). Strategy for the Development of Agriculture and Rural Areas 2023-2028, Government of Montenegro, Podgorica.

Ministry of Agriculture, Forestry and Water Management (2023b). Register of Agricultural Farms, Podgorica.

Ministry of Agriculture, Forestry and Water Management. (2006). Montenegro's Agriculture and European Union Agriculture and Rural Development Strategy. Final Report of the EU Funded Project. Podgorica, July 2006.

Ministry of Agriculture, Forestry and Water Management. (2021a). Preliminary Flood Risk Assessment for the Adriatic River Basin. June 2021.

Ministry of Agriculture, Forestry And Water Management. (2021b). Preliminary Flood Risk Assessment for the Danube River Basin. June 2021.

Ministry of Sustainable Development and Tourism (2020): Montenegro Third National Communication on Climate Change. https://www4.unfccc.int/sites/SubmissionsStaging /NationalReports/Documents/8596012_Montenegro-NC3-1-TNC%20-%20MNE.pdf

Ministry of Sustainable Development and Tourism. (2015). The Second National Communication on Climate Change of Montenegro to the United Nations Framework Convention on Climate Change (UNFCCC). February 2015.

Ministry of Sustainable Development and Tourism. (2016). The National Strategy on Sustainable Development by 2030 (NSSD). Podgorica, July 2016.

Ministry of Sustainable Development and Tourism. (2018). Land Degradation Neutrality Target Setting Process National Report. Podgorica, June. https://Www.Unccd.Int/Sites/Default/Files/Ldn_Targets/201905/Montenegro%20 ldn%20tsp%20country%20report.Pdfb

Ministry of Sustainable Development and Tourism. (2020). Montenegro National Drought Plan. November 2020.

Monstat (2017). Structural statistics: https://www.monstat.org/eng/page.php?id=1007&pageid=59.

Monstat (2023a). Gross domestic product of Montenegro: http://monstat.org/uploads/files/BDP/2022/Annual%20GDP%202022_eng.pdf.

Monstat (2023b). Crop production: https://www.monstat.org/uploads/files/poljoprivreda/biljna/2022/Crop%20production_2022.pdf

Montenegro, Ministry Of Agriculture, Forestry And Water Management. (2022). Programme For The Development Of Agriculture And Rural Areas In Montenegro Under IPARD III 2021-2027. May 2022.

Pržulj, N., Jovović, Z. (2020). Plant breeding for drought conditions. In: Pržulj, N., Trkulja, V. (editors) From genetics and external environment to food. Academy of Sciences and Arts of the Republic of Srpska, Banja Luka, Monograph XLI: 127-180.

Regional Rural Development Standing Working Group in SEE (SWG). (2018a). Land Market Development And Small Farms' Access to Land in The Pre-Accession Economies. Final Report.

Regional Rural Development Standing Working Group In SEE (SWG). (2018b). Agri-Environmental Policy in South-East Europe.

Šeremešić, S., Jovović, Z., Jug, D., Đikić, M., Dolijanović, Ž., Bavec, F., Jordanovska, S., Bavec, M., Đurđević, B., & Jug, I. (2021). Agroecology in the West Balkans: pathway of development and future perspectives, Agroecology and Sustainable Food Systems, Volume 45, Issue 8, 1213-1245.

Soil Management In The Western Balkans – Gaps and Recommendations. (2022). Skopje. Retrieved from https://Seerural.Org/Wp-Content/Uploads/2022/12/Soil-Management-In-The-Western-Balkans-Gaps-And-Recommendations.Pdf.

State of the Art of Soil Management in the Western Balkans. (2022). Skopje. Retrieved from https://Seerural.Org/Wp-Content/Uploads/2022/12/State-Of-The-Art-Of-Soil-Management-In-The-Western-Balkans.Pdf

Statistical Office of Montenegro. (2011a). Agricultural Census 2010, Structure of Agricultural Holdings-Special Interest Topics. Podgorica, October 2011.

Statistical Office of Montenegro. (2011b). Agricultural Census 2010, Structure of Agricultural Holdings-Livestock Resources. Podgorica, July 2011.

Statistical Office of Montenegro. (2011c). Agricultural Census 2010, Structure of Agricultural Holdings-Utilised Land. Podgorica, July 2011.

Statistical Office of Montenegro. (2012). Agricultural Census 2010, Structure of Agricultural Holdings. Podgorica, February 2012.

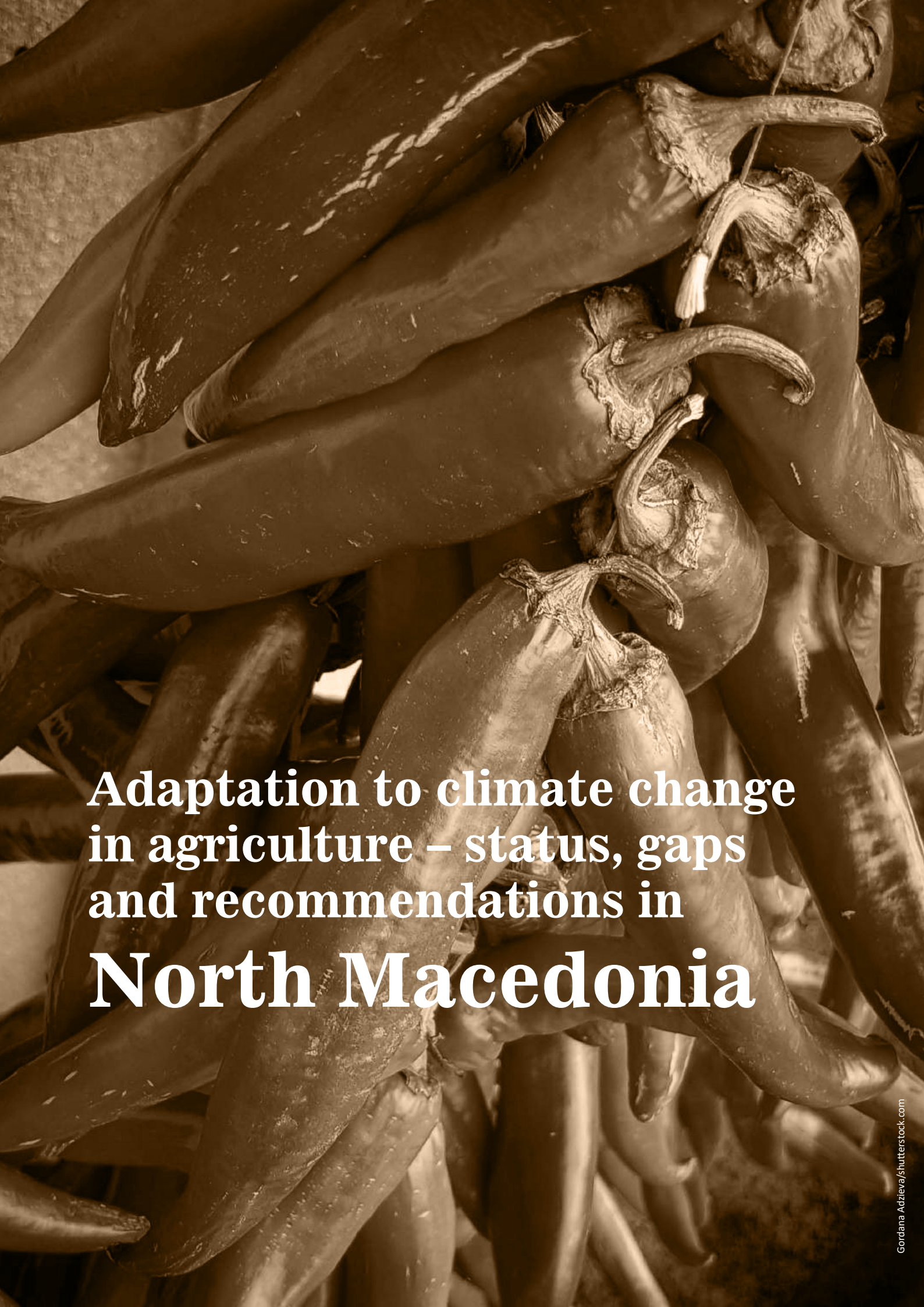
Velimirović, A., Jovović, Z., & Pržulj N. (2022). Mitigating climate change effect: the case of wheat, International Congress and Workshop on Agricultural Strucrures and Irrigation, 12-15 May 2022, Diyarbakır, Turkiye, 395-402.

Vlada Crne Gore (2021). Završni izvještaj o realizaciji Strategije regionalnog razvoja Crne Gore, za period 2014-2020. godine: https://www.gov.me/dokumenta/fe94e317-a6ec-4f6e-a7de-82425b266ae0.

Zavod za hidrometeorologiju i seizmologiju (2023): Izvještaj o radu zavoda za hidrometeorologiju i seizmologiju za 2022. https://www.meteo.co.me/page.php?keyword=reports.

Zavod za hidrometeorologiju i seizmologiju: Godišnjaci meteoroloških i hidroloških podataka (2015-2022) https://www.meteo.co.me/page.php?keyword=reports.

Adaptation to climate change in agriculture – status, gaps and recommendations in North Macedonia



Gordana Adzieva/shutterstock.com

5. Adaptation to climate change in agriculture – status, gaps and recommendations in North Macedonia

Aleksandra Martinovska Stojcheska [45], Dushko Mukaetov [46], Vjekoslav Tanaskovikj [47], Ordan Chukaliev [48], Sreten Andonov [49]

5.1. Status of economic, socio-economic and agricultural sector related to climate change

Climate change effects may have a direct or indirect impact on North Macedonia's agricultural sector. Changes in agricultural productivity and yields have a direct economic impact, while trade flow shifts brought on by these changes have an indirect economic impact on this sector through transmissions on food prices, agricultural income, and, ultimately, food security on a local, regional, and international level (EEA, 2019). From a socioeconomic standpoint, the economy exhibits high vulnerability because of the relatively high, although declining, unemployment rates, especially among women and the youngest, and a still significant portion of the population employed in the agricultural sector, which is itself extremely vulnerable to climate variability and climate change. This reinforces the need to increase the resilience to climate change impacts on key socio-economic sectors and ecosystems, with a defined system to monitor socio-economic vulnerability to climate change.

5.1.1. Macro-economic aspects on the national economy level

North Macedonia is classified as an **upper middle income economy**, though more efforts are still required to spur economic growth and improve the living standard for the whole population. The Gross Domestic Product (GDP) in North Macedonia has been steadily increasing overtime, with well-functioning coordination between fiscal and monetary policy, reaching around 11.7 billion EUR or 5,135 EUR per capita in 2022 (including a slight setback in 2020 due to the COVID-19 crisis (SSO, 2023)). However, the latest global crisis caused by the effects of the war in Ukraine has spiked the previously low inflation rate of less than 2% in the last decade to a staggering 14.2% in 2022. This situation has **put a pressure on household expenditures**, which in in 2022 have recorded 51.5% of expenditure on food, beverages and tobacco consumption (Table 5.1).

45 Agricultural economics expert, Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food (amartinovska@fznh.uki.edu.mk)
46 Soil expert, Ss. Cyril and Methodius University in Skopje, Institute of Agriculture (d.mukaetov@zeminst.edu.mk)
47 Water expert, Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food (vtanaskovic@fznh.ukim.edu.mk)
48 Crop expert, Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food (cukaliev@gmail.com)
49 Livestock expert, Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food (sandonov@fznh.ukim.edu.mk)

Table 5.1. Key macroeconomic indicators

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
GDP (at current prices)	mill. EUR	6,208	8,428	11,247	135.8	133.5	181.2
Value added (at current prices)	mill. EUR	5,357	7,313	9,841	136.5	134.6	183.7
GDP per capita	EUR	3,034	4,079	5,143	134.5	126.1	169.5
External trade balance	mill. EUR	-1,441	-1,798	-2,325	124.8	129.3	161.3
Unemployment rate	%	34	28	18	82.0	63.2	51.8
Food, beverages and tobacco in household expenditures	%	36	38	44	105.6	114.7	121.1

Source: SSO (2023);

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

Both **income inequality and poverty levels have decreased** over time, however, disparities persist across social groups and regional development. The Gini coefficient, measuring income concentration parity, has continuously decreased by almost 10% over the last decade, reaching 31.4% in 2020 (Figure 1), but still not reaching the pre-independence level of around 26% in 1991 (World Inequality Database, 2021). Even though poverty rates are declining, around 400,000 people still live in substandard conditions with very limited resources, urging for a stronger governmental commitment and resource mobilization to accelerate the improvement of the quality of life for this large portion of the population. Young people and numerous households with three or more children are the most vulnerable to poverty.

With an estimated population size of 1.83 million (2021 census data, a substantial fall from 2.1 million in the previous census in 2002), the average **population density is moderate** with 71 inhabitants per km². Population density varies substantially across the economy; the largest concentration is in Skopje (around 29% of the population lives in the capital city), followed by Polog as the second most densely populated and urbanized region exceeding 100 inhabitants per 1 km², while regions like Pelagonia, Vardar and the East have less than 50 inhabitants per 1 km². Regional disparities are also evident in terms of the GDP, with 44% of the GDP accumulated in the Skopje region, compared to 11% in Pelagonia and less than 10% in all other regions, down to only 5% in the Northeast region. The GDP per capita is 32% higher in Skopje region, and only 54% in Polog compared to the average (SSO, 2023).

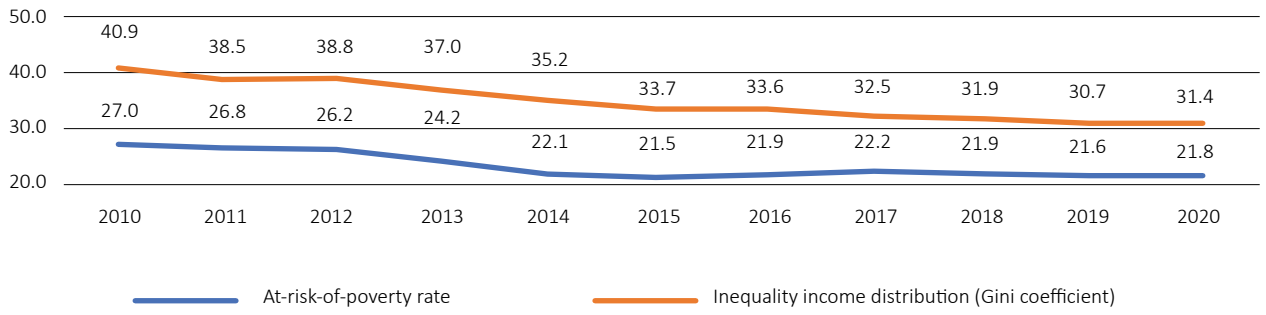


Figure 5.1. Key poverty and inequality indicators for North Macedonia

Source: SSO (2023)

The **population is aging**, with the proportion of citizens above the age of 65 having increased from 11.9% in 2002 to 17.7% in 2022. The ratio between live births and deaths, as indicator of natural population increase, had a persistently negative trend reaching -2.4% in 2022 (SSO, 2023). The increasing external migration adds to the population challenge. With the relatively small size of the workforce, low birth rate and migration, the overall pool of talent and skills in the economy is significantly affected.

North Macedonia is a **moderately urbanized economy**, with the latest figures from the census classifying 38.4% of the population living in rural areas, with a persevering trend of urbanization (52.9% were considered rural population in 1970s, World Bank, 2021). Other sources estimate 47.5% of the population as rural, with rural areas covering 88.7% of the territory (MAFWE, 2021). Nevertheless, the high concentration of peri-urban and urban centres, along with the scattered rural population across the economy, affects the availability of agricultural labour.

5.1.2. Macro-economic aspects on the agricultural sector level

Agriculture is **one of the main economic sectors** of North Macedonia, right after industry and services. Due to the higher gross value added (GVA) realized in other economic activities, the sector's contribution decreased gradually from 11.3% in 2005 to 9% in 2022, reaching a gross value added of 1 billion EUR. Together with the food industry (including beverages and tobacco industry), the share of the agri-food compounds 13-15% of the national GVA. Regional GVA diffusion is uneven, where the Southeast region had the biggest share of 28.2%, followed by the Pelagonia region with 24.1%, while the Southwest region participated with only 3.5% in the agricultural GVA in 2021 (SSO-EAA, 2023). Around three-fourths of the agricultural output comes from crop production (Table 5.2).

Primary agriculture accounts for a significant portion of total employment, albeit constantly reducing its share (halved from 19% in late 2000s to 10% or 69 thousand people in 2022 (SSO, 2023). Despite the sector's still low productivity and income, agriculture continues to be the key source of employment and serves as a social safety net, particularly in rural areas.

Table 5.2. Key indicators for the agricultural sector

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
GVA of agriculture (at current prices)	mill. EUR	620	807	907	130.1	112.3	146.2
Share of AgGVA in all activities	%	12	11	9	95.9	83.6	80.2
Employed in agriculture	000	119	122	101	102.7	82.6	84.8
Share in total employment	%	19	18	13	94.2	73.7	69.4
Export of agri-food products	mill. EUR	346	485	603	140.2	124.3	174.2
Share in exports of all products	%	16	14	10	85.0	71.1	60.4
Imports of agri-food products	mill. EUR	448	664	875	148.1	131.9	195.3
Share in imports of all products	%	12	12	10	99.1	84.8	84.0
Trade balance in agri-food products	mill. EUR	-102	-178	-272	174.7	152.5	266.5
Share of crops in total agricultural output	%	74	76	77	101.9	101.8	103.7
Share of livestock in total agricultural output	%	26	24	23	94.5	94.4	89.3

Source: SSO (2023)
Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

North Macedonia is **net agri-food importer**, although exports have substantially increased over time, so have imports, further widening the negative trade balance, reaching 420 million EUR in 2022 (Table 5.2). Prices of main agricultural products have risen over time, most notably for cereals, industrial crops and fruits. The increase in input prices was much more drastic in 2021 and 2022, especially in energy and fertilizer prices since the war in Ukraine.

5.1.3. Land use

The total agricultural area in North Macedonia covers 1,262 thousand hectares (or around 50% of the economy's territory, whereas 44% is land under forests). Almost two-thirds (64%) of the agricultural area is under pastures with 800 thousand hectares (Table 5.3). These are mostly low productive mountainous pastures, distributed on high elevations (above the forest belt). Arable land takes 33%, and the remaining 3% are covered with permanent crops (Figure 5.3, left side). Nearly one-third of the total arable land is abandoned or it is not used for agricultural production (WB, 2020).

Table 5.3. Agricultural land use and agricultural holdings

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
Total agricultural land	000 ha	1,117	1,240	1,262	111.1	101.8	113.0
- Arable land	000 ha	430	415	417	96.5	100.6	97.1
(of which fallow/uncultivated land)	000 ha	135	135	/	100.4	/	/
- Land under permanent crops	000 ha	37	37	41	102.1	109.1	111.4
(of which orchards)	000 ha	13	15	17	112.5	110.6	124.4
(of which vineyards)	000 ha	23	22	24	99.0	107.2	106.1
- Permanent grassland	000 ha	650	788	804	121.2	102.0	123.7
(of which meadows)	000 ha	59	60	60	100.6	99.9	100.4
(of which pastures)	000 ha	590	728	744	123.3	102.2	126.0
Utilized agricultural area (UAA)	000 ha	309	318	/	103.2	/	/
Number of agricultural holdings	000	192	175	/	90.7	/	/

Source: SSO (2023)

Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

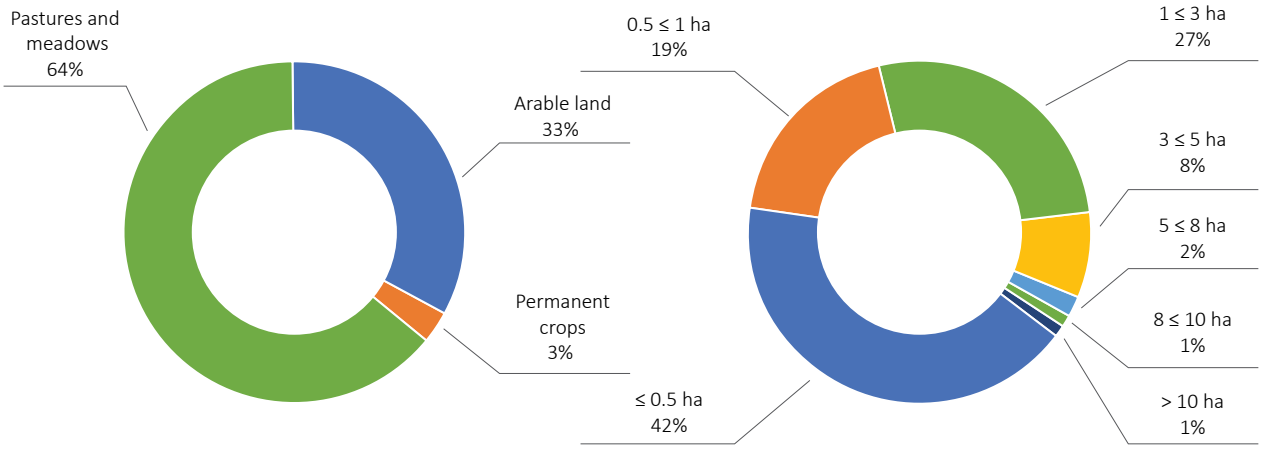


Figure 5.2. Agricultural land use (average 2017-22, left side), number of farms by UAA (2016, right side)

Source: SSO (2023)

More than 40% of the total area of arable land (approximately 240 thousand hectares) and 80% of pastureland (approximately 570 thousand hectares) in North Macedonia is state owned (MAFWE, 2021). Between 2015 and 2020, a total of 10,481 ha of state agricultural land were leased, and there were four public calls for the sale of 280.4 ha of land used for greenhouses and surrounding areas around greenhouses (MAFWE, 2021).

The utilized agricultural area is characterized by a **large number of small plots** (on average fragmented into over five spaced plots per holding), with an average size of 0.24 ha on private land, or 0.62 if the state land is also included (MAFWE, 2021). This is a big obstacle for implementing modern adaptation techniques and technology in agriculture. Some efforts have been made to encourage agricultural land consolidation; presently, 4,500 ha at ten different locations across the economy are undergoing intensive land consolidation processes, with several locations already completed (supported by the MAINLAND FAO project). However, this process appears to be rather slow and expensive.

Classic techniques of land cultivation are prevailing, which causes serious disturbances of soil surface. Parcel size and shape, as well as relief characteristics very often prevent the possibility of more advanced and friendly land cultivation practices, like contour ploughing, reduced or no-tillage. Cover crops, as a replacement of cultivation, are implemented mainly in orchards and vineyards.

The **Land Parcel Identification System (LPIS)** is in place; since 2017, based on aerial recordings, orthophoto maps, and a digital field model, digitalization of the physical blocks (initial layer) was made. The LPIS is adapted to support measures that are part of the greening, which includes pasture maintenance and ecological areas, but lacks regulation defining the ecological areas as well as measures for the use of financial support related to pastures (MAFWE, 2021). LPIS is also adapted for measures in line with NATURA 2000 compliance as well as areas with natural constraints. As of 2020, 463,780 parcels of 92,520 agricultural holdings were digitized within LPIS, covering an area of 238,000 ha with on average 0.51 hectares/plot (MAFWE, 2023).

5.1.4. Brief agricultural sector overview

Out of the roughly 300,000 ha of utilized agricultural area, approximately one-half is used for cereal production (Figure 3). Wheat is the dominant crop, covering on average around 71,000 ha or 24% of UAA, followed by maize (11%) and cereals including barley and rice (19%). North Macedonia produces around 250 thousand tons of wheat and 150 thousand tons of maize annually. Although vegetables take up around only 11% of the utilized agricultural area, their share in the total gross agricultural output reaches 35%. Around 850-900 thousand tons of vegetables and 200-250 thousand tons of fruit are produced annually.

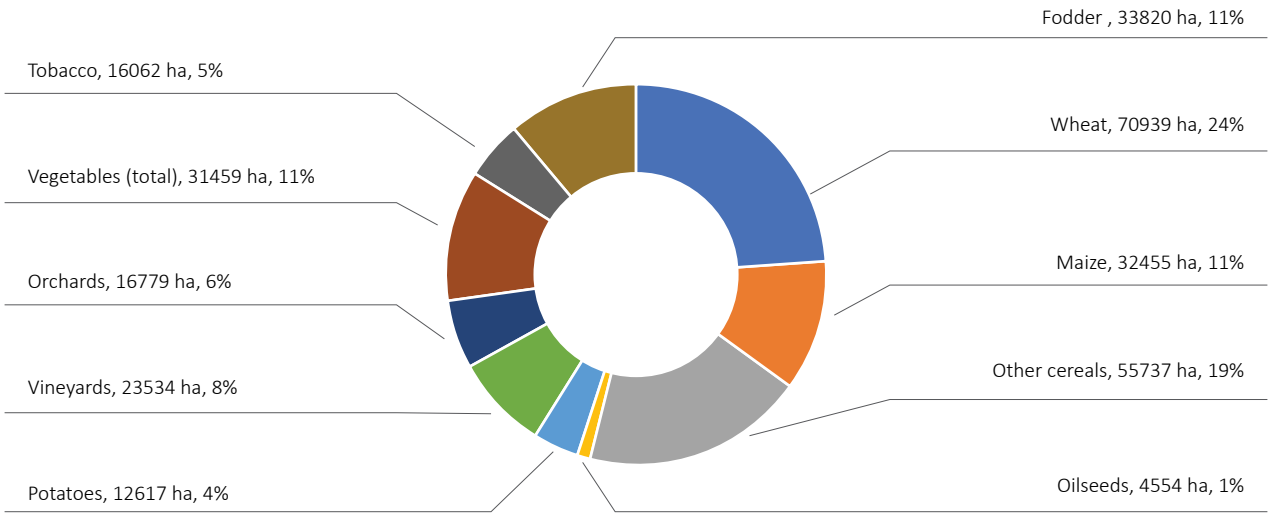


Figure 5.3. Area under major crops (average 2017-2022, in hectares)

Source: SSO (2023)

Milk and meat (cattle, pigs and lamb) are most important in livestock farming. Livestock numbers nevertheless underwent a serious decline over the period (Table 5.4).

Table 5.4. Number of livestock heads

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
Cattle	000	255	251	216	98.4	86.0	84.6
(of which dairy cows)	000	119	127	114	107.3	89.3	95.9
Pigs	000	222	184	178	83.1	96.6	80.2
(of which breeding sows)	000	33	23	19	68.0	85.5	58.2
Sheep and goats	000	792	738	674	93.2	91.4	85.2
(of which breeding ewes/goats)	000	557	544	529	97.6	97.2	94.9
Poultry	000	2,151	1,915	1,653	89.0	86.3	76.9
Beehives	000	62	69	123	111.1	177.1	196.7

Source: SSO (2023)
Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

There is a gradual upward trend in increasing the yields of most agricultural products in the economy, but significantly lagging behind those achieved in other developed economies and the EU average (Table 5.5).

Table 5.5. Yield of major crops and livestock

Indicator	Unit	Average			Index 1	Index 2	Index 3
		2005-2010	2011-2016	2017-2022			
Wheat	t/ha	2,977	3,234	3,285	108.6	101.6	110.3
Maize	t/ha	4,345	4,301	4,479	99.0	104.1	103.1
Potatoes	t/ha	14,052	14,162	14,714	100.8	103.9	104.7
Grapes	t/ha	11,192	12,771	11,228	114.1	87.9	100.3
Cow milk	t/cow	3,108	3,043	3,361	97.9	110.5	108.2

Source: SSO (2023)
Note: Change in %, Index 1 = (2011-2016)/(2005-2010); Index 2 = (2017-2022)/(2011-2016); Index 3 = (2017-2022)/(2005-2010)

5.1.5. Farm structure and producers' adaptive capacities linked to climate change

Farm size and typology. With 178 thousand farms and an average farm size of 1.8 hectares (SSO, 2017), small-scale family farming accounts for the majority of the agricultural sector in North Macedonia (only 280 are business entities). Less than 2% of farms are producing on more than 10 hectares, whereas 61% of producers farm on less than one hectare (Figure 2, right side).

The largest portion of agricultural holdings, 34%, are specialist field crop farms, followed by 17% each specialist permanent crops and mixed crops-livestock farms, 11% specialist grazing livestock, 6% specialist granivores, 8% mixed cropping farms, 5% mixed livestock holdings, while the remainder are specialist horticulture or non-classified holdings (SSO, 2017). Such structure of specialization, with prevalence of low-income field crop production, indicates insufficient adaptive capacities in terms of financial resources.

Over 89 thousand farms, or **50% of the farms, realize less than 2,000 EUR of annual output value**, i.e. 124 thousand farms, or 70% of all farms, have under 4,000 EUR of annual output value. However, these 70% of farms (with less than 4,000 EUR annual turnover per farm) generate only 22% of the total primary sector output value; inversely, the bigger farms in economic terms (producing more than 4,000 EUR average output value per farm), constituting 30% of the number of farms in the economy, generate 78% of the agricultural output value. This distribution points out to the high inequality in the sector among the farms in terms of physical and economic size, and high concentration of turnover value within the smaller number of bigger farms. It also indicates that the small-sized farms, mostly specialized in field crop production that occupies the most of arable land, have low income and low adaptive capacity. However, the interest of farmers in more intensive cropping systems has increased in the past decade, especially for vineyards and orchards.

Agricultural machinery is quite outdated, which usually prevents implementing advanced adaptation practices. Over 70% of tractors are older than 20 years (SSO, 2017). This situation is gradually improving, especially through the IPARD measure for modernization of farms with physical resources, but exact figures are lacking, pending the new agricultural census.

The **average number of persons** typically engaged per agricultural holding is 2.5, or 1.36 AWU when expressed in annual work units (AWU). One agricultural holding has 0.76 AWU on average per hectare of utilized agricultural area, while 0.64 AWU are used per 1 Livestock Unit (SSO, 2017).

Producers usually produce on **several land plots**, which raises transport costs and makes it more difficult to upgrade to modern technologies. All of this has an impact on the market potential, product quality, and poor level of producer integration, as well as the generally low productivity of primary agricultural output. Additionally, there are limitations to access to emerging technologies, innovation and market opportunities as well as to knowledge and skills in many areas, such as quality standards, postharvest handling, business and marketing management, and financial and digital literacy (WB, 2020).

Producer age, gender aspects, and education levels. The aging workforce is one of the main issues facing the sector. The largest age group of total agriculture labour force is that from 55 to 64 years of age. Only 4% of agricultural holders are younger than 35 years of age, 34% are between 35 and 54, and the majority or 62% have more than 55 years of age. Data from the farm registry show that the share of young farm holders of registered agricultural holdings up to 40 years of age take about 14% (MAFWE, 2021). Lacking quality of life and lower wages compared to other sectors deter young people from settling in rural areas and engaging in agriculture, seeing the sector as less attractive than other livelihood and professional options.

In terms of **gender**, more men are engaged in agriculture, with women making up 42% of the entire labour force in agriculture. However, women's participation in the management of individual agricultural holdings is quite low, as only 10% are female managers – out of all 177,845 agricultural households, only 18,632 are managed by women (SSO, 2017). Women are underrepresented among employees in individual agricultural holdings and agricultural enterprises, which is a reflection of their reduced economic independence and limited capacity to make decisions about the application of adaptation measures. Women dominate in the group of unpaid family workers in agricultural holdings, which further restricts their access to resources and prevents them from having access to the financial instruments needed to build climate resilient practices. This should be taken into account when establishing and implementing policies, measures and actions to address specific adaptation needs, and steps should be made to safeguard vulnerable communities and ultimately ensure equitable socio-economic development.

The level of **education** is quite unfavourable in the sector: the majority of holders of individual agricultural holdings have secondary education (43%), followed by those with primary education (35%) and those with no or incomplete primary education (11%), while the share of holders of individual agricultural holdings with higher education is the lowest (8%). Most of the operators possess significant practical experience, which is usually inherited or gained during practical work and knowledge sharing among the community. However, inherited practices are usually traditional and, in many cases, outdated. As a result, the majority of the agricultural workforce lacks managerial and business skills as well as formal agricultural education and training. The advisory system is also insufficiently equipped to adequately meet the needs of and support farmers especially in relation to climate change adaptation and underlying necessities for farm modernization, restructuring, cross-compliance, promoting innovation, and digitalization.

Apart from the formal educational system, there are **limited alternatives for informal or vocational training** programmes in agriculture. Numerous ad hoc training programmes have been organized within various initiatives for a targeted group of farmers in the past decades, mostly through donor projects, aiming towards transfer of certain techniques and practices. However, a systematic approach is lacking, which is a big obstacle taking in consideration the role and importance of individual capacities in implementing climate change adaptation practices. Within the recently adopted IPARD 2021-2027 programme, a measure on advisory services and training programmes for farmers is foreseen, but not yet implemented. Another initiative by MAFWE is the support of a more functional advisory system for agriculture and rural development, for training of certified trainers who will be engaged in the strengthening of extension and advisory services in the economy.

The adaptive response of Macedonian crop farmers to the **impact of climate change and its effect on farm income** reveals that farm returns are highly sensitive to different climate change scenarios and tend to decrease unless adequate adaptation measures take place, both at micro and macro levels (Martinovska Stojcheska et al., 2019). Using an alternative specification of the Ricardian model through a composite aridity index, to capture the response of farm returns to temperatures and precipitation, the econometric results indicate the significance of winter and summer season weather-related variables and confirm the non-linearity of the climatic function in relation to the farmers' economic results and adaptation capacity.

Within the Third Communication on Climate Change, sectoral vulnerability assessments also included a socio-economic component (MOEPP, 2014). Ten municipalities were included in the determination of a **Social Vulnerability Index**. However, data constraints due to comparability and classification issues and the lack of disaggregated data on household income and employment allowed for only partial assessment of the Southeast region, where Radoviš, Vasilevo and Dojran municipalities were found to be with the highest levels of social vulnerability. The climate vulnerability assessment through the **Livelihood Vulnerability Index** determined within the sectoral report of the North Macedonia's Fourth National Plan on Climate Change (Martinovska Stojcheska and Dimitrov, 2021) proved to be a useful tool for a multidimensional analysis, providing evidence for programming and implementing tailored policy instruments and measures for addressing more targeted local-level needs. This is a composite indicator based on a diverse combination of variables connected to exposure, sensitivity and adaptive capacity to climate change. The results revealed the Northeast region municipalities of Rankovtse, Kratovo and Staro Nagorichane as the most vulnerable in the overall livelihood dimensions. Policy response options should account for the uneven distribution of impacts across different territorial units and ultimately the affected population in different regions and municipalities, since the multidimensional character of climate change effects requires a comprehensive understanding of the economic, social and environmental vulnerability specifics.

5.2. Status of soils linked to climate change in agriculture

5.2.1. Exposure and sensitivity of soils to climate change and its influence on overall soil health

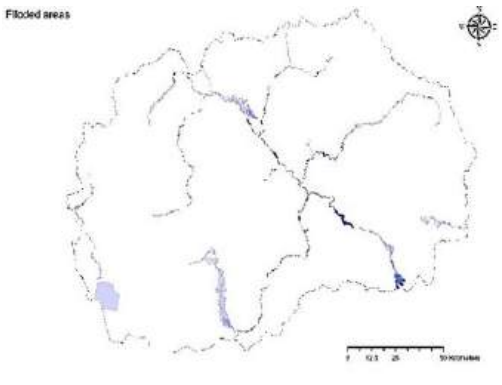
Soils in North Macedonia are a product of soil-forming factors with significant spatial variability which as a result have very diverse soil cover. Due to this, it is very difficult to manage and protect soils, especially in an environment of various pressures induced by human activities and exacerbated by the negative influence of the changing climate. The negative past trends and future projections of climate in Macedonia are well documented. The exposure of soils to climate events and extremes has aggravated, especially in the past few decades, which, coupled with the high sensitivity of the soils, causes serious impacts on this valuable natural resource. The sensitivity is mainly a result of the promptness of the degradation processes that occur when soils are exposed to extremes, compared to the very expensive and long-term processes of its restoration and recultivation, if possible.

Highly vulnerable to floods are regions along the water courses of big rivers (Vardar, Bregalnica, and Crna River), some valleys in the central part of the economy, and the Pelagonia plateau (Map 5.1). The most affected soil types in these regions are the soils in the valleys, for example: Fluvisols, Gleysols and Histosols. According to global data for the EU and North Africa (Dottori et al., 2021), more than 65% of the total area of 54,380.6 ha prone to floods are Fluvisols, Molisols (10.41 %) and Gleysols (7.2%). Soils affected by floods can suffer serious damage to their function and their production potential. If the floods result in torrential water flows and runoff from the adjacent hilly and steep terrains, the flat areas at the foothills are usually buried with deep layers of stones, gravel, and other sterile material which instantaneously causes the loss of fertile soils. Although the areas in North Macedonia affected by floods every year are rather limited, the sensitivity of soils affected by this extreme is extremely high, so it can be concluded that the impact from this weather extreme on productive agricultural soils is rather high.

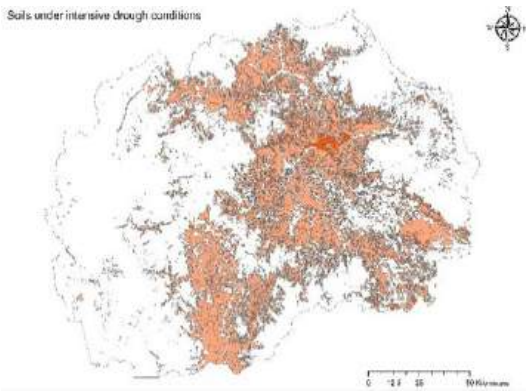
Areas significantly exposed to drought conditions (Map 5.2) cover almost one-third of the economy (Blinkov et al., 2020). Drought-affected areas are categorized into five categories depending on the degree of drought intensity. Almost 76,782.8 ha falls within the two strongest categories of areas: vulnerable (96.5%) and strongly vulnerable (3.5%) to drought. All valleys along the Vardar River and valleys in the eastern part of the economy (Kumanovo, Kochani, Strumica, and Radovish valleys), as well as the Pelagonia plane have been identified as **vulnerable to drought**. **Strongly vulnerable** to drought are small areas in the central east and south-east part of the economy. Dry periods usually appear during the summer months, causing ascending movement of groundwater and possible alkalization and salinization of the topsoil. **Strongly vulnerable** areas are soils of valleys and adjacent hills, like Chernozems (2,930 ha), Cambisols Chromic and Vertisols (5,240 ha), Fluvisols (2,981 ha), while in the zone vulnerable to drought there are vast areas with Fluvisols (127,283 ha), Vertisols (41,460 ha) and Regosols (54,899 ha).

Desertification is a process of losing soil biological productivity and is a product of the combination of unfavourable climate conditions and unsustainable management practices. The most recent analysis (Map 5.3, Mukaetov et al., 2020), showed that the most affected areas highly prone to desertification are some valleys along the river Vardar, like the lowest part of Skopje, Tikvesh, and Gevgelija valleys as well as some areas along the Strumica River in Radovish and Strumica valley. Most affected are Fluvisols along river terraces (over 55,450 ha) and Regosols and Leptosols with more than 11,000, and 10,000 ha, respectively.

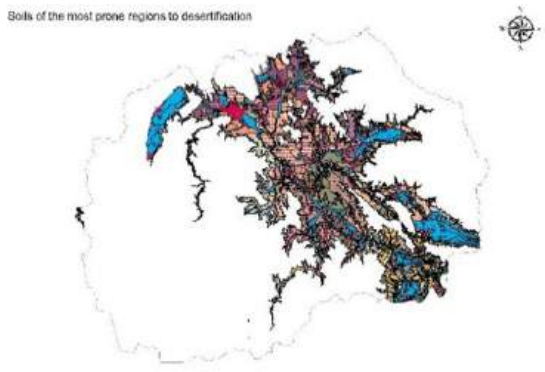
Almost 97% of the economy's territory is affected by the processes of soil erosion (Map 5.4). Most prone areas that fall within the first three categories of soil erosion are spread all over the economy on mountainous and hilly terrains with degraded vegetation or agricultural areas on inclined terrains. In conditions of profound negative influence of climate change, soil erosion as a process is expected to aggravate in the near future. The estimated area affected by the first (highest) category of soil erosion is a bit more than 52,000 ha, mostly Regosols (13,577 ha) and Leptosols (7,347 ha). Big areas are affected by the second (< 226.160 ha) and third (553,736 ha) categories of soil erosion, mostly Leptosols Calcaric, Leptosols Dystric and Cambisols.



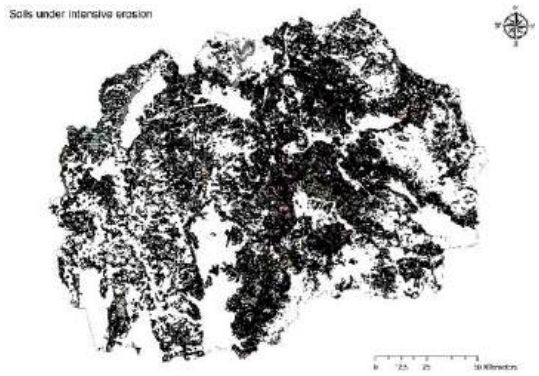
Map 5.1. Flooded areas*



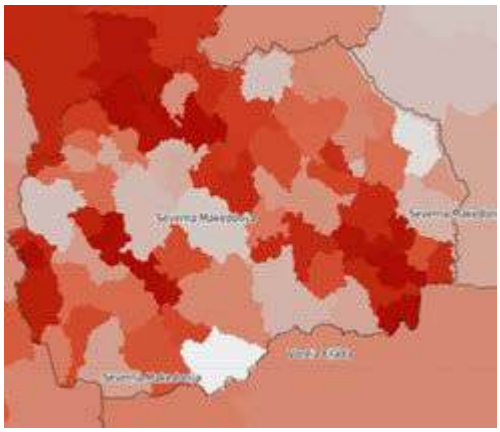
Map 5.2. Drought vulnerability – soils under intensive drought conditions*



Map 5.3. Soils highly exposed to desertification*



Map 5.4. Soil erosion – soils under intensive erosion*



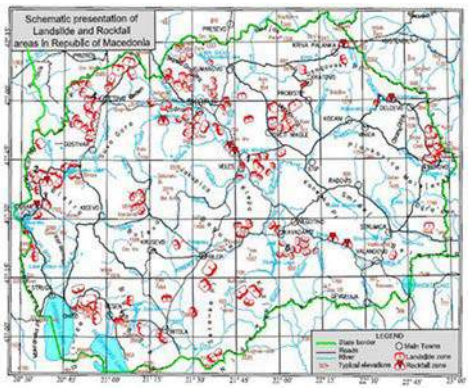
Map 5.5. Aggregated wildfire risk index – intermediate (EFFIS)



Map 5.6. Index of ecological and economical vulnerability to forest fires (EFFIS)



Picture 5.1. Landslides (NAP_LDD, Photo: Blinkov, I.)



Map 5.7. Landslides (Jovanoski, M.)

*Source: Mukaetov, 2023 (own analysis)

Forest fires are another climate-induced phenomenon that has a fatal influence over soil properties (Map 5.5, Map 5.6). Almost every summer, after prolonged dry periods and high temperatures, forest fires affect various locations causing serious loss of forest and bushes, generating serious economic loss. Burnt locations, especially those on inclined terrains, are highly prone to soil erosion. According to the EFFIS data, the total burnt area in 2022 was 4,384 ha. The most affected regions were the Southwest region with 1,364 burnt areas, and the Vardarski region with almost 967 ha.

Landslides are rather frequent and are the result of a combination of geomorphological conditions on specific locations, geology, climate, and human activities (Map 5.7). According to the available data officially recorded, there are more than 400 landslides, with a known location for only 255. Landslides most commonly appear on Regosols, Vertisols, and Chromic Luvisols on saprolite formed over diluvial, proluvial or fluvioglacial sediments. In more than 60% of the cases, landslides are deep or medium deep in a range of 25-30 m (MOEPP, 2018). The exposure of soils to landslides is rather low since landslides affect a small portion of cultivated land. At the moment, the number of active landslides is 21, most of it located in the humid and mountainous north-west (Jovanovski, 2010; Pesevski, 2018).

5.2.2. Existing gaps and challenges to meet the newly adopted EU strategic and legal documents on soil and adaptation

One of the benchmarks set in the National Strategy on Agriculture and Rural Development 2021-2027 (NARDS) is the policy of natural resource management and mitigation of the negative impact of climate change. The chapters on the management of agricultural soil and adaptation to climate change outline a set of measures and actions aimed at sustainable soil management and adaptation. A key point for achieving the foreseen actions is the digital transformation of agriculture (Ch. II/6.4.), which is fully in line with the EU Adaptation Strategy goal for digital transformation as a critical point in achieving the Green Deal objectives. At the moment, the new National Adaptation Strategy is in the process of preparation and adoption, and it still remains unclear how and to which extent the agricultural sector will be included.

The National Programme on Agricultural and Rural Development for the period 2023-2027 foresees numerous measures of importance for the enforcement of farmers' adaptive capacities, such as training programmes for the transfer of knowledge and informative sessions, agricultural advisory system and investments in infrastructure for the protection of agriculture from weather extremes and to mitigate the negative impacts of climate change. In addition to this, the plan foresees measures to support the ANC regions and implement GAP standards. The foreseen measures related to soil protection are of particular importance, such as anti-erosive cultivation techniques, cover crops and mulching. The planned measures related to soil protection and adaptation, although very positive, are cumbersome and ambitious, and require a well-developed mechanism for implementation, which is quite challenging. MAFWE annual programme on financial support for 2023 foresees only one measure related to soil protection – analysis of physical and chemical characteristics of soil, which will be supported with only 1 million MKD (16,000 EUR). This is a good example how technical and financial mechanisms are important in the implementation of measures and actions.

The EU Strategy on Adaptation to Climate Change emphasizes the necessity of smarter adaptation: improving knowledge and managing uncertainty, this is fully in line with the Action Plan of the Third National Report on Climate Change which foresees measures like: establishing a national centre for drought and yield forecasting, establishing a national network for long term monitoring of agro-climatic and agro-edaphic parameters. The Fourth National Report on Climate Change (FNC) also foresees a set of measures which are complementary with the EU Adaptation Strategy, such as the establishment of a research centre on climate change in agriculture, improving soil monitoring, development of the institutional setup and legal framework. Main gaps for achieving the foreseen measures in the AP of both reports are the lack of awareness, lack of finance and capacities. The foreseen measures are rather complex and cumbersome, which requires strategic and comprehensive approach.

The assessment of the current status with land degradation was conducted in 2020 and based on this analysis, North Macedonia has set is national targets to achieve Land Degradation Neutrality (LDN) by 2030. The implementation of the set national targets is very challenging since it needs sound mainstreaming of land degradation in the current legislation, development of the needed capacities, establishing of a monitoring system and corresponding databases.

Soil monitoring, which is in the focus of the EU with the newly proposed regulation on soil monitoring, is not addressed in any of the existing legal or strategic documents. Such condition is mostly due to a lack of awareness among the policy makers, low administrative capacities, inexistence of specific legal documents like a law on soil protection. The lack of cross-sector governance on soil-related matters exacerbates the issue, leading to a communication gap among policy makers. Inadequate collaboration with the academia/research community hinders the addressing of relevant issues for soil protection. Lack of financial resources for research and monitoring of soils is another big challenge. All these existing gaps pose significant obstacles to successfully meeting the requirements outlined in the newly adopted EU documents.

5.2.3. Sustainable measures and best practices applied for protection of agricultural land

Soil in North Macedonia is under constant pressure causing different types of land degradation which results in losing its function and its production potential. For a long time during the former Yugoslavia, soils were not treated as a fragile natural resource, but as a tool for food production, so to this end massive ameliorative projects were implemented in order to increase its production potential.

In recent times, the Ministry of Agriculture, Forestry and Water Economy (MAFWE) has begun acknowledging the importance of addressing soil threats. This is evident in the latest strategic document, the National Agriculture and Rural Development Strategy (NARDS), as well as its annual Programmes, which outline specific adaptation and mitigation measures to safeguard the soil. It is noteworthy that the most recent Instrument of Pre-Accession Assistance Fund for Rural Development (IPARD 3), foresees a specific measure on agro-environmental, climate and organic agriculture. This measure encompasses a range of agro-ecological and adaptive sub-measures, including the introduction of green cover in perennial crops to mitigate soil erosion and enhance soil quality, implementation of crop rotation, and support to organic farming.

In the past decade, cover crops have become very popular especially among apple and vine producers. There are numerous examples of this best practice in the economy and the feedback from the practice is very positive, especially in more humid areas. Cover crops protect the soil surface from direct destructive impacts of rainfall drops, which reduces the surface runoff and significantly reduces soil erosion. Projections are that intensive rainfall incidents will become more frequent and the mineralization of soil organic carbon will be more intensive. Organic material from cover crops left as mulch, can in the long run increase the level of soil organic carbon in the top layer.



Picture 5.2. Permanent grass in apple orchards – Prespa Lake



Picture 5.3. Strawberries in vineyard as cover crop – Ohrid Valley

UV nets covers in perennial plantations is an adaptation measure that has multiple benefits for both plants protecting them from hail and sun burns, and for soil, reducing the intensity of evapotranspiration. UV nets shadow the surface with various intensity depending on the density of the net. In such cases, soil is protected from overheating, which is beneficial for soil moisture conservation and the biological and chemical processes in the soil.



Picture 5.4. UV nets on apple demonstration field – Prespa Lake



Picture 5.5. UV nets on a persimmon plantation – Dojran Lake

Meteo stations and fertigation are another best practice that has become very popular among farmers, especially in intensive agricultural production.



Picture 5.6. Fertigation of apples – Prespa Lake



Picture 5.7. Meteo station on an apple plantation – Ohrid

Fertilizer use in most cases schematic, and voluntary, without any previous laboratory testing of nutrient level or fertilization programmes. In the past decade, the Ministry of Agriculture, Forestry and Water Economy, has supported laboratory testing of areas aimed for perennial crops plantations. However, in most cases mineral fertilizers are used in the long run, while organic fertilizers are used on a very small area, e.g. on vegetables and perennials. Manure management, like storage and application, is usually inappropriate and should be improved.

Fertigation is another on-farm adaptation measure, which enables nutrient application in numerous small portions dissolved in irrigation water, enabling optimal quantities of nutrients for the plant during the entire period of vegetation. Composting of organic by-products has been attracting more and more attention among producers, since with a small effort organic waste which was previously improperly dumped or burned, now becomes a valuable source of organic matter. However, this measure should be further supported and promoted among producers.

5.2.4. Mechanisms and opportunities for effective adoption of adaptation measures for soil health protection

Adaptation of agriculture to climate change is a complex process, which relies on several building blocks. The legal framework is one crucial for governing all aspects related to the process of adaptation and defining the role of all key stakeholders. At the moment there are several significant steps forward in this direction. For instance, one of the measures supported within IPARD 2021-2027 focuses on implementing agro-environmental measures, climate change adaptation and organic farming. The recent NARDS contains a special chapter on climate change and sustainable use of natural resources, outlining all objectives and needed actions. However, there is no special legislation for dealing with soil-related issues in agriculture. The existing Law on Agricultural Land is rather outdated and tackles only certain issues related to the sustainable use of agricultural soils.

Implementing adaptation measures requires the existence of well-developed technical capacities and infrastructure, which will enable precise and reliable estimation of the current situation, identifying priorities for adaptation, supporting implementation in practice, and evaluation and verification of the effects of adaptation. At the moment, there are several mechanisms in place that can support some aspects of the process of adaptation. In collaboration with FAO, MAFWE has successfully finalized the creation of the Macedonian Soil Information System in the past few years, which represents a good example of referent digital soil data source. Another good example is the agro-ecological zoning of the economy, which outlines the best zones for certain land utilization types on the basis of actual climatic and edaphic factors, as well as the current socio-economic conditions. In the past decade, MAFWE has supported a measure for laboratory testing of soils under perennial plantations. However, in order to be fully operational, this measure needs to be further developed in terms of making this measure obligatory for all agricultural producers, lab tests should be repeated once in five years and accompanied with fertilization programmes, and laboratory data need to be collected in a common database. At the moment, MAFWE is supporting the creation of an advisory system for agriculture and rural development. Such systems can contribute towards dissemination of good practices among producers. In its Rural Development Programme for 2023, MAFWE foresees the installation of platforms for precise agriculture, equipped with a set of sensors for measuring various meteorological and soil parameters on 10 locations in the economy. If properly configured and calibrated, such systems can serve a wider group of producers.

The hydrometeorological system is rather modernized in terms of its technical capacities, and will be upgraded with additional platforms for monitoring soil parameters. Human capacities and soft skills are rather limited, which prevents successful development and implementation of an adaptive mechanism. Research and development support has been marginalized in the past decades.

5.3. Status of water resources and their importance for agricultural production

According to hydrographic characteristics, the Republic of North Macedonia covers part of the Vardar, Crn Drim, Strumica, and South Morava river basins. In its entire territory, 84% of the waters are domestic, and only 16% are external waters that come into the economy. According to multi-year measurements, the total available surface water resources are estimated at 6.372 billion m^3 or 4.80 billion m^3 in a dry year. Most of these resources are located in the Vardar Basin (72%), followed by the Crn Drim Basin with 26% and to a small extent in the Strumica Basin (2%) (Water Management of the Republic of Macedonia, 1999; Chukaliev et al., 2004).

Due to the fact that waters in North Macedonia are mainly domestic, precipitation plays a key role, which, among other things, is of particular importance for agricultural production. The average annual precipitation is approximately 730 mm/year, and by catchment areas, precipitation amounts are 700 mm in the Vardar Basin; 980 mm in the Crn Drim Basin; 791 mm in the Strumica Basin and 720 mm in the South Morava Basin. As a result of the continental climate and the Mediterranean influence, the distribution of precipitation is quite unfavourable both in time and space. Such an uneven distribution of precipitation results in long dry periods (Water Management of the Republic of Macedonia, 1999; Chukaliev, et al., 2005; Radevski, 2009).

As for groundwaters, they are a very significant water resource. According to some research, a value of 31.43 m^3/s or 314.3 million m^3/year is obtained, which can be taken as a lower limit of the capacity of underground waters in our economy (Water Management of the Republic of Macedonia, 1999). In general, the data on groundwater reserves in our economy have not been sufficiently researched.

Finally, spring waters should also be mentioned as a water resource. In North Macedonia, there are 4,414 registered springs, 58 of which have the capacity of over 100 l/s (Chukaliev et al., 2004; Radevski, 2009). According to existing estimates, the total flow of springs in North Macedonia is 24 m^3/s (Water Management of the Republic of Macedonia, 1999).

Total water needs in the economy are estimated at 2.030 billion m^3 per year. Predominantly, water is used for irrigation or 900 million m^3 (46%), followed by minimum accepted flows with 635 million m^3 (28%), industry with 275 million m^3 (14%), and supply of drinking water for the population and tourists with 220 million m^3 (12%) (Tanchev et al., 2011). The annual resource potential per capita is about 3,000 m^3/inhabitant, (2,592 m^3/inhabitant according to the FAO Aquastat database, 2020).

Analyses indicate that water resources satisfy the needs of the economy (drinking water, industry, irrigation, biological minimum). However, we have continuously been facing huge damages caused by drought of varying intensity. It is a consequence of the uneven spatial and temporal distribution of precipitation and watercourses. The impact has intensified in recent years, primarily due to atypical and extreme impacts of CC (Chukaliev, et al., 2017).

5.3.1. Brief analysis of the irrigation status in the Republic of North Macedonia

To ensure sufficient water quantities for all purposes in the Republic of North Macedonia, and thus for quality and stable agricultural production, so far, 27 large and 110 small dams have been built in the economy, covering a total reservoir area of about 2.5 billion m^3. In the past period, irrigation systems have been built on about 163,000-174,000 ha (according to various sources). About 126,617 ha are covered with a detailed irrigation network – 99,918 ha in the basin of the Vardar River, 18,432 ha in the basin of the Strumica River and 8,267 ha in the basin of the Crn Drim River (Water Management of the Republic of Macedonia, 1999; Chukaliev et al., 2005; Radevski 2009).

In the past period, the area under irrigation systems has decreased to 135,912 ha, while the possible area for irrigation is 91,469 ha. The efficiency is only 24% of the areas that can be irrigated (Irrigation and Drainage Strategy Proposal, 2022).

Table 5.6. Hydro-ameliorative systems in the economy, irrigated area according to project documents and possible irrigated area in ha

Hydro-ameliorative systems in the economy		Irrigated area in ha according to project documents ~1970-1980	Possible irrigated area in ha 2019
1	Tikves	20,225	12,984
2	Bregalnica	28,890	28,111
3	Prilepsko pole	6,200	2,450
4	Kumanovsko-Lipkovsko pole	10,820	6,471
5	Strezevo	20,200	18,815
6	Radovisko pole	5,581	3,462
7	Juzen Vardar	7,699	5,662
8	Strumicko pole	14,050	11,180
9	Skopsko pole	350	234
10	Polog	12,101	1,140
11	Crn Drim	7,679	450
12	Berovo	917	510
13	Lisice	1,200	1,200
14	Zletovica	0	0
	Total	**135,912**	**91,469**

The most efficient use of hydro-melioration irrigation systems was recorded before 1990. The highest efficiency achieved during that period was 78% (Radevski, 2009). The analysis of the efficiency of the use of irrigation systems for the period 1987-2020 shows that the use of irrigation systems has seriously decreased in the past period. In some years, utilization decreased 5 to 6 times (2002) compared to 1987. There are several reasons for this, including obsolete irrigation systems, damaged equipment and infrastructure, reduced number of professional staff, fragmentation of areas after the transformation of large agricultural plants, institutional and technical changes, restructuring, and changes in the legal framework. Panov (2020) reported an analysis with satellite images, according to which there is a much larger irrigated area within the hydro-melioration systems (47,000 ha) than the one presented by AD Water Management (19,050 ha).

State Statistics Office data indicate that there is a larger irrigated area than the area covered by hydro-meliorative systems in North Macedonia, with a total of 84,434 ha irrigated. This result is much closer to the situation in the field, and it was made based on the analysis of data from statistical surveys, which also include agricultural producers on the area they irrigate. According to these data, 26.3% of the used land in North Macedonia is irrigated.

Table 5.7. Irrigated land in North Macedonia in 2016

Region	Total available land by holdings (ha)	Utilised land (ha)	% of utilised land in comparison with total available land	Irrigated land		
				Total (ha)	% from total available land	% from utilised land
North Macedonia	366,462	320,738	87.5	84,434	23.0	26.3
Vardar	46,848	42,708	91.2	14,139	30.2	33.1
East	56,205	43,949	78.2	8,743	15.6	19.9
Southwest	22,869	17,635	77.1	4,686	20.5	26.6
Southeast	38,813	32,995	85.0	16,823	43.3	51.0
Pelagonia	96,369	90,243	93.6	17,612	18.3	19.5
Polog	26,856	25,180	93.8	14,277	53.2	56.7
Northeast	49,313	43,263	87.7	4,253	8.6	9.8
Skopje	29,189	24,765	84.8	3,902	13.4	15.8

Source: SSO, 2016

On the other hand, field experiences testify that irrigated areas are larger. Namely, if the climatic water balance on the territory of our economy is taken into account, it is logical that most agricultural crops grown in the given conditions need irrigation, which is why the expected areas for irrigation are larger. According to Tanaskovikj (2023), about 185,000 hectares of agricultural crops (without wheat, oats, barley, and rye) are irrigated in North Macedonia.

Table 5.8. Irrigated land by group of crops in 2016 in ha

Regions	Total irrigated area	Cereals	Industrial crops	Fodder crops	Pods/ Leguminous	Vegetable	Orchards	Vineyards	Meadows	Other
North Macedonia	84,434	28,874	3,536	10,902	1,841	13,821	11,497	8,206	2,454	3,304
Vardar	14,139	1,745	539	3,241	106	1,242	2,251	4,801	-	214
East	8,743	5,111	31	1,233	209	399	1,120	292	111	238
Southwest	4,686	1,885	3	721	267	308	1,090	22	55	334
Southeast	16,823	3,528	1,054	716	178	6,392	1,387	2,815	21	731
Pelagonia	17,612	5,421	1,311	1,895	229	3,521	4,216	28	521	471
Polog	14,277	7,284	4	2,425	511	1,095	642	0	1,596	721
Northeast	4,253	2,226	495	411	252	251	165	15	13	427
Skopje	3,902	1,674	99	260	90	614	626	233	138	168

Source: SSO, 2016

As for irrigated crops, the highest representation is recorded in cereals (generally rice and corn), with 34.70% of the irrigated area. Vegetable crops and orchards come second and third, and they are closely related to irrigation. Fodder crops come fourth. Vineyards, industrial crops, etc. follow.

Technical solutions for about 65% of constructed areas for irrigation include irrigation with sprinkler irrigation, whereas surface techniques are preferred for about 35% of the areas (Radevski, 2009). The

use of drip irrigation in the economy has intensified after 1990s, and today, almost all orchards and vineyards, as well as most vegetable crops have a drip irrigation system (Tanaskovikj and Chukaliev, 2014).

Drainage systems in the Republic of North Macedonia cover a total area of 82,195 hectares (Water Management of the Republic of Macedonia, 1999). The reduction of the drained area is a pressing issue. According to AD Water Management data, over 50 percent of the drained area is not in operation (National Irrigation and Drainage Strategy proposal, 2022).

Table 5.9. Area covered by drainage systems in North Macedonia

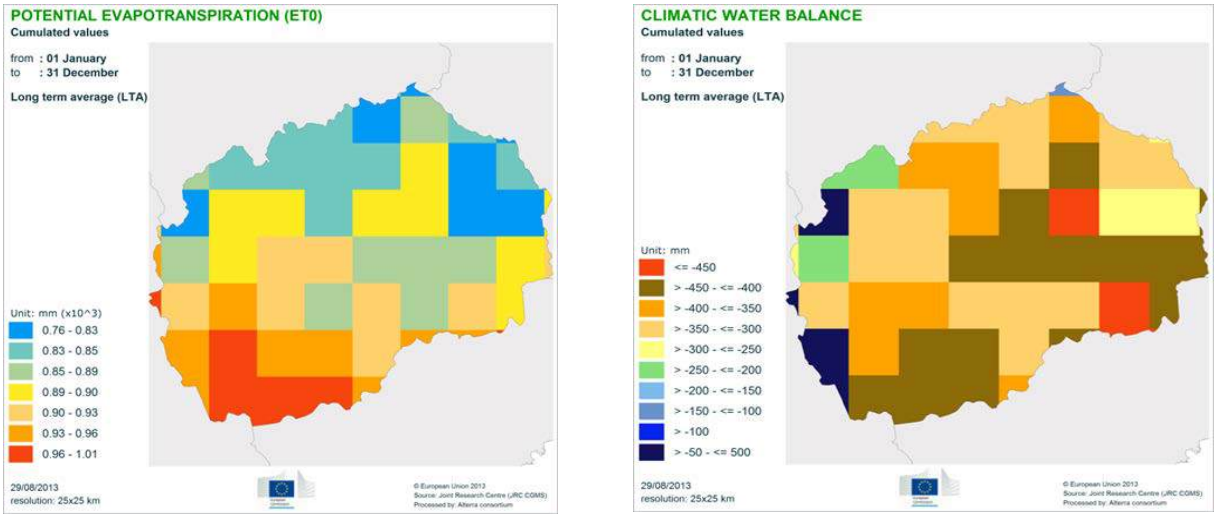
	Drainage systems in the economy	Drainage area in the economy according to project documents (ha)	Main recipient
1.	Skopsko pole	6,600	Vardar River
2.	Pelagonija – Bitolsko pole	30,000	Crna River
3.	Pelagonija – Prilepsko pole	24,150	Blato River
4.	Strusko pole	2,680	Crn Drim River
5.	Strumicko pole	9,000	Strumica River
6.	Kochansko pole	6,000	Bregalnica River
7.	Ovce pole	1,700	Azmak River
8.	Prespansko pole	1,800	Golema reka River
	Total:	81,930	

5.3.2. Drought risk assessment and crop water requirement

The geographical position and climatic conditions in the Republic of North Macedonia enable high and quality production of agricultural crops. However, lack of water is the limiting factor for stable production. Dry periods with different intensity and duration are common, even in flood years. For example, on an average of 20 years, 10 years are intensely dry, 9 are average, and 1 is characterized as wet. Due to climate change, the risk of intensification of dry periods increases, while the need for water for all purposes grows (Chukaliev et al., 2004; Tanaskovikj et al., 2011).

Major agricultural regions in the economy are characterized by annual precipitation of 400-600 mm. Despite the small amounts of precipitation, potential evapotranspiration is high and ranges from 760 to over 1,000 mm. This results in a huge water deficit, and therefore, the climatic water balance in the entire territory of the economy is negative, except for a few small areas in the far west (Figure 1). This lack of water from natural sources can exceed-450 mm. Such weather conditions have negative effects on production conditions in agriculture.

In the conditions of climate change, when water shortage increases, a significant drop of wheat yields caused by limited water supply can be expected. Unlike wheat, sunflower, and especially corn, have very limited yields due to the lack of water, that is, the maximum yield of biomass in corn drops from potential 31 to only 13 t/ha (Chukaliev, 2014).



Map 5.8. Potential evapotranspiration (ETo) and climatic water balance for the period 1975-2012

Source: JRC MARS Weather database, Chukaliev (2014)

The third national report to UNFCCC (2013) reports that climate change would lead to increased droughts, longer dry periods, and further yield reduction caused by drought and heat stress. Among other things, the report lists several models and options for adapting corn, sunflower, and winter wheat crops to climate change, especially focusing on irrigation practices.

The immense importance of irrigation for climatic conditions in the economy is evident in the results highlighted by Iljovski and Chukaliev (2003) for crops that can survive without irrigation (only with natural rainfall and agrotechnical measures). Thus, autumn grains (wheat, oats, barley, and rye), which are atypical crops for irrigation, have a doubled yield only with two irrigation applications in April and May. Maize, as a typical irrigation crop, is unprofitable and yields below 2 t/ha without this measure, whereas with irrigation, the yield increases by 400-500%, in sugar beet by 200-300%, in fruits by 200-300%, etc.

Table 5.10. Irrigation water requirement and irrigation techniques by group of crops in North Macedonia

Crops	Average irrigation water requirements by season (mm)	Applied irrigation techniques	Irrigation efficiency	Average irrigation application rate (mm)	Number of applications during the season
Rice	1,800	Flooding	>50%		
Maize	420	Sprinkler	60-70%	60-70	6-7
Industrial crops	374	Sprinkler	60-70%	55	7
Fodder crops – alfalfa	614	Sprinkler	60-70%	87	7
Pods/Leguminous – soybeans	275	Sprinkler	60-70%	45	6
Vegetable (tomato, pepper)	360	Drip irrigation	70-90 %	12	30
Orchards – apple, pear	390	Drip irrigation	70-90 %	18	20
Vineyards	277	Drip irrigation	70-90 %	18.5-13.9	15-20
Meadows/clover	258	Sprinkler	60-70%	52-65	4-5

Unfavourable environmental conditions in the context of escalating climate change create an environment in which the production of agricultural crops in most of the economy is almost impossible without additional irrigation. Crop water needs for irrigation vary depending on the year, crop structure, growing conditions, etc. In Table 5.10 the average results for the irrigation water requirements in North Macedonia are presented, prepared by the Department of Water Management and Erosion at the Faculty of Agricultural Science and Food in Skopje for the needs of the Spatial Plan of North Macedonia (2021-2040) on the basis of average climate parameters using the CROPWAT 8.0 for Windows computer programme and FAO's Penman-Monteith method. According to the same report, total irrigation water needs projected for the period 2021-2040 will vary from 953 to 1,596 million m^3 per season.

5.3.3. Overview of farmers' existing adaptive practices for proper water use under CC

A number of national reports, policy documents, and research papers indicate that irrigation is considered the best available adaptation option, achieving significant yield increases. According to data of the State Statistics Office (SSO, 2016), surface irrigation is still dominant in North Macedonia with 59%, drip irrigation comes second with almost 10%, and about 7% of the surfaces are irrigated by sprinkler irrigation. Our field experiences testify that drip irrigation covers a larger area than the one presented by the SSO (2016), at least 50-60,000 hectares of orchards, vineyards, vegetable crops, and some corn fields. Our research indicates that surface irrigation is characterized by very low efficiency (less than 50%). Also, a common problem among producers is the tendency to over-irrigate, even with drip irrigation systems, primarily due to not knowing the importance of properly determining the time and quantity of irrigation. On the other hand, yield potential and quality of production in North Macedonia are lower than they should be, primarily because a significant area irrigated by drip irrigation is not equipped with injectors (fertigators), which means that farmers are still using classical spreading of fertilizers on the soil (Tanaskovikj et al., 2016; Tanaskovikj et al., 2019). In this respect, the results of some research with different crops conducted in our economy show up to 70% fertilizer use efficiency (FUE) in drip fertigation systems or up to five times less FUE only as a result of using the furrow irrigation technique and traditional spreading of fertilizer on the soil. As for water use efficiency, it is over 90% higher in drip fertigation treatments compared to furrow irrigation and traditional fertilization (Iljovski et al., 2003; Tanaskovikj et al., 2011; Tanaskovikj et al., 2016; Tanaskovikj et al., 2019)

According to field data (Department of Water Management and Erosion at the Faculty of Agricultural Science and Food in Skopje), the use of modern techniques in irrigation practice and application of adaptation measures in conditions of climate change need to be further improved. However, it should be pointed out that in the last 20 years, intensive efforts have been made to improve the capacities of producers in this sector. To this end, many activities supported by various donors (UNDP, USAID, GTZ, IAEA, IPA, GEF, many domestic donors, etc.) have provided adequate scientific equipment for conducting research in this area as well as proper equipment for farmer's fields. Also, it should be emphasized that a large number of farmers are trained in the proper use of irrigation systems, equipment for determining the time and water irrigation quantity, drip fertigation programmes, data loggers and soil moisture sensors, weather stations, mulch materials, UV nets, as well as other types of equipment for rational water use, conservation and adaptation to climate change. Some of the results of the application of adaptive measures and best practices in North Macedonia are shown in Annex 5.2 of this report.



Picture 5.8. Applied adaptive practices in North Macedonia (drip irrigation and fertigation, tensiometers, soil sensors with data logger, organic and inorganic mulch material, UV nets, cover crops)

Source: Tanaskovikj, 2012-2019

5.4. Crop production analysis linked to climate change in agriculture

5.4.1. Analysis of meteorological data availability and accessibility

The National Hydrometeorological Service and a network of meteorological stations were established in 1947. Since then, the economy has been covered by systematic meteorological measurements with a well-developed network of meteorological stations.

Under the Law on Hydrometeorological Activity (Official Gazette of North Macedonia, No. 103, 19 August 2008), a single meteorological and hydrological observation system was established on the territory of the Republic of North Macedonia. The responsible institution that operates this network is the National Hydrometeorological Service (UHMR). The meteorological system in the Republic of North Macedonia is an integral part of the global observing system and all activities which are performed in this system are determined by the regulations and standards of the World Meteorological Organization.

Stations with full and part-time observers. A state meteorological station network with professional observers is established within the meteorological observation system in the Republic of North Macedonia. At the end of 2020, this network included 19 main meteorological stations and 2 meteorological radars and hail suppression centres. In addition to this, a network of stations with part-time observers has been established, which consists of 7 climatological stations, 103 precipitation stations and 24 phenological stations (map in Annex 5.3).

Automated Meteorological Stations (AMS). In the last years, the meteorological observation system in the Republic of North Macedonia has also been completed by installing automatic meteorological stations. However, the number of AMS is permanently growing, but their number and geographical locations are not reported on the UHMR web page. Nevertheless, UHMR reports near-real-time hourly meteorological data for 56 AMS from their network.

Agrometeorological stations. Moreover, there is an agrometeorological monitoring network, which is composed of 6 Automated Weather Stations (AWS) equipped with more sensors than regular AWS, to fulfil tasks of agrometeorological monitoring. Data are available on www.agrometeo.mk.

Meteobot. Meteobot is a private company that operates more than 50 mini-automated agrometeorological stations in the economy and provides services for crop protection, irrigation, etc. Their network is distributed in the central and south parts of the economy: Tikvesh wine growing region with more than 30 stations, Southeastern Region (Radovish-Strumica) with more than 10 stations, Pelagonia with more than 10 stations, about 10 in the Eastern Region, several in Ohrid-Prespa region, etc. Their station network can be both open access and private. Open access stations provide data access through the smartphone application.

Analysis of phenological monitoring. Phenological monitoring is organized through the UHMR in 24 stations. The phenological network monitors the date of appearance of different plant growth stages during the season. The network covers agricultural crops (cereals, industrial, and forages), fruits (apple, cherry, sour cherry, pears, and others, including the number of varieties), and vine grapes including table and wine varieties. The sowing date and harvest are also recorded. Moreover, a large number of wild herbaceous and tree species are monitored.

The data from the phenological monitoring are posted at the website www.agrometeo.mk. The total of 45 phenological stations are listed, but many of them are not active. Moreover, data are not easily accessible, there are many data gaps and inconsistencies. Therefore, even publicly available phenological data are not usable in the form published. The period covers the years 2018-2023, which is too short for a serious analysis of climate change effects. Data should be restructured and cleaned from errors, allowing bulk download and providing longer time series.

The agrometeorological indices used in the economy for climate change analysis in agriculture are drought and temperature indices.

Drought indices. Most frequently used indices are related to aridity: Drought Factor by Lange, Drought Index by De Martonne, Aridity Index as defined by UNFCDDD, and the meteorological water deficit. Moreover, the National Hydrometeorological Service uses the Standardized Precipitation Index (SPI). However, this index uses only precipitation and is deficient regarding the temperature component, which is important to the overall water balance and water use by the crops. This drawback can make it more difficult to compare events of similar SPI values but different temperature scenarios.

Temperature indices. Increased temperatures modify the growing season and create an environment for an earlier start and later end of the periods with optimal temperatures for crop growth, thus the season is prolonged. However, careful analysis is required due to the appearance of other limiting factors, such as late spring frost and crop damage (for example frost at the end of April 2017). Moreover, the Growing Degree Days for temperatures over 0, 5, and 10°C were used. However, these indicators were analyzed using monthly data (only available for research purposes). Nevertheless, after the decision to use daily data from international sources, there have been intensive activities on adopting a new methodology for these indicators. Moreover, the use of daily data opens new perspectives for using other agrometeorological indices in the future.

Crop modelling for estimating crop response to climate change in the economy is not very popular and there is a limited number of papers and reports that implement crop models.

Early period – empirical model. The early activities on analyzing climate change effects on crop yields were based on the empirical model developed by FAO – Crop Yield Response to Water Deficit, and the approximation that increased water deficit will further decrease crop yield. The rough estimate was later confirmed by using the biophysical CropSyst model.

Bioma and CropSyst. The process of capacity building for using the CropSyst model and BiOMA modelling platform took place in 2013-2014 during the preparation of the Third National Communication to UNFCCC. A number of analyses were conducted using a model calibrated by the European Commission Joint Research Centre (JRC) and weather/remote sensing datasets from the same institution. However, the developed capacities were lost because insufficient attention was given to human capacities.

Aquacrop. The attempt to use biophysical models was not successful, therefore a new process of using the water crop productivity model (AquaCrop, developed by FAO) was initiated. The model is less data-intensive than biophysical models, it is calibrated worldwide, and there are a number of modules that provide an opportunity for implementing crop management practices and their effects on final biomass productivity and crop yield. Moreover, the Representative Concentration Pathways are implemented in the model, which provides an opportunity for climate change analysis in different scenarios. The model is considered a very good option to model the effects of climate change on crop yield in the case of data restrictions. Nevertheless, again we are at risk of losing the developed capacities, due to a low level of support to human capacities.

5.4.2. Analysis of extreme weather events

Extreme weather events are very important for climate change analysis. Some of those can be estimated and analyzed using historical and future weather datasets and/or crop models.

Extreme weather events should be recorded by the National Hydrometeorological Service, but a low level of data transparency makes these records unavailable to the public and the research community. Moreover, when weather events are getting the dimension of crisis, the responsibility is located at the Crisis Management Centre. However, their web site reports only fires and floods. When extreme weather events cause damage to agriculture on a larger scale, the Ministry of Agriculture, Forestry and Water Economy (MAFWE) undertakes activities for damage assessment and eventual support of farm damages, and likely hail, frost, prolonged drought, and some other events that jeopardize agricultural productivity are recorded by their departments.

Nevertheless, the media have reported on several extreme weather events, and an analysis of the contents of these reports could provide valuable information on extreme weather events and their negative effects on agricultural production. The table reporting the data collected by searching for extreme weather events reported by the media is attached in Annex 5.3.

However, the number of crop damages caused by the changing weather is not included in any of these sources, such as sunburns, heat waves, changes in crop growth, shortened grain filling periods, etc. Therefore, the systematic recording of all crop damages associated with climate change should be regularly recorded and data should be analyzed by research institutions to assess risk for agricultural productivity in the future, and to design appropriate adaptation practices.

5.4.3. Crops sensitive to climate change, vulnerable regions, adaptation measures and practices

Crops sensitive to climate change. The climate and edaphic factors in the economy have created conditions for the cultivation of a variety of cereals, industrial crops and forages. Moreover, there are good conditions for growing vegetables, grape vines and deciduous fruits. Water scarcity is a major limiting factor for crop productivity that leads to decreased water availability and significant impacts on crop yield. Crop yields are among the lowest in Europe and climate change will further increase the severity of water limitations and reduce the already low yield potential of rainfed agriculture.

However, crops cultivated on irrigated land may even benefit from the increased CO_2 concentration, prolonged season and some other expected changes. Winter cereals will have earlier ripening and will be less sensitive to climate change negative effects than summer crops that will be exposed to adverse effects during the hottest and the driest part of the growing season. Moreover, vine grapes and fruit trees will be the most exposed to the effects of climate change. Their sensitivity is high, particularly in rainfed cropping systems. Therefore, the most sensitive will be rainfed fruits and vine grapes. The adaptive capacities of grape growers are usually higher than those of fruit growers, and are frequently supported by advanced knowledge coming from the vineries in the region. Vegetable crops, particularly the most important ones, such as pepper and tomatoes if kept in traditional areas for growing (southeastern and southern parts of the economy) and grown in open fields, will be the second group of sensitive crops, followed by maize, sunflower and other summer crops.

Vulnerable regions and crops and their combination. The Second National Communication to the UNFCCC established vulnerable regions based on the level of changes of biophysical indicators, such as climate, expected crop response to climate change, etc. The following vulnerable regions were determined:

The most vulnerable area:

- Central Vardar Valley with Kavadarci as the representative meteorological station

Very vulnerable areas:

- Southeastern part (Strumica as the representative meteorological station)
- Southern Vardar valley (Gevgelija as the representative meteorological station)
- Skopje–Kumanovo region (Skopje as the representative meteorological station)
- Ovche Pole Region (Amzabegovo as the representative meteorological station)

The most sensitive crops were established as the most represented (important) crops in the region. The following crops were determined as most sensitive: Kavadarci – grape; Strumica and Gevgelija – tomato and pepper; Skopje-Kumanovo – winter wheat; Ovche Pole – winter wheat and alfalfa.

Nevertheless, this information should be revised, because during the preparation of the Fourth National Report to the UNFCCC, the methodology for assessing vulnerable regions was revised and replaced by the Livelihood Vulnerability Index (LVI). This methodology takes into consideration not only biophysical, but also social, economic, structural, and other indicators and completely changes the perspective of the vulnerable regions. This methodology places the most vulnerable region to climate change in the northeastern part of the economy. Therefore, the most vulnerable regions (municipalities) are Rankovtse, Kratovo and Staro Nagorichane (more in Annex 5.3).

The revision of vulnerable crops should be conducted, bearing in mind the importance of some crops as a major source of income for rural populations, or even for maintaining the livelihood of rural populations. The revision is planned for the 5th National Report to the UNFCCC.

Practices used by farmers to protect their crops from damages caused by weather variability (hot weather, drought, excessive water, hail, intensive sun, etc.). Farmers have accumulated the experience of growing crops in different weather conditions. Weather variability from season to season has made farmers build up their experience and know-how to adjust their practices to the existing situation. During the last period, with more pronounced climate change effects, farmers have autonomously adapted to the environment. Several practices have been recorded, such as:

- Covering grape clusters with grape branches to avoid sunburns on western exposition
- Using nets to cover greenhouses and plastic tunnels and/or using lime to white-paint roofs
- Using mulching to reduce evapotranspiration and conserve soil water
- Using green cover in orchards
- Using plastic bottles as orifices to control water flow in furrows, etc.
- Moreover, farmers have readily accepted the promoted and supported measures, such as using hail nets and increasing water efficiency with drip irrigation.

Climate change adaptation measures and practices have been already tested or promoted in the economy or established in national documents related to climate change and agriculture. The project on adaptation to climate change in agriculture, implemented by the Rural Development Network of North Macedonia (RDN) and supported by the United States Agency for International Development (USAID) in the period 2012-2016, tested a number of adaptation measures in the North Macedonian environment and determined some very suitable measures. The measures are presented below. Moreover, RDN conducted the economic feasibility of each measure and promotional activities. Therefore, RDN can be a good source of information for the implementation of the measures below.

- **Fruit Growing**
  - Use of anti-hail/UV protective nets in pear, plum, apricot and peach orchards
  - Use of drought tolerant apple, sweet and sour cherries rootstocks as an agricultural measure against lack of water in the soil
  - Changes in planting depth of trees in apple and cherry orchards
  - Use of different materials (Trichoderma spp., Zeolit/Zeofit and Hydrogel) as a measure for water conservation in sour and sweet cherry orchards
  - Using pruning techniques on peaches and apples as a measure for reducing sunburns on fruits
  - Use of specific protecting materials for preventing sunburns on apple and pear fruits
  - Row space mulching in apple and pear orchards
- **Vineyards**
  - Utilization and influence of T-pruning system application
  - Utilization and influence of UV protective net
  - Application of calcium carbonate
- **Vegetable**
  - Implementation of Trichoderma harzianum
  - Utilization of UV protective nets
  - Use of plastic bags filled with soil mixtures
- **Efficient Agricultural water management (precision irrigation)**
  - Irrigation scheduling on the basis of meteorological parameters from installed meteorological stations
  - Improvement of drip irrigation and drip fertigation practices for efficient use of water and fertilizer and soil water conservation

5.4.4. Brief analysis of the current infrastructure and systems for preventing and mitigating the negative effects of weather extremes on crop production

Irrigation and Drainage Systems. Water limitations during the summer period have hampered crop growth and sustainable productivity of agriculture in the economy. Therefore, several important investments in the development of the irrigation system have been undertaken as the most efficient available practice for reducing water shortage during common agricultural production. According to the technical documentation based on which the systems were constructed, it was initially planned to provide irrigation to 163,693 ha of fertile land. However, in a medium dry year, the constructed basic facilities (dams, reservoirs, pumping stations, main canals, etc.) can provide irrigation to not more than 144,894 ha of agricultural land. According to SSO data, irrigation systems cover about a quarter of the total arable agricultural land (123,000 ha), about 80,000 ha of which are irrigated. According to MAFWE, the effective irrigated area is of a smaller size, and in 2019 it was merely 24,303 ha in total. It has to be noted, however, that MAFWE is reporting only about those areas that are provided with irrigation through Public Enterprises. Therefore, about 50 thousand hectares have unregulated irrigation, developed by farmers. The irrigation potential is estimated at approximately 250,000 ha of arable land.

Drainage systems cover a total area of 81,930 ha to provide drainage for the agricultural land and prevent against frequent floods. Irrigation and drainage systems are operated by the public enterprise JSC Water Economy of the Republic of North Macedonia.

Forest Fires Information System (FFIS). The Crisis Management Centre (CMC) is an independent government body responsible for coordination, timely reaction, efficient and reasonable use of available resources in the case of crisis. The CMC is the responsible institution for crisis risk assessment. Among other systems, CMC operates the Forest Fires Information System (FFIS), based on remote sensing analyses as well as real-time weather information. FFIS uses 15 AWS for the assessment of the forest fire risk. However, CMC cooperates with UHMR, and AWS installed for FFIS are included in UHMR datasets. FFIS covers forest land in the economy, which for now is not in focus of agrometeorological activities in the economy. Therefore, this system is somehow out of the scope of agrometeorological services.

Agrometeorological network of the National Hydrometeorological Service. The Agrometeorological Department of the National Hydrometeorological Service, supported by FAO project, developed a network of 6 agrometeorological stations that measure and report hourly data on meteorological parameters. Data access is available on the website developed by the project (www.agrometeo.mk) offering a number of data from the six installed weather stations for this purpose.

The portal agrometeo.mk provides even more services for its users, such as:

- Weekly information for farmers in textual form and additional information provided if there is alarm
- Documents with seasonal forecast
- Phenological database from the network of 24 operational stations
- Image from Gradsko AWS 2 times daily on phases of vine grapes
- Calculation of SPI index for 1, 2 and 3 months for all locations

Moreover, the forecast for the next 5 days is provided as the output of the prognostic model NMM v3.9. This forecast is used for early prediction (5 days in advance) of frost and use of agrochemicals.

Agro-meteorological services for early warning of the risk of apple diseases in Resen area. The system for apple protection has been offered by agrometeorological services since the early 2000s. The system started with only 3 AWS and was upgraded during that time to 7 AWS located on characteristic spots with high concentrations of apple growers. The system was developed through several projects conducted for the protection of the Prespa Lake, and emphasized to reduce pollution of lake waters from agricultural sources (reducing the number of spraying and pesticide use, optimizing water use for irrigation and optimizing the fertilization process). The system is based on METOS AWS and METOS crop disease models, and targets only one disease: Apple Scab (*Venturia sp.*). The system is operated by the Farmers' Association in Resen.

Meteobot is a Bulgarian private company that produces and sells Automated Weather Stations (AWS) dedicated to agro-meteorology. The data measured in the field is transferred by GPRS, aggregated and processed into agro-meteorological information that can be accessed by a smartphone app. Various services are provided to users, depending on the subscription they have.

5.5. Livestock farming analysis linked to climate change in agriculture

5.5.1. Livestock farming and climate change

Environmental conditions, such as solar radiation, high air temperature, and relative humidity, are the main stress factors for livestock. The aetiology of heat stress consists of failure to maintain the core body thermo-neutrality with increasing ambient temperature and humidity. Climate change has a severe negative effect on animal production and welfare, reflecting frequent and prolonged heat stress (Martinsohn et al., 2012; Collier et al., 2019). Climate change scenarios for North Macedonia demonstrate an increase in average temperature and a relatively mild decrease in annual precipitation. Overall, this will increase aridity, but the impact will manifest itself differently in terms of regions and seasons. Due to a mixture of influence of the continental and Mediterranean climate in the economy, the producers are faced with mild to cold winters and prolonged hot summer periods, but also rapid extreme weather events.

National livestock farming has been predominantly organized on small farms, and it is characterized by intensive production systems in dairy cattle, pigs, and poultry.

Dairy cattle production is currently undergoing a decrease in the number of farms and the process of enlargement of farm size. The challenges in dairy production are 1) lack of investment in farm modernization (milking, manure management, animal welfare), 2) improved feeding, 3) limited access to land area for own forage production, 4) providing milk quality, since in 2019 only 20% of the annual production was in accordance with the national regulations on milk safety and milk quality.

Pig production provides national self-sufficiency in fresh pork meat. It is organized on several large farms (40% of all hogs) that are applying intensive and modern production systems, based on genetically superior animals. On pig farms, investments in modernization of technology, feeding and biosecurity are continuous. The sector is growing but challenged by disease spreading (African swine fewer) and market instability.

Layers are the most dominant in poultry production. The production of eggs is intensive and national demand self-sufficient. Broiler production is very limited (only 2% of the national market). The sector is under pressure because of the instability of the market and trends.

Intensive production systems require genetically superior animals, strictly controlled nutrition and an optimal environment (closely controlled temperature, humidity and ventilation).

Production systems in beef cattle, sheep and goats are less intensive and closely related to near-farm pastures. Beef production is mainly organized in rural areas and provides about 20% of the national demand for beef meat. It is mostly based on crossbreeds, kept extensive, exploring natural pastures and alternative feedstuffs. Sheep and goat production is extensive, traditionally exploring mountain pastures. It has never been intensified, and due to national socio-economic trends and population size, is sheep production has been constantly decreasing, and is based on local sheep breeds and their crosses, while in goat production locally adapted breeds are predominant.

Success reduction of the negative effect of heat stress in livestock is foreseen in four direct adaptive sets: housing, feed and feeding, breeding for resilience and emerging infectious diseases. Heat stress is even more substantial on modern high-productive breeds than on local breeds adapted for ages to the local environment. In the last two decades, rapid development has been observed in larger dairy,

pig and poultry farms, adopting technical solutions resulting in increased ventilation, air conditioning, air recirculation, and insulation to influence climate parameters such as air temperature, velocity, humidity, and conditions for radiation heat exchange. The less intensive production systems possess higher adaptive capacities to severe weather events, due to the exploration of locally adapted breeds (local, imported or crossbreds between locals and imported ones) and their higher tolerance to nutritional requirements (diverse feeding regime, feed components, less selective to different feeds, etc.).

Climate change could have an impact on disease outbreaks in livestock. The occurrence of diseases can be directly on animals exposed to extreme weather conditions, or indirectly by the presence of vectors whose spatial distribution is usually very dependent on climatic conditions. The direct influence of climate change is one of the preconditions of the livestock environment, which can be observed through disturbance in feeding, availability of water, and water quality, but also ensuring favourable conditions for the occurrence of many parasites and diseases. All those diseases generally do not have an impact on the health status in the economy, but influence significantly the economic profitability of farming. However, some contagious diseases are transmitted by vectors or by wild animals, and the spreading of those vectors can be enhanced by climate change. Diseases such as Bluetongue, Rift Valley fever, West Nile fever, African horse sickness, African swine fever, etc. are among others related to climate change. To reduce the risks and vulnerability of livestock to outbreaks of diseases, actions are needed towards adopting farm management and technologies to prevent outbreaks, but also their further spreading.

5.5.2. Analysis of meteorological data availability, accessibility and extreme weather events

The main source of meteorological data for climate change analysis is the National Hydrometeorological Service (UHMR, www.uhmr.gov.mk). UHMR publishes data from its area of responsibility, but the usability of these data is very limited. Part of the collected meteorological data is publicly available in monthly summarized (one-page Word documents), and summarized yearbooks. Historical data can be obtained by purchasing services in a format agreed upon. However, the density and spatial distribution of data varies over the years.

So far, for the needs of studies and reports, the main sources of meteorological data used were from international publicly available sources (Copernicus database), where high resolutions of historical daily data and different models of predicted weather events are foreseen until the year 2100. However, for the use of such data, large data storage, powerful computers and skilled staff are necessary.

Extreme weather events are very important for climate change analysis. Extreme weather events should be recorded by the National Hydrometeorological Service, but a low level of data transparency makes these records unavailable to the public and the research community and when weather events are getting the dimension of crisis, the responsibility is with the Crisis Management Centre (reporting only on fires and floods). However, it was not possible to find any official reports regarding losses in livestock farming (quantification of animal loss or productivity loss) related to climate change or extreme weather events. The system for recording damages associated with climate change should be regularly recorded and data should be analyzed by research institutions to assess risks on livestock productivity in future periods and to design appropriate adaptation practices.

5.5.3. Heat stress risk assessment for ruminants, pigs and poultry

As an integral part of the 4th National Communication on Climate Change (2021) the Report on Climate Change Vulnerability and adaptation in agriculture, forestry and land use was developed. The report is the first of its kind in the economy. Heat stress was assessed in ruminants and pigs, specific thermal-humidity index (THI) and THI loads expressed for three periods of 30 years starting from 1986, under three scenarios (RCP 2.6, RCP 4.5 and RCP 8.5). The assessment covered the entire territory of the economy in 12x12 km points. Additionally, the regions where dairy cattle and intensive pig production are located were deeply analysed. Under the RCP 4.5 scenario, it was reported that increased heat loads up to 17% in the latest 30 years (2045-2075), compared to the reference period 1986-2015, resulting in alert status over 120 days annually in the lowlands. Special attention was given to the Pelagonia region with predominant dairy production, where 23% of the total national cattle population was kept. In that region, annual loss of production was estimated at value of up to 190 USD per cow. For pigs, the central part of the economy was chosen (Veles–Gradsko, and Ovche Pole), and the THI load alert status should reach 60-90 days in the Vardar valley. The increased economic loss of 5-10% in pig production should be expected. Poultry was not accessed in the report.

The quantification of the increased heat stress in livestock in the economy in the future has indicated that risk assessment and recommendations for the needs of future actions in mitigating the negative impacts of heat stress. However, modelling should be improved, where a better approach, resolution and source data will provide more precise results for the entire territory. Those results could be used for further analysis, adaptation strategy development, policies, and research.

5.5.4. Farmers' existing adaptive practices for mitigating impacts of climate change in livestock

Adaptation measures involve production and management system modifications, breeding strategies, institutional and policy changes, science and technology advances, and changing farmers' perceptions and adaptive capacities. Adaptation is key for mitigation of negative impacts of climate change on livestock farming. Direct adaptive measures are foreseen as 4 main activities: genetically heat-tolerant breeding animals; adoption of modified feed and feeding techniques in periods of excessive heat; improved housing (ventilation, cooling); monitoring heat stress and fast responding. However, farmers are aware of the heat stress, but active measures have been moderately implemented. So far, most of the measures are related to improved housing, due to the fact that there are fewer investment requirements, technical solutions are available, and the effects are easily visible.

In dairy cattle, large farms and some medium-sized farms have implemented improved ventilation with or without evaporative cooling systems. The improved milk performance of lactating Holstein cows and the reduction in the severity of heat stress during summer months were observed. In pig farms, large farms have already installed various solutions for indoor cooling for reproductive animals. Small and medium farms are not so prompt, but some of them have installed window cooling pads (evaporators) and a system of low-pressure ventilation, aiming to reduce high temperatures in farms and reduce heat stress. In poultry farms, in addition to improved installation, modified vitamin and mineral supplements are promoted.

Research is needed on assessments for implementing these adaptation measures and tailoring them based on location and livestock system. Nevertheless, an economic calculation is needed to determine when it is the most appropriate time to invest in farm adaptation measures. Perhaps incentive measures can boost the implementation of adaptation measures to decrease production loss due to global warming.

5.6. Legislative and strategic framework and institutional setup related to climate change adaptation in agriculture in North Macedonia

5.6.1. Institutional setup for adaptation to climate change in agriculture

The two key state administration bodies related to climate change adaptation in agriculture in North Macedonia are the ministries covering agriculture and environment. The government institution responsible for agricultural and rural development policy in North Macedonia is the line **Ministry of Agriculture, Forestry and Water Economy (MAFWE)**. MAFWE is responsible for the strategy and policy of agricultural and rural development, as well as for the management of agricultural resources (land, forest and water). MAFWE does not have a separate department dealing with climate change, but this policy is rather horizontally partially covered across different sectors. The institution has a complex structure with 19 sectors and 62 divisions, out of which no sector has been directly associated with climate change adaption. However, sectors associated indirectly with climate change are Sector for agriculture; Sector for grapevine, wine and fruit production; Sector for analyses of agricultural policy; Sector for marketing and quality of agricultural products and Sector for rural development. Rural policy, encompassing sustainability and public goods provision, quality of life and employment in rural areas and other socio-economic issues underlying rural areas is concentrated at MAFWE departments/sectors for rural development and the IPARD Managing Authority. MAFWE Sector for rural development, through its departments, provides support to sustainable rural development, programming, evaluation and implementing of IPARD funds. There are 5 employees who are directly responsible for implementing agro-environmental measures and the LEADER programme. Beside this, the sector is responsible for giving support to ANCs for agricultural production. MAFWE (with two separate departments) and the Public Enterprise for Pasture Management currently administer the economy's agricultural land.

MAFWE is responsible for the overall governing of the agricultural and forest land, for drafting and implementing the legislation and the relevant by-laws and work programmes, and for maintaining the systems securing sustainable use of agricultural and forest land. However, issues related to climate change, evaluation of the impact of the sector, its vulnerability and corresponding mitigation and adaptation measures are not well addressed in the current legislation and programmes of MAFWE. The most recent EU legislative acts and strategic documents in the EU, such as the Soil Strategy, Soil Deal Mission, Regulation on Land, Land Use Change and Forestry (LULUCF Decision) and the most recent soil monitoring proposal foresee a wide spectrum of activities which consider strong collaboration among key institutions and efforts sharing for the implementation of the required monitoring and reporting activities. At the moment, MAFWE capacities related to sustainable management and protection of land, are rather limited and concentrated within the Sector for land consolidation and exchange and identification of land parcels, which is responsible for activities related to land consolidation and land use (LPIS). A new administrative body within MAFWE (Integrated Agricultural Land Management System) is foreseen to be soon established, as responsible for the implementation of overall land policy, leasing of state-owned land, including pastures, selling of agricultural land, consolidating and protecting, and facilitating and regulating the agricultural land market.

The **Water Management Administration** is a body operating within MAFWE responsible for tasks related to the management of water for agricultural purposes and infrastructure facilities, such as dams, reservoirs, irrigation systems, drainage systems, etc. The Law on Water Management generally

defines the scope of activities of MAFWE, specifically of the Directorate for Water Management, and also delegates the supervision of the operation of AD Water Management to the Directorate for Water Management. The state-owned joint stock company for Water Management (AD Water Management) uses, maintains, and manages irrigation and drainage systems as a whole, including supply of irrigation water, arrangement of riverbeds, arrangement of land, removal of discharged water, etc. In accordance with the Water Law, AD Water Management also builds and maintains facilities for protection and defence against floods, erosion, for arranging rivers and streams and performs other tasks in accordance with the law. AD Water Management has a directorate in Skopje and fourteen subsidiaries for water management activities in specific geographical areas of operation. Furthermore, three public water management companies operate in the water management sector, beyond the competences of AD Water Management, including, Public Enterprise Strezevo – Bitola, Public Enterprise Hydro System Zletovica – Probishtip and Public Enterprise for Water Management Lisiche – Veles. Several agricultural cooperatives have also been established that manage small irrigation systems. More precisely, there are six agricultural cooperatives that manage irrigation systems in the region of Gevgelija, Valandovo and Bogdanci and one small irrigation system in the area of Prespa Lake.

The **Agency for Financial Support to Agriculture and Rural Development (AFSARD)** is responsible for the implementation of annual national programmes for financial support measures, direct payments in agriculture, rural development measures and other measures funded from national funds. It is also the accredited institution for the management, implementation, monitoring and control of pre-accession funds for rural development (IPARD).

The **Ministry of Environment and Physical Planning (MOEPP)** leads the economy's climate action and is the National Contact Point of the UNFCCC and the National Implementation Authority of the Kyoto Protocol. MOEPP as a body of the state administration has the most significant role in the area of protection and improvement of the environment. Its responsibilities include undertaking measures and activities on environmental protection, preparing a national plan on climate change, conducting analysis and projections of greenhouse gases inventory, emissions and their reduction, and monitoring the implementation of the planning documents related to climate change.

MOEPP is also responsible for the monitoring of the overall land in the economy and for controlling management activities of potential soil polluters and to support the sanitation and restoration of degraded land. In addition to this, MOEPP is responsible for reporting to several UN conventions, and the status of soil quality. Unfortunately, at the moment there is no soil monitoring system in place for collecting the needed data for reporting purposes, or legal acts that will govern the process. MOEPP capacities for soil related issues are concentrated within the Sector for the environment which has a Department for estimation of the impact on the environment and soil protection with a wide range of responsibilities, such as preparation of strategic and legal documents, implementation of international and EU legal acts and measures for protection from soil contamination and improvement of soil quality. The Department consists of 7 employees, but only one senior advisor is directly responsible for land protection issues.

Other government institutions related to climate actions as well as socio-economic and natural resources dimensions are the Ministry of Economy (for instance, Sector for energy, with the authority to propose, implement and monitor measures and policies for energy saving, energy efficiency, use of renewable energy sources and biofuels), Ministry of Transport and Communications (transport as part of the energy sector has a significant impact on the creation of greenhouse gas emissions), Ministry of Local Self-Government (environment programmes are also carried out through municipalities;

municipalities are key stakeholders in the LEADER initiatives and Local Action Groups), Ministry of Labour and Social Protection (responsibilities in the domain of socio-economic issues), Ministry of Education and Science (although negligible funding is dedicated to research, this ministry together with the Ministry of Economy is instrumental in the Smart Specialisation Strategy implementation), the Ministry of Health and the Institute for Public Health, etc.

Although there is a formally established umbrella **National Committee on Climate Change** since 2000, the purpose of which is to act as multidisciplinary inter-governmental body and provide guidelines for overall climate actions, as well as contribute to the integration of activities in sectoral policies, plans and measures, it is still not fully functional in practice (SAU, 2022). The planning and implementation of instruments and measures related to climate change mitigation and adaptation strategies, as well as their monitoring, suffer from a lack of functional connectivity and coordination between institutions at both national and local levels. The inability to integrate climate policy into all sectors due to a lack of financial, human, and technical resources also contributes to the inability to produce the anticipated results of climate action.

Hydrometeorological Service (UHMR) has a crucial role in the process of adaptation to climate change. Within its scope of work, it carries out hydrological and meteorological activities related to the development and functioning of hydrological monitoring, atmosphere, soil, climate and water resources, anti-hail defence and works on the application of hydrology and meteorology. The technical capacities of the Hydrometeorological Service are continuously enforced, but still there is a need for additional services which are important for vulnerability assessment and forecasting of weather extremes.

Other capacities related to adaptation of agriculture to the negative impact to climate change are situated within the **National Extension Agency (NEA)**. The responsibilities of NEA are to disseminate technologies and advisory support for the producers. NEA has six regional offices, and a number of local offices, but due to the lack of capacities and finance, its activities are rather limited while employees are overburdened with administrative work. NEA is not yet sufficiently prepared to provide services for the application of relevant practices to prevent and mitigate the effects of climate change.

On the other hand, in the **academic community**, there is some knowledge and experience in climate change. The academic staff has been so far involved in the preparation and development of various reports and projects, but less in creating national policies and support programmes of MAFWE, as well as demonstrational trials and knowledge transfers. Educational and some technical capacities related to resource monitoring are concentrated in the research and education centres of the University (for instance, Faculty of Agricultural Sciences and Food, Institute of Agriculture, Faculty of Forestry).

5.6.2. Legislative framework related to adaptation to climate change in agriculture

The cornerstone document is the **Law on Agriculture and Rural Development** (Official Gazette of North Macedonia, No. 49/2010, 53/2011, 126/2012, 15/2013, 69/2013, 106/2013, 177/2014, 25/2015, 73/2015, 83/2015, 154/2015, 11/2016, 53/2016, 120/2016, 163/2016, etc.), which regulates the sector and defines key policy objectives, including providing stable production of good quality affordable food and providing the population with sufficient quantities of food; increasing sector competitiveness; providing stable income of agricultural holdings; sustainable development of rural areas; and optimal use of natural resources.

Other important laws, supplemented by numerous by-laws and rulebooks, related to adaptation to climate change in agriculture in North Macedonia include:

- Law on Agricultural Land (Official Gazette of North Macedonia, No. 135/07,... 91/23)
- Law on Consolidation of Agricultural Land (Official Gazette of North Macedonia, No. 187/13, ... 122/21)
- Law on Forests (Official Gazette of North Macedonia, No. 64/09,... 274/22)
- Law on Livestock farming (Official Gazette of North Macedonia, No. 07/08, ... 122/21)
- Law on Environment (Official Gazette of North Macedonia, No. 53/05, 81/05, 24/07, 159/08, 83/09, 48/10, 124/10, 51/11, 123/12, 93/13, 187/13, 42/14, 44/15, 129/15, 192/15, 39/16, 28/18, 65/18, 99/18, 89/22, 171/22)
- Water Law (Official Gazette of North Macedonia, No. 87/08)
- Law on Determining the Prices of Water Services (Official Gazette of North Macedonia, No. RM 7/16)
- Law on Water Management (Official Gazette of North Macedonia, No. 51/15)
- Law on Balanced Regional Development (Official Gazette of North Macedonia, No. 24/21)

Adaptation to climate change has not been addressed directly in most of these laws. However, it is foreseen in the most recent national strategic documents, although in a general and very superficial manner.

In terms of legal acts on climate change, a **draft Law on Climate Action** has been developed by MOEPP and submitted for public discussion in 2023 (the final draft is available but not yet adopted by the Parliament). It is expected to transpose EU climate legislation, enabling low-carbon development, climate change resilience and adaptation measures. Adaptation is part of the general articles. In the draft Law, agriculture has been addressed several times, while livestock farming is only in terms of reducing GHG emissions.

Regarding the adjustment of the national legal framework for climate change to the United Nations Framework Convention on Climate Change, the Republic of North Macedonia has adopted the following laws:

- Law on the Ratification of the United Nations Framework Convention on Climate Change – UNFCCC (Official Gazette of North Macedonia, No. 61/97)
- Law on the Ratification of the Kyoto Protocol to the UNFCCC (Official Gazette of North Macedonia, No. 49/2004)
- Law on the Ratification of the Paris Agreement (Official Gazette of North Macedonia, No. 161/2017)
- Law on the Ratification of the Doha Amendment to the Kyoto Protocol to the UNFCCC (Official Gazette of North Macedonia, No. 152/2019)
- Other legal and institutional framework related to climate change and adaptation measures can be found on: https://klimatskipromeni.mk/article/248#/index/main.

5.6.3. Strategic framework related to adaptation to climate change in agriculture

In August 2021, the Government of North Macedonia adopted the **Long-Term Strategy on Climate Action** (with an Action Plan). It sets a long-term vision for North Macedonia to become, by 2050, a prosperous, low-carbon economy, following sustainable and climate resilient development pathways. In fact, the Strategy and its Action Plan focus on climate change mitigation measures and policies, while the National Adaptation Plan focuses on comprehensive adaptation policies and measures (implementation of priority actions in the climate change sector, 2021).

The **4th National Communication under UNFCCC** was reported in 2023 and the adaptation component is part of the document. In addition, the Third Biannual Report on Climate Change was adopted in 2022, where water resources and adaptation measures are some of the priorities. As part of the reporting on implementation to UNCCC, the focus is not only on natural resources perspective and crop adaptation, but also livestock adaptation to climate change and socio-economic aspects have been addressed more frequently. Most of the experiences, awareness and results were generated there, including assessment of the overall vulnerability of agriculture to climate change (through the Livelihood Vulnerability Index), as well as vulnerability of livestock farming, identification of the need for adaptation and implementation of some of the measures on demonstration trails and examples.

Within agriculture and rural development, the key strategic document is the **National Strategy on Agriculture and Rural Development (NARDS) 2021-2027**. It follows the overall concept of the EU Common Agricultural Policy (CAP) framework as a benchmark for the national agricultural and rural development policy. NARDS 2021-2027 has the following three strategic goals: (1) improving the competitiveness and income sustainability of agricultural holdings, (2) applying environmental practices in production that lead to mitigation and adaptation to climate change, and (3) ensuring sustainable rural development (MAFWE, 2021).

Within the second strategic goal of applying environmental practices in production that lead to mitigation and adaptation to climate change, the foreseen interventions of the national agricultural policy in the upcoming strategic period 2021-2027 include three specific objectives: SO 4. Contributing to climate change mitigation and adaptation, as well as greater use of sustainable energy; SO 5. Encouraging sustainable development and efficient management of natural resources such as water, soil and air; SO 6. Contributing to the protection of biodiversity, improvement of ecosystem services and conservation of natural habitats and landscapes. Improvement of the adaptive capacity and socio-economic status is largely present in the specific objectives, particularly emphasized through the following: SO 1. Supporting the sustainable income of agricultural holdings due to their contribution to improving food security; SO 7. Attracting young farmers and facilitating the development of businesses in rural areas; SO 8. Promoting employment, growth, social inclusion and local development in rural areas, including bio-economy and sustainable forestry; SO 9. Improving agriculture's response to society's demands for food health aspects, including food safety, nutritional composition and sustainability, food ending up as waste, and animal welfare.

In order to make greater contribution of direct payments to the achievement of the second strategic goal, support schemes are planned to be introduced after 2023 to encourage security of public goods through agricultural practices beneficial to the environment and climate, the so-called eco schemes. The establishment of environmental schemes will be voluntary for farmers who are committed to implementing agricultural practices that are beneficial to the climate and the environment. Agri-environmental measures will continue to be financed using the National Programme for Financial Support to Rural Development, until the moment of accreditation of the agri-environment, climate and organic farming measures under the IPARD Programme.

NARDS 2021-2027 points out the need to invest in research and extension services, to enhance the capacity and delivery of information to the agriculture sector, and to improve the adaptive capacity of farmers with appropriate advisory packages on correct practices and training to reduce the impact of climate change. In the SWOT analysis of the strategy, adaptation is identified as a weakness with "insufficient advisory support and lack of training sources for agri-environment and climate change actions". Climate change impact has been identified as a threat. One of the main answers is seen through planned large capital investments for the rehabilitation of the existing and construction of

new irrigation and drainage hydro systems that should improve the regional availability of water during irrigation periods, as well as flood protection.

Furthermore, other strategic and programming documents related to climate action focus on the agricultural sector and adaptation measures in agriculture in North Macedonia, such as:

- National Programme for Agricultural Development and Rural Development for the period 2023-2027
- Strategy for Regional Development of the Republic of North Macedonia (2021-2031)
- Draft Smart Specialisation Strategy (2023-2027), which includes the priority domain Smart Agriculture and Food with Higher Value Added, aiming to act as the new innovation strategy in the economy
- National Strategy on Sustainable Development (2009-2030)
- Strategic Plans of the Ministry for Agriculture, Forestry and Water Economy (2022-2024)
- Proposed National Strategy on Irrigation and Drainage (2021-2031)
- The Programme for the use of funds from the instrument for pre-accession assistance for agriculture and rural development – IPARD Programme for the period 2021-2027, which was approved in 2022 and started in 2023 in North Macedonia as one of the first economies in the region. This is the third programme period of European Union support to Macedonian agriculture and rural development.
- Action Plan 2014-2025 for investments in the water sector in the economy, reported by the Ministry of Agriculture, Forestry and Water Economy
- National Strategy on Water (2012-2042) of the Ministry of Environment and Physical Planning

Almost all these national strategies, documents, programmes, and action plans put special emphasis on climate change, new challenges related to key resources essential for sustainable agricultural production. Furthermore, during the last 20 years, many research and project activities with the aim to improve the capacities and introduce adaptation measures in the agricultural sector in the economy have been supported by international and domestic funds. Also, many other documents and national plans related to climate change and adaptation measures can be found on https://klimatskipromeni.mk/article/31.

5.6.4. Agricultural policy measures and support related to climate change

The **agricultural policy support system** foresees a number of measures that can be directly or indirectly correlated with climate change adaptation. Within the **programme for financial support to agriculture (direct payments)**, there is aid for premiums for insurance of primary agricultural production against natural disasters and adverse climatic events; aid for consolidation and protection of agricultural land in the analysis of the physical and chemical properties of the soil as a basis for applying the principles of good agricultural practice on soil; and additional direct payments for registered holdings and young farmers. Moreover, there is support for the Areas with Natural Constraints (ANC) that can help areas that are more prone to climate change to overcome yield losses and increase farm resilience.

The **National Rural Development Programme** foresees some measures that relate to climate change adaptation. There is support for research, demonstrative trials, education, information, advisory services and dissemination of knowledge which is the essence of adaptive capacity building. Other foreseen measures include support to preserving genetic diversity of autochthonous crops and livestock; aid to introduce activities for soil preservation; aid to introduce activities for preserving natural habitats; aid for preserving pastures and new pastures; support to young farmers; support to

enhance or leave agricultural production; support to active women in rural households; support to rural infrastructure (also through IPARD, pending accreditation); and a set of measures supporting local rural development. Moreover, new technologies and innovative solutions are supported. Investments in irrigation and drainage infrastructure and the hydrometeorological network are directly related to climate change. Investments in cloud seeding is a direct weather modification. A list of selected measures is presented in Annex 5.3.

T**otal budgetary support to agriculture and rural development** in North Macedonia generally follows a stable upward trend, reaching 164 million EUR in 2021 (MK APMC, 2023). However, although environmental and climate change combat goals are equally present in the strategic policy framework, actual policy implementation dedicates a very small portion to measures providing environmental and societal benefits (around 3% of total budget transfers are for payments to farmers in areas with natural and environmental constraints, and for agro-environment, organic and animal welfare payments to farmers). Even less resources are provided to support the rural economy and population (around 1.5%, payments for creation and development of non-agricultural activities in rural areas, rural infrastructure, basic services and village development). The LEADER-type measures for building local capacities are still negligible (MK APMC, 2023). In a nutshell, apart from the large array of declared instruments and measures linked to climate change mitigation and adaptation, biodiversity preservation and sustainable use of resources, as well as strengthening the resilience of rural population and better quality of life in rural areas listed in NARDS 2021-2027, very little is effectively implemented in practice.

The new **IPARD Programme for the period 2021-2027** will provide an additionally higher proportion of public co-financing of investments aimed at mitigating and adapting to climate change. Projects to support the reduction of GHG CO_2 equivalents will represent at least 5% of the total number of projects financed through Measure 1 of the IPARD Programme (compared to 1.6% at the beginning of the period). Measure 4: Agri-environment, climate and organic farming is still not accredited, but adaptive measures with direct or indirect improvement potential in socio-economic terms are possible within the currently accredited measures (investments in physical assets on agricultural holdings and at the processing industry, and farm diversification and business development). EU funds of approved projects amounted 62.7 million EUR as of end 2022, out of which 56% or 34.9 million EUR were paid to beneficiaries. The distribution of the funds is relatively equal among measures in terms of approved funds.

5.7. Data availability and quality for analysis of climate change adaptation in agriculture in North Macedonia

Agricultural and socio-economic statistics are in general well available in the economy. The State Statistical Office is the main provider of regular statistics, surveys and census data, with open access to most available datasets. However, many statistics are only available at a NUTS 3 (regions) level. NUTS 4 (municipality) level statistics are available on census data, and at the moment on crop production and crop area data. Census data are very valuable and very comprehensive (based on NUTS 4 level), but given that the last Agricultural Census took place in 2007, it is imminent to obtain new data, especially on structural dimensions as well as agricultural socio-economic aspects, which have probably significantly changed in the intercensal period and reveal the actual adaptive capacity of the farmer population (for instance, the latest population census carried out in 2022 revealed many important structural and socio-economic trends, not least a significant drop in general population of almost 10% from the last census in 2002). Several sample-based Farm Structure Surveys (FSS) were carried out since the last 2007 Agricultural Census, with the latest one carried out in 2016. Important farm structure and typology data are reported within FSS, but only on NUTS 3 level, and given the different methodological approach to the regular statistics reported annually, some differences between the two datasets often occur.

The State Statistical Office has already started preparations for the **new Agricultural Census** and piloted the census questionnaire harmonized with EU standards in June 2022. The Census was expected to be carried out at the end of 2023, but it was further delayed. This valuable dataset will provide a fresh outlook on the current situation and more reliable grounds for tailored policy making.

Data **related to soil** quality, spatial distribution of soil types, the extent of land degradation, and applied management practices are in the heart of the process of effective adaptation of soils to climate change. Soil data in the economy are rather limited and outdated, which is due to the prolonged inexistence of a national soil quality monitoring programme. Datasets for some degradation processes are generally modelled and are, to a great extent, ballpark estimates due to a lack of quality input data. Management practices are only roughly tackled in the annual publications of the State Statistical Office or some project reports.

Despite data constraints and gaps, some of the existing historical soil data sets were collected and systematized in digital format within the **Macedonia Soil Information System (MASIS)**. The MASIS soil datasets contain data for the chemical, physical and texture characteristics of soils, as well as boundaries for soils at the level of a soil types. Another soil dataset was collected during the long-term Land Productivity Potential Programme. After almost a decade, the Programme ended due to a lack of funds. A significant amount of quality soil data and detailed maps on distribution of soil types was collected. At the moment, it is archived as a hard copy in the Ministry of Agriculture, Forestry and Water Economy (MAFWE) and is not available. Although only a part of agricultural and forest land was surveyed, the programme has never continued. In both cases, soil data are either outdated or not in proper format. Soil data from various ad hoc soil surveys for various pilot projects and studies, as well as soil data from laboratory testing of soil under perennials, are scattered within a various reports and institution. Obviously, well organised long-term national soil monitoring as a part of the overall soil protection program, needs to be established.

The **Land Parcel Identification System (LPIS)** within the MAFWE collects digital GIS data on cropping patterns on agricultural land with a high resolution at parcel level. This dataset belongs to MAFWE

and is not freely available. The Copernicus – CORINE Land Cover dataset contains data on land cover in a scale 1:100000 as GIS coverage and is refreshed in 6-year cycles. The CORINE LC is an open source dataset at pan-EU level. There are no available datasets on land use and land cover for the whole territory on annual level which is a constraint that needs to be resolved.

Some **valuable soil-related datasets in digital format** have been recently developed. Many of these environmental co-variables, like the Digital Terrain Models (DTM) (0.5 m resolution) for the whole economy, SENTINEL satellite images starting from 2014 in a 10 m resolution, climate data from national monitoring and global datasets on various climate extremes, vegetation indices, etc., can be used for the purposes of implementing adaptation measures to CC. All of these datasets, except DTM, which belongs to MAFWE, and national meteorological and climate data, which belong to the Hydrometeorological service, are freely available.

In addition to this, modelled datasets for certain soil degradation process and climate extremes, like soil erosion, soil carbon depletion, soil sealing, soil salinization, drought map, desertification map, etc. have been recently developed.

Concerning the existing data in the **water sector** in North Macedonia, various data on irrigated areas presented by the State Statistical Office (SSO), AD Water Management, as well as expert knowledge should be highlighted. In the last 15 years, SSO has published data on irrigated areas only three times, which is not enough data to draw a reliable conclusion.

Also, in the area of **adaptive measures, capacities, and the results of their application** by farmers in the field, apart from the data from allocated funds for subsidies, project research carried out and field activities of experts, there are no other official documents where such data can be found. Keeping a register on the application and the results of appropriate adaptive practices can contribute to increasing their application and traceability.

Even though the economy is well covered by the **meteorological network**, and the spatial coverage is very good, the increasing number of AMS has to be kept in mind. The data from stations operated by full- and part-time observers in most cases exist from 1947 until now, with the temporal resolution based on WMO standards (hourly or lower). Data from AMS (meteorological and agrometeorological) is available on the UHMR website. However, there is no aggregated data available (daily values) and there are no options for downloading and using data for research purposes. The Agrometeorological Station Database is presented as a whole, but it is very hard to obtain usable data.

Therefore, **meteorological data costs** required for climate change analysis are not transparent. Moreover, the Tariff book for the amount of compensation for direct costs induced by providing services for issuing hydrometeorological data and products from the National Hydrometeorological Service Archive stipulates a price of about 50 EUR for daily data for one year and one meteorological parameter. A simple calculation is that at least 6 parameters are required (maximum temperature, minimum temperature, rainfall, wind, relative humidity, and sunshine duration), which is 300 EUR for one year for one station. One climate dataset is composed of 30 years of data, which makes one station of data cost 9,000 EUR. Only data from 19 main and 7 climatological stations (26 stations) would be 234,000 EUR, for one period only (e.g. baseline 1961-1990), with the same amount for the period that would be analyzed and compared to the baseline makes data cost close to half of million EUR. This is one of the biggest obstacles to the development of climate change research in the economy. Therefore, researchers are managing by using international open source datasets (JRC MARS Agrometeo gridded data 25x25 km, CORDEX historical and future datasets, modelled on 10x10 km grid, and some others).

O**ther data** required for assessment of crop response to climate change are also available in the economy, however not in the spatial and temporal resolution required for such analyses. For example, yield data is available only at LAU1 level for the period 2005-2022. The temporal period is not long enough. Moreover, the spatial distribution is not the same as for the meteorological data. Additional research is required to collect data for the period from 1961 to the present. To be able to use spatial analysis and convert yield data to grid data, crop mask should be developed and a number of other datasets should be converted to grid data.

5.8. Conclusions and recommendations on climate change adaptation in agriculture in North Macedonia

Climate change affects all aspects of human life and food security, mostly through ecosystems. Because most ecosystems have a rural component, people are affected quite directly. Climate change is also influenced by activities in rural regions. Rural areas are significantly impacted by climate change. The economy faces a number of risks as a result of these climate change-triggered hazards, including decreased public safety, loss of life and livelihoods, increased mortality and morbidity, impaired ecosystem functioning, extinction of species, water scarcity causing irrigation deficits and decreased energy security (Alhftan et al., 2015).

The expected **negative effects of climate change on yield size and quality** put additional pressure on agricultural holdings. According to projections, climate change will lower the productivity of the economy's crop and animal sectors, which will have a large socioeconomic impact on the economy as a whole and farmers in particular, unless timely and adequate adaptation measures take place. In order to adapt and perform better under such circumstances, climate-smart approaches and creative solutions supported by adequate financial resources must boost the resilience of the sector and life in rural areas.

The agricultural sector in North Macedonia is very complex, mostly due to the large number of households applying various management practices and the small average farm size. Farm structure, in terms of technical capacities, production systems and intellectual level, is very diverse. Today's modern agriculture must be significantly **supported by the quick flow of information** due to the incredibly fast technological, socioeconomic and natural conditional changes, as well as the serious impact of climate change. Although there have been significant advancements in system development and adoption of information and communication technology in agriculture over the past few years, these must continue at a faster rate through strengthened interconnectedness of systems and databases, as well as greater use by agricultural producers and other stakeholders in the agri-food systems. Digitalization of the processes would undoubtedly provide valuable tools for better adaptation to climate change.

Knowing how to adapt to climate change and the opportunities for alternative production methods using contemporary technologies are especially crucial for farmers. Climate change measures should be incorporated into a **functional Agricultural Knowledge and Innovation System**, including a set of procedures for creating and transferring knowledge in agriculture, such as research projects, advisory services, and mandatory trainings, in order to increase the adaptive capacity and support farmers and other stakeholders in promoting and facilitating successful adaptive measures.

The adaptation of soil to climate change is one of the issues that needs to be treated in a **separate legal act on soil**, and mainstreamed within the current legislative framework. Measures for sustainable use of soils and adaptation to climate change need to be properly addressed and supported in strategic documents, action plans and programmes of MAFWE, such as:

- Sound and effective systems and mechanisms need to be set in place for enabling successful adaptation.
- Monitoring, reporting and verification system for the overall process of adaptation of soils to climate change.
- National and regional cooperation among key institutions and inclusion of local government and civil society organizations in all processes of adaptation.
- National soil monitoring system and establishing of digital databases for soil quality and corresponding environmental co-variables, for successful implementation of adaptation measures and sustainable use of soils.
- Integral inclusion of the scientific community in the process of adaptation to climate change.

The situation with **hydro melioration systems and irrigation** in general in the Republic of North Macedonia is not satisfactory. Namely, there are large areas built and equipped for irrigation, which are not used for various reasons. Out of a total of 135,912 hectares of agricultural land under irrigation, according to the reports of the AD Water Management, about 91,469 can be irrigated, and no more than 25,000 hectares are actually irrigated. This means that about 66,000 irrigable hectares can be rehabilitated and reach the level of irrigated fields of the mid-1980s. The part of about 45,000 hectares built for irrigation (the same is not possible at the moment) can be rehabilitated and the total irrigated areas can increase to over 100,000 hectares through the rehabilitation process. Of course, improvement of irrigation systems should be done not only in terms of rehabilitation of current systems, but through in-depth changes in the entire approach to irrigation and management of the systems, investments in the construction of new facilities with priority to end users (small irrigation systems), continuous maintenance of systems, inventory of existing facilities and equipment, etc.

Also, **harmonization of the water management sector** with all strategic and projection documents of the state and EU should be one of the priorities. The priority step in the future is to adopt the National Strategy on Irrigation and Drainage. Since many stakeholders are in charge of managing waters in the economy, it is important to carry out institutional mapping, determine overlapping functions, possible opportunities for cooperation, and legal changes to improve inter-institutional cooperation. Key recommendations include:

- Supporting farmers and all interested stakeholders to introduce technologies and equipment for proper water use and adaptive climate change measures (additional support).
- Increasing support from domestic and international funds for the implementation of research and trainings, conducted by higher education and research institutions, with the aim of sharing results, experiences, practices and introducing new technologies to interested stakeholders.
- Defining a standard methodology for estimating irrigated areas and water use for irrigation.
- Keeping a register of results of applied appropriate adaptive practices in irrigation, and their traceability.

The **Fourth National Communication under UNFCCC and the National Strategy on Agriculture and Rural Development for the period 2021-2027** set up similar conclusions and recommendations for adaptation of the crop sector to climate change. Implementing and monitoring their implementation with emphasis on the results in the area of adaptation to climate change is necessary, along with

substantially increased budget transfers linked to measures supporting climate actions, with simultaneous economic, social and environmental components. Therefore, here we are highlighting the following recommendations to keep policy consistent and employ all available resources in the same direction:

- Strengthening cooperation among relevant stakeholders at institutional level.
- Establishment of the centre for research of climate change in agriculture.
- Rehabilitation of existing irrigation and drainage systems for improved resilience to climate change.
- Construction of new irrigation infrastructure for improved resilience to climate change.
- Strengthening the agro-meteorological service in the economy to provide services to the agricultural sector for increasing resilience and improving adaptation to the changing climate.
- Strengthening the capacities of the Phytosanitary Directorate and Agency for Food and Veterinary in climate change and risk of new diseases and pests.
- Evaluation of mitigation measures with high adaptation potential (biochar and photovoltaic irrigation) as adaptation measures and development of pilot projects, standards and advisory packages.
- Evaluation of the cover crops adaptation measure and the preparation of advisory packages for the selected options.
- Evaluation of adaptation measures already tested in the economy, and preparation of advisory packages for the selected options.
- Introduce climate change adaptation measures into the National System of Support to Agriculture.
- Development of agri-environmental measures for supporting climate change adaptation measures.

Livestock farming is important for food supply, economy and rural development of the economy. The impact of climate change on the livestock sector was evaluated, and documented in the 4th National Communication to UNFCCC. It clearly addressed the negative future impact of frequent and severe heat stress in ruminants and pigs. Except from sporadic initiatives and implementation, the national system for adapting livestock farming to climate change has not been developed. Hence, the following actions are needed:

- Preparing a national strategy and action plan for adaptation with specific responsibilities, time, priorities and resources allocated. This will provide a sustainable approach to planning further actions and adaptation policy.
- Systematic monitoring of climate change impact on livestock as a base for evidence of the events will generate policy and strategic approaches to combating negative effects; development of early warning system for unfavourable weather events; commitment to research and development of adaptive measures; building knowledge and understanding the development of tailor-made adaptive measures specific for the region, type of livestock farms, and applied farm system.
- Revision of national rural development plans and adopting short- and medium-term adaptation measures (e.g. improved housing in small and medium-sized farms, training for feed and feeding modifications during heat waves).
- Providing mid-term adaptive research funds for knowledge transfer in the adaptation of livestock, including farmers, advisory services and researchers.
- Developing mechanisms for technical and environmental capacity building, resources that are lacking, knowledge, experience and skills, and public awareness, perhaps with project-based activities as the most efficient way, since the national institutional setup is usually inert and inflexible.

The economy's **legal and institutional framework still lacks important elements** for efficient and effective implementation and monitoring of the policies adopted to combat climate change (SAU, 2022).

The **lack of systemized and unified databases** for existing weather and risk data, coupled with the unsuitability of meteorological data formats for direct analysis, poses an increasingly serious threat that requires urgent attention. Although meteorological data are publicly available, they are in a format that is not suitable for direct analysis, making additional analysis difficult and even completely impossible. As climate change continues to impact extreme climate events and anomalies, it is crucial to have reliable and relevant data for decision-making in the livestock sector. Moreover, the process of preparing all future programmes and sectoral documents must be based on relevant and reliable data on the impacts of climate change and the expected changes in the livestock sector.

It is also foreseen that explicit documentation requires adequate equipment and skills and access to international databases, expertise and knowledge. The gap should be bridged by establishing a system within public institutions (MAFWE, contracted public institutions), where the impact of climate change will be evaluated systematically, and that will be used as an early warning system (to prevent losses due to high-risk events) and support strategic policy and adaptive measures applied on farms.

5.9. References

A.D. Water Management of North Macedonia (2023). Water Management Enterprise. https://www.vodostopanstvo.mk

Alfthan, B., Krilasevic, E., Venturini, S., Bajrovic, S., Jurek, M., Schoolmeester, T., Sandei, P.C., Egerer, H, and Kurvits, T. (2015). Outlook on climate change adaptation in the Western Balkan mountains. United Nations Environment Programme, GRIDArendal and Environmental Innovations Association. Vienna, Arendal and Sarajevo.

AQUASTAT – FAO (2020). Global Information System on Water and Agriculture. North Macedonia. http://www.fao.org/aquastat/en/geospatial-information/global-maps-irrigated-areas/irrigation-by-country/country/MKD

Blinkov, I, Trendafilov A., Mukaetov D., Monevska Alcinova S., Stevkova S., Stevkov A., Mincev I., Trendafilov B. (2020) Atlas on Erosion, Drought and Desertification of the Republic of North Macedonia. Project: Achieving Biodiversity Conservation through Creation and Effective Management of Protected Areas and Mainstreaming Biodiversity into Land Use Planning, UNEP.

Collier, R. J., L. H. Baumgard, R. B. Zimbelman, Xiao, Y. (2019). Heat stress: Physiology of acclimation and adaptation. Anim. Front. 9:12–19. https://doi .org/10.1093/af/vfy031

Copernicus (2023) Copernicus Emergency Management Service, Current Situation Viewer, https://emergency.copernicus.eu/

Cukaliev, O., (2014). Climate change adaptation in agricultural sector in Republic of Macedonia. USAID and Rural Developing Network in the Republic of North Macedonia.

Cukaliev, O., Iljovski, I., Tanaskovic V., (2004) Sustainable Using of Water in Agriculture Production, Proceedings of the scientific-proficient advice "Sustainable Developing of Agro-complex – Administer in European Integration", pp. 105-117, Skopje, R Macedonia.

Cukaliev, O., Iljovski, I., Vukelić-Šutoska, M., Tanaskovic, V., (2005). History of Irrigation in Republic of Macedonia. 11-th Congress of the Serbian and Montenegro Society for Soil Science, Soil as a resource of sustainable development, Budva 13-16 September, pp. 50-57.

Cukaliev, O., Mukaetov, D., Tanaskovik, V., Kiprijanovski, M., Nechkovski, S., (2015). Irrigation scheduling of apple based on soil water properties in Prespa region of the Republic of Macedonia. International Conference of Soil. Proceedings. Agricultural University in Tirana, pp. 250-251, Tirana, 4-6 May 2015.

Directorate-General for Environment (2021). EU Soil strategy for 2030, strategic plan (europa.eu).

Dottori, F.; Alfieri, L., Bianchi, A. ,Skoien, J., Salamon, P. (2021): River flood hazard maps for Europe and the Mediterranean Basin region. European Commission, Joint Research Centre (JRC) [Dataset] doi: 10.2905/1D128B6C-A4EE-4858-9E34-6210707F3C81 PID: http://data.europa.eu/89h/1d128b6c-a4ee-4858-9e34-6210707f3c81

EC Research and Innovation (2023). EU Mission: A Soil deal for Europe - EU Mission: A Soil Deal for Europe | European Commission (europa.eu).

FAO (1998). Crop Evapotranspiration (guidelines for computing crop water requirement), Irrigation and Drainage Paper 56, Food and Agricultural Organization, Rome.

Iljovski, I., Cukaliev, O. (2003). Situation and development of irrigation in the Republic of North Macedonia. Proceedings of the International Symposium for Irrigation, Vodoprivreda, pp. 199-202, Becej.

IPARD 2021-2027 (2021). EU Instrument for Pre-Accession (IPA) Rural Development Programme 2021-2027. The Republic of North Macedonia, Skopje. https://ipard.gov.mk/wp-content/uploads/2023/07/IPARD-PROGRAMME-2021_2027-I-st-modification-ENG.pdf

Jovanovski, M. (2010). Landslide and Rock Fall occurrences and processes in R. Macedonia. CROATIA–JAPAN Project on risk identification and land-use planning for disaster mitigation of landslides and floods in Croatia 1st PROJECT WORKSHOP „INTERNATIONAL EXPIRIENCE", Dubrovnik (Croatia), 22-24 November 2010.

Kiprijanovski, M., Tanaskovik, V., Dimov, Z., Beleski, K., Bandjo, S., Gjamovski, V., Cukaliev, O., Mukaetov, D., (2015). The adaptation measures of agriculture on climate change. Final report of three year investigation. USAID and Rural development network of the Republic of North Macedonia.

Law for Climate Action (final draft) (2023). Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje. https://www.moepp.gov.mk/wp-content/uploads/2023/07/10082023.pdf

Law for livestock farming (2021). Official Gazette of the Republic of North Macedonia 122/21.

List of Special Minimal Conditions for Good Agricultural Practices and Environment Protection, Official Gazette of the Republic of North Macedonia 178/2015.

MAFWE (2013). Information of the Working Group for the development of a model for restructuring water utilities and

water communities for improved functioning, Ministry of Agriculture, Forestry and Water Management, p. 31.

MAFWE (2021). National Strategy for Agriculture and Rural Development (2021-2027). Ministry of Agriculture, Forestry and Water Economy of the Republic of North Macedonia.

MAFWE (2022) Annual programme on financial support to agriculture 2022. Ministry of Agriculture, Forestry and Water Economy of the Republic of North Macedonia. [in Macedonian]

MAFWE (2023). Annual report on Agriculture for 2021. Ministry of Agriculture, Forestry and Water Economy of the Republic of North Macedonia. [in Macedonian]

MAFWE (2023). Programme for financial support of rural development for 2023. Official Gazette 45, 2023. https://www.ipardpa.gov.mk/Upload/Documents/202023.pdf

MAFWE (2023) National Strategy for Irrigation and Drainage-Proposal (2021-2031). Ministry of Agriculture, Forestry and Water Economy of the Republic of North Macedonia. [in Macedonian]

Martinovska Stojcheska, A., Agich, R., Janeska Stamenkovska, I., Gjosevski, D. … Tuna, E. (2019). Preparation of analysis for investments for construction of buyout-distribution centres – Production, Buyout and Trade of Fruits and Vegetables Faculty of Agricultural Sciences and Food - Skopje. Prepared for the Ministry of Agriculture, Forestry and Water Economy of RNM.

Martinovska Stojcheska, A., Dimitrov, L. (2021). Climate vulnerability assessment through the Livelihood Vulnerability Indices. In: Mukaetov, D., Andonov, S., Chukaliev, O., Dimov, Z., Martinovska Stojcheska, A., Tanaskovik, V., Nikolov, N., Mincev, I. Poposka, H., Dimitrov, L. (2021). Report on climate change in agricultural sector, vulnerability and adaptation. Ministry of Environment and Physical Planning of the Republic of North Macedonia, Financial and Technical support by Global Environment Fund, United Nations Development Programme, 130-143.

Martinovska Stojcheska, A., Hristov, J., Surry, Y. (2019). Farm response to climate change: exploratory analysis of Macedonian agriculture using the Ricardian modelling approach. Contributions, Section of Natural, Mathematical and Biotechnical Sciences, 40(1), 105-114.

Martinsohn M., Hansen H. (2012). The impact of climate change on the economics of dairy farming – a review and evaluation. German Journal of Agricultural Economics 61, 80–95.

MASIS (2015) Macedonian Soil information system. Data on the distribution of certain soil types. www.maksoil.ukim.mk [in Macedonian]

Melissa Rojas-Downing, M., Pouyan Nejadhashemi, A., Harrigan, T., Woznicki, S.A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Management. Vol 16. P.145-163. ISSN 2212-0963, https://doi.org/10.1016/j.crm.2017.02.001.

MES (2023). Draft Smart Specialisation Strategy of the Republic of North Macedonia S3 – MK 2023 – 2027. Ministry of Education and Science, and Ministry of Economy of the Republic of North Macedonia, Skopje.

https://mon.gov.mk/stored/document/Draft%20S3%20MK.pdf

MK APMC database (2023). Agricultural Policy Measure Classification Database for North Macedonia, updated 2023.

MK StatDatabase (2023). North Macedonia Statistical Database, SWG AgPolicy project, updated 2023.

MOEPP (2008) Sector report on agriculture, Second National Communication to UNFCCC (2008). UNDP-GEF, Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje, p. 136.

MOEPP (2012). National Strategy for water (2012-2042), Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje.

MOEPP (2014). Third national communication on climate change. Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje.

MOEPP (2016). Ministry of Environment and Physical Planning: National action Plan Tocombat Land degradation and Desertification (NAP_UNCCD) (draft). Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje. [in Macedonian]

MOEPP (2018). National Strategy for Nature Protection (NSZP) 2017-2027. Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje. [in Macedonian]

MOEPP (2021). Long-term Strategy on Climate Action and Action Plan. Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje.

MOEPP (2023). Annual report of processed environmental quality data for 2022. Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje.

MOEPP (2023). Climate change – website. Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje. https://klimatskipromeni.mk/article/248#/index/main), https://klimatskipromeni.mk/article/31 .

MOEPP (2023). Fourth National Communication on Climate Change. Ministry of Environment and Physical Planning of the Republic of North Macedonia, Skopje. ISBN: 608-4860-03-6. https://klimatskipromeni.mk/data/rest/file/download/ 15644574e26d61c276c5899e7ccfca8c191f7207b5393d352d6ca2ba51e91406.pdf

MOEPP PSSUP (2004). Spatial Plan of the Republic of North Macedonia. Ministry of Environment and Physical Planning of the Republic of North Macedonia and Public Enterprise for Spatial and Urban Plans, Skopje, p. 158.

Mukaetov, D., Blinkov, I., Trendafilov, A., Poposka, H., Andreevki, M., Mincev, I., Trendafilov, H., Alcinova-Monevska, S., Stevkova, S., Stevkov, A. (2020). Achieving biodiversity Conservation through Creation and Effective Management of Protected Areas and Mainstreaming Biodiversity into Land use Planning (Database development of soil sealing rate and loss of soil organic matter on 3 pilot sites in Macedonia and analysis of their impact to biodiversity). GEF Global Environment through UN Environment Programme – UNEP.

Mukaetov, D., Andonov, S., Chukaliev, O., Dimov, Z., Martinovska Stojcheska, A., Tanaskovik, V., Nikolov, N., Mincev, I. Poposka, H., Dimitrov, L. (2021). Report on climate change in agricultural sector, vulnerability and adaptation. Prepared for Ministry of Environment and Physical Planning of the Republic of North Macedonia (MOEPP), Financial and Technical support by Global Environment Fund, United Nations Development Programme (UNDP). https://klimatskipromeni.mk/data/rest/file/download/7e77d1acb9ea1677e56fb75cfbefd79b7d97f2b26ed0177fc4e02aebcfc011a1.pdf

Panov, A. (2020). Technical Cooperation Program. Increasing resilience of the agricultural sector through the promotion of climatic smart Agricultural practices (TCP/MCD/3705 (660041). Preliminary assessment of irrigated areas using NDMI. Expert analysis.

Peshevski, I. (2015). An approach to modelling susceptibility to land subsidence using GIS technology. Doctoral dissertation. UKIM Faculty of Civil Engineering – Skopje. [in Macedonian]

PWE, Water Management of Macedonia (1999). Water Management of the Republic of North Macedonia, p. 58.

Radevski, A. (2009). Irrigation systems in the Republic of North Macedonia. Rading, DOO, Skopje.

SAO (2022). Final audit report on "Measures and policies taken by RNM/competent authorities to mitigate climate change". No: 02 2021 00 10, State Audit Office of the Republic of North Macedonia.

SSO (2007). Agricultural Census 2007. State Statistical Office of the Republic of North Macedonia http://makstat.stat.gov.mk/pxweb2007bazi/Database/Census%20of%20Agriculture%202007/databasetree.asp

SSO (2017). Structure and Typology of Agricultural Holdings, 2016. State Statistical Office of the Republic of North Macedonia, Skopje. 5.4.17.02/888. ISBN 978-608-227-292-4.

SSO (2023). MakStat database. State Statistical Office, Republic of North Macedonia. Retrieved from http://makstat.stat.gov.mk/PXWeb [Online Resource]

MLG (2021). Strategy for Regional Development of the Republic of North Macedonia (2021-2031). Ministry of Local Government of the Republic of North Macedonia, Skopje. Official Gazette of RM 76/21.

Tanaskovik, V., Cukaliev, O., Kanwar S.R., Heng, L.K., Markoski, M, Spalevic V., (2016). Nitrogen Fertilizer Use Efficiency of Pepper as Affected by Irrigation and Fertilization Regime. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, Vol 44, Issue 2, pp.525-532. DOI:10.15835/nbha44210415

Tanaskovik, V., Cukaliev, O., Romić, D., Ondrasek, G., Savić, R., Markoski, M., Nechkovski, S., (2019). Water use efficiency and pepper yield under different irrigation and fertilization regime. CONTRIBUTIONS, Section of Natural, Mathematical and Biotechnical Sciences, MASA, Vol. 40 No. 1, pp. 53–62, Dedicated to academician Gjorgji Filipovski on the occasion of his 100th birthday. ISSN 1857–9027; e-ISSN 1857–9949.

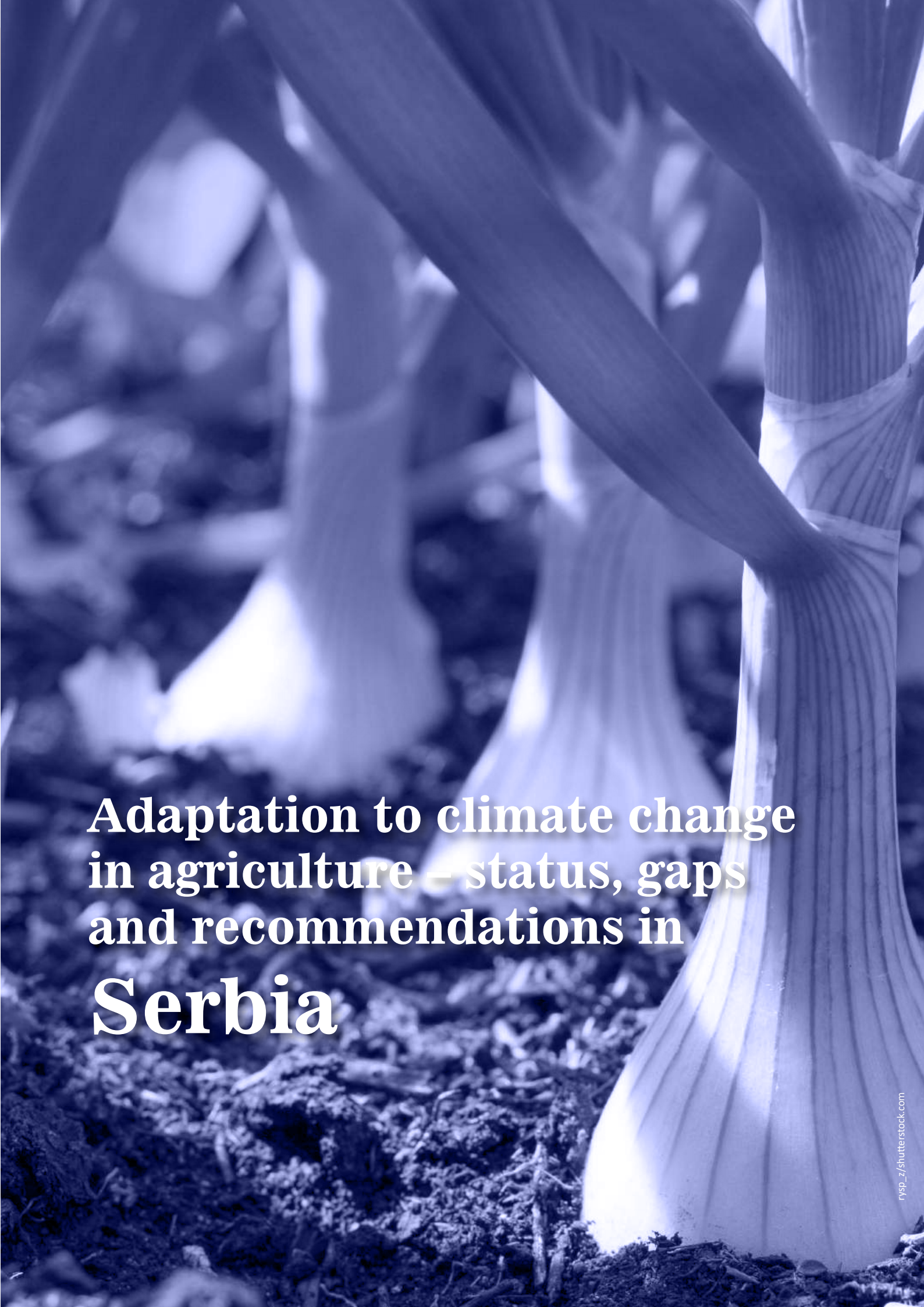
Tanaskovik, V., Cukaliev, O., Romic, D., Ondrasek, G., (2011). The Influence of Drip Fertigation on Water Use Efficiency in Tomato Crop Production. Agriculture Conspectus Scientificus. Vol.76, No. 1, 57-63.

Tanaskovikj, V. et al. (2023). Section Irrigation and Drainage, In: Draft Spatial Plan of the Republic of North Macedonia 2021-2040, Agriculture and agricultural land. Faculty of Agricultural Sciences and Food – Skopje (prepared for the Spatial Planning Agency of the Republic of North Macedonia).

Tancev, Lj, Petkovski, Lj., Mitovski, S. (2011). Dam engineering in the Republic of North Macedonia. Proceedings of the Symposium SLOCOLD-MACOLD, Skopje, Ss. Cyril and Methodius University, Faculty of Civil Engineering-Skopje.

Water Management Base of SR Macedonia (1976). Assembly of the Socialist the Republic of North Macedonia, Skopje.

Adaptation to climate change in agriculture – status, gaps and recommendations in Serbia



rysp_z/shutterstock.com

6. Adaptation to climate change in agriculture – status, gaps and recommendations in Serbia

Vlado Kovačević [50], Dragana Vidojević [51], Ružica Stričević [52],
Ana Vuković Vimić [53], Vladan Bogdanović [54]

6.1. Status of economic, socio-economic and agricultural sector related to climate change

6.1.1. Macro-economic aspects at the national economy level

Under the influence of global crises, caused by the pandemic first and the war in Ukraine after, and following price increases and market disturbances, Serbia has increased values of macroeconomic indicators containing price components especially since 2020. The GDP was at the level of 60.4 billion EUR in 2022, which has significantly contributed to the increased five-year average, which is 61% higher than the average GDP in the period 2005-2010. The GDP per capita follows, reaching almost 8,900 EUR in 2022 and resulting in a 71% higher average GDP per capita in relation to the GDP per capita a decade ago. Nevertheless, in addition to the growth of economic activity, this indicator is affected by the reduction of the population as well since the population of Serbia has decreased from 7.2 million citizens in 2011 to 6.8 million in 2023. Following GDP development, GVA achieved a level of almost 50 billion EUR in 2022 (almost 60% higher in the period 2017-2022 than in 2005-2010). Certain influences on these indicators include inflation, with prices rising on the global level influencing Serbian economy as well, resulting with the record inflation in 2022 of 15.1%.

The total number of employees in Serbia is about 2.9 million in 2022, which is 30% more than in 2010, while the number of unemployed persons was 302 thousand in 2022 (half of the number in 2010). The employment rate in Serbia continues a growing trend, reaching the maximum level of 50.3%, in 2022, while the unemployment rate was at the minimum 9.4%. The increase in employment is visible in relation to the average unemployment rate in the period 2017-2022 and 2005-2010, with average unemployment 21% lower at the end of the period. Employment indicators vary among regions; the highest employment rate is in the Belgrade Region (54.2%), while the lowest is in the Region of South and East Serbia (45.5%). Also, the highest unemployment rate is in the Region of South and East Serbia (11.7%) and the lowest in the Belgrade Region (7.8%).

50 Agricultural economics expert, Institute of Agricultural Economics Belgrade (kovacevic_vlado@yahoo.com)
51 Soil expert, Serbian Environmental Protection Agency (dragana.vidojevic@sepa.gov.rs)
52 Water expert, University of Belgrade, Faculty of Agriculture (sruzica@agrif.bg.ac.rs)
53 Crop expert, University of Belgrade, Faculty of Agriculture (pazisadana@gmail.com)
54 Livestock expert, University of Belgrade, Faculty of Agriculture (vlbogd@agrif.bg.ac.rs)

The downward trend of the Gini coefficient in the last decade shows that income distribution in Serbia has become less unequal, having achieved 33.3% in 2021, which is 6.7% less than in 2015 (Figure 6.1). Decreased inequality of income distribution has resulted in a lowering of the at-risk-of-poverty rate, which recorded the minimum of 21.2% in 2021. Nevertheless, at-permanent-risk-of-poverty-rate[55] records a level of 16.5% in 2021, which is by 2 percentage points higher than in 2020, but still below the levels in the period 2016-2018.

Following the decrease of population in Serbia in the last decade, the population in rural areas has decreased too, recording 2.5 million citizens in 2022. Over a long period of time, the share of the population in rural areas was around 40% with a slow downward trend, resulting in 38% of people living in rural areas in 2022. This supports the fact that the long-term tendency of depopulation of rural areas is expected to continue.

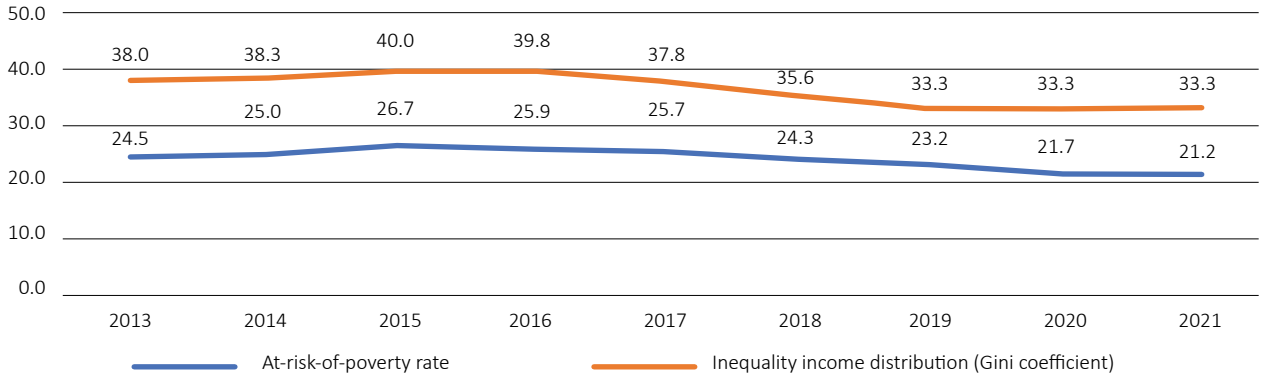


Figure 6.1. Key poverty and inequality indicators for the Republic of Serbia

Source: Republic of Serbia StatDatabase (2022)

6.1.2. Macro–economic aspects on the agricultural sector level

The sector of agriculture contributes to the total GDP with 6%-7.4% in the last decade. In terms of participation in the total GVA of the Serbian economy, agriculture participated with 8.2% in 2021, which is a slight share rise compared with several previous years. The total agricultural goods output of Serbia is based on crop production that varies around 70%, recording 77% in 2021, which is the maximum share of crop production in the last 15 years. Although this result is a consequence of a very good year in terms of crop production, there has been a long-term downward trend in livestock numbers.

Keeping in mind that the population in rural areas, mostly engaged in agriculture, has decreased in the previous period, a reduction in the number of employees in agriculture is expected. The average number of employees in agriculture in the last five-year period is almost 26% lower than the average in the period 2005-2010. From 533,000 in 2010, the number of employees in agriculture dropped to 421,000 in 2020, but the next two years show recovery, achieving the level of 430,600 in 2022. Since the total number of employees in Serbia is growing, the share of employees in agriculture in the total number of employees is decreasing, reaching slightly below 15% in 2022. The average share of agriculture in total employment in the period 2017-2022 was by even 21 percentage points lower than at the beginning of the period (2005-2010).

55 At-permanent-risk-of-poverty-rate represents the percentage of persons who are at risk of poverty in the current year and who were at risk of poverty in at least two of three previous years.

Serbia is a net exporter of agricultural and food products and the only sector in the Serbian economy to have a positive trade balance since 2005. Record levels of imports and exports have been achieved in 2022 – 4.7 billion EUR of exports and 3.2 billion EUR of imports. The average export value in the last five years is almost three times higher than in the period 2005-2010, while the import value shows an increase of 2.5 times. The trade balance in agri-food products shows an increasing trend – the average trade balance in the period 2017-2022 is 3.8 times higher than in the period 2005-2010. Agricultural and food products contribute to total exports with 17.2%, while their participation in the imports is 8.3% in 2022. The share of agri-food products in exports shows a long-term decrease (9%, comparing the first and the last five-year averages), while this share in import records an increase of 15%. The export/import coefficient was 1.47 in 2022, which is a slight decrease in comparison with the previous five years (around 1.7).

6.1.3. Land use

The total available land[56] in Serbia is about 5.2 million ha. Serbia has about 3.5 million ha of utilized agricultural area, three-quarters of which is arable land; permanent grassland makes one-fifth of UAA, while permanent crops are grown on 6%. The majority of available land is in private ownership (almost 95%). Concerning the legal form of land utilizers, 74% of available land is utilized by family holdings, while legal entities and entrepreneurs, although they participate in the total number of agricultural holdings with only 0.3%, utilize 26% of the land area.

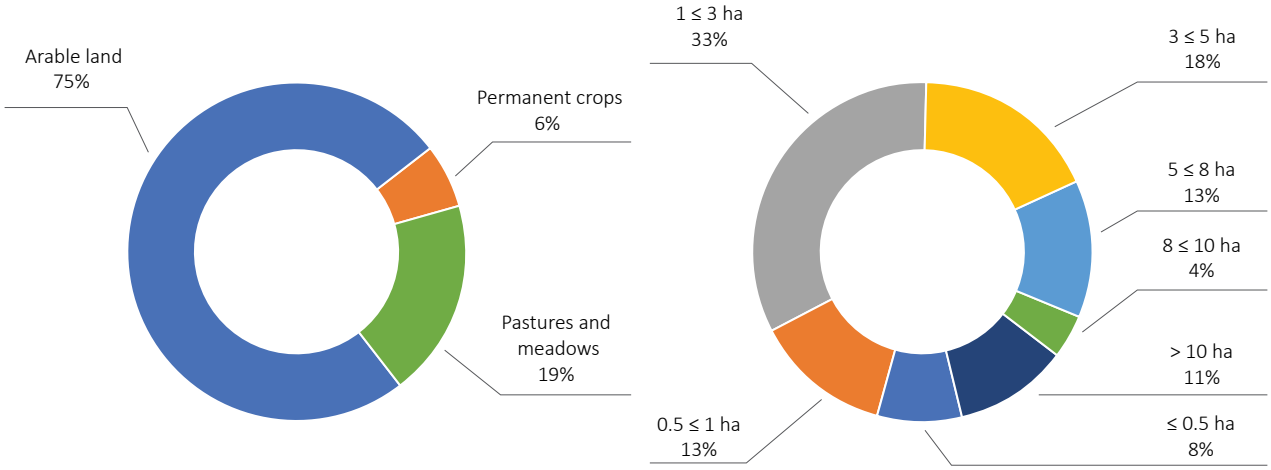


Figure 6.2. Agricultural land use (average 2017-2022, left side) and number of farms by UAA (2018, right side)

Source: Republic of Serbia StatDatabase (2022)

Soil in the Republic of Serbia is very diverse, which is the result of great heterogeneity of geological structure, climate, vegetation and microfauna. Two-thirds of agricultural land is in areas where, owing to favourable distribution of rainfall, crop cultivation is possible over 200 days a year. About 45% of agricultural land is suitable for cultivation without significant limitations, while the rest consists of agricultural land that is mostly not suitable for cultivation or can be cultivated with significant limitations. The main threats to soil quality are soil structure closing, organic matter reduction, soil acidification, soil pollution and erosion. Approximately 88% of the total land area in Serbia is exposed to water erosion, while wind erosion affects about 25% of the territory of the Republic of Serbia. Obstacles to more efficient use of land potential in Serbia are the fragmentation of land parcels,

56 This land includes all areas that agricultural holdings have at their disposal: utilized agricultural area, unutilized agricultural area, area under woods and other land.

lack of infrastructure, unfavourable loans, social insecurity of landowners, unfinished restitution, etc. (UNDP, 2019).

However, further development is hindered by socio-economic factors, mainly stemming from the prevalence of small, economically fragile and independent farms. These farms struggle to compete effectively in value-added product markets, such as organics and eco-friendly goods. Unfortunately, there has been limited support for small agricultural producers, cooperative subsidies, and the development of value chains (SWG, 2020). Addressing these issues is crucial for boosting growth and sustainability of Serbian agriculture (Kovacevic et al., 2022).

The land market has been developed to some extent since 2005, by establishing and improving a unique register of real estate, which has significantly contributed to security in agricultural land trade.

Management of state-owned land is under the jurisdiction of the Directorate for Agricultural Land (MAFWM). There are 392,849 ha of land in state ownership, of which 276,433 ha are rented[57]. About 60% of state-owned land is arable land, while permanent grassland covers 34%. The Directorate for Agricultural Land has developed the Geoportal as an interactive GIS of agricultural land in state ownership that contributes to a better overview and faster collection of data on state agricultural land, parcels and soil quality and allows monitoring of the process of leasing state-owned agricultural land in real time at the level of LAU.

6.1.4. Brief agricultural sector overview

Grain production is the dominant crop production in Serbia since half of UAA is covered by wheat and maize. Maize is grown on about a million ha with an average yield of 6.0-6.3 t/ha. Wheat is produced on about 600 thousand ha, achieving an average yield of 4.8 t/ha in the last five years. Also, about 500,000 ha are covered by oilseeds, providing over a million tons of oilseeds annually. Serbia produces non-GMO soybeans, which represents its market advantage.

Although orchards cover 7% of UAA only, yield and production enable Serbia to be among the top five world producers of raspberry and sour cherry, as well as among the top ten world producers and exporters of quince. Serbia produces around 1.5 million t of fruits annually, predominantly apples, plums and sour cherries. Plums are grown in almost half of the orchards area (of woody fruits). Among berries, raspberries are the most important export product, recording an annual production of over one hundred thousand tons.

Areas under vegetables show a downward trend in the last decade with the most significant area decreasing in potato production, although it is the most important vegetable production both in terms of area and production.

57 Data from September 2023

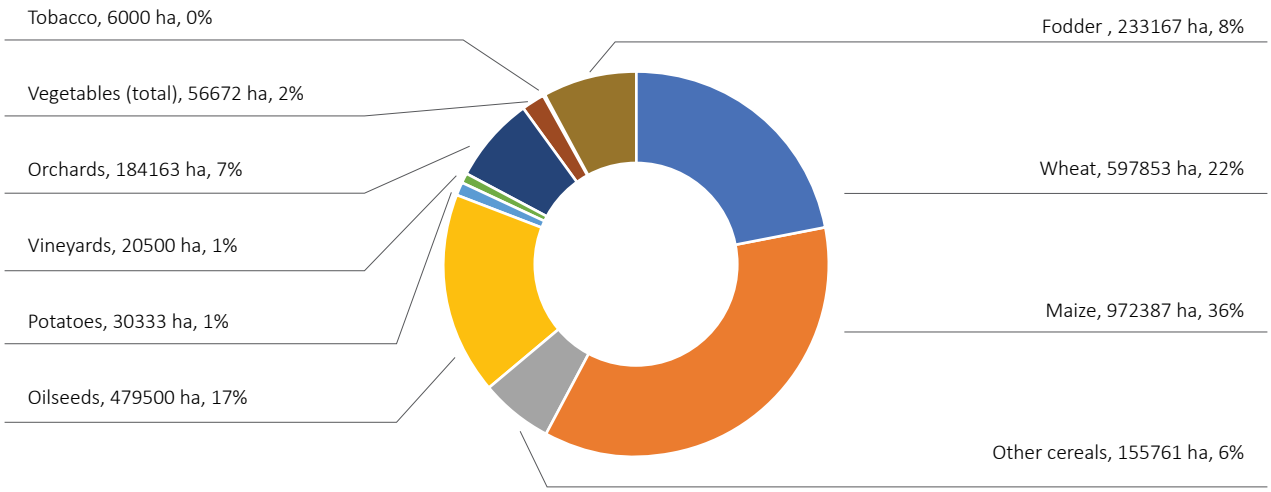


Figure 6.3. Areas under major crops (average 2017-22, in hectares)

Source: Republic of Serbia StatDatabase (2022)

Regarding livestock farming, almost all livestock categories show a multiannual decreasing trend in terms of number, which is particularly worrying in the case of cattle and pigs. The average number of cattle in the last five years is 17% lower than average in the period 2005-2010, while this reduction in the case of dairy cows is even 24%. Also, the last five-year average of pigs shows a decrease of 21% in comparison with the beginning of the period; there is a special concern regarding the number of breeding sows since their number has decreased by 23%. Currently, there are about 800 thousand cattle, 2.7 million pigs, 1.9 million sheep and goats and around 14.8 million poultry. On the other hand, the number of beehives has been growing constantly, achieving 977 thousand beehives in 2022, which is 3.6 times higher than in 2005. Governmental support in apiculture contributes significantly to the development of this sector, as well as increased exports of honey.

Having in mind a high level of dependence on weather conditions and recent extreme climate change events, agricultural production imposes a requirement for insurance of production in order to preserve income stability. In this sense, the Serbian agricultural policy has implemented subsidies for insurance premiums as a long-term scheme with a goal to mitigate climate change and adapt to its impacts. The scheme is being implemented through subsidizing 40% of insurance premium costs. Taking into account the most vulnerable regions, which are important fruit producers, the level of support is higher (70% of insurance premium costs) in eight regions. Also, under credit support intended for the purchase of animals, the insurance premium for animals is covered by the support through subsidizing part of the interest rate.

6.1.5. Farm structure key indicators and context

According to the latest FSS (2018), 564,541 agricultural holdings in Serbia are using 3,475,894 ha. The majority of holdings are family farms (99.7%), which use 84% of UAA, while legal entities and entrepreneurs participate in the total number of holdings with only 0.2%, but use 16% of UAA. The average farm size is 6.2 ha (of UAA) – family farms on average use 5.2 of UAA, while the average size of farm legal entities is 406.3 ha. Viewed by regions, the biggest farms are located in the Vojvodina Region – 12.4 ha on average, while in other regions[58], the average farm size is between 4.3 and 4.8 ha of UAA. One-third of holdings use between 1 and 3 ha of UAA and holdings with UAA bigger than 10 ha cover 57% of total UAA (Figure 6.2, right).

58 Belgrade Region – 4.8 ha; Region of Šumadija and West Serbia – 4.3 ha; Region of South and East Serbia – 4.4 ha.

The total available land of agricultural holdings in Serbia is 5.17 million ha, of which 67% is UAA, 19% is land under forest, 6% is unutilized land and 8% is other land. The majority of available land is in private ownership (almost 95%).

One-third of holdings use some irrigation in production, covering 4.6% of UAA.[59] Among the irrigated land, 70% is arable land and 20% are orchards, with vegetables, orchards and strawberries mostly irrigated. Most of irrigation (66%) is conducted as surface irrigation, using groundwater on farms (52%).

Farms engaged in livestock farming participate in the total farm number with 77% and they grow 1.9 million LSU. Most farms have between 1 and 3 LSU, while one-third of holdings have between 0 and 1 LSU. The most common herd size in Serbia is 1-2 cattle, 1-2 pigs and 3-9 sheep.

Mechanization used for on-farm production is mostly outdated and ineffective since 86% of tractors and 82% of harvesters are older than 20 years. Eight of ten holdings use their own tractor; one tractor is engaged on 7.7 ha of UAA on average and 4.3 of LSU. There are more than 450,000 double-axle tractors in Serbia, most of which (57%) have the power of 19-37 kW.

The gender and age structure of farms in Serbia is unfavourable. Among farm holders, 19% are women, while their share in farm members is 59%. In the case of farm managers, 15.3% of managers are women. Women participate in seasonal labour with 36%, while the share of permanent female employees on family farms and legal entities in the total number of employees is 16% and 23%, respectively. The majority of farms (65%) have 1 or 2 members. About 43% of farm holders are over 65 years of age, while only 3% are under 35 years of age.

Almost half of farm managers (49%) have no formal education in agriculture and their work is based on experience gained through practice; 45% have high school and only 6% of managers have university-level education.

The farm labour force in Serbia counts around 1,3 million persons, engaging 645.7 thousand AWU. Almost all labour on holdings is family labour force – 98.5% (91.6% of AWU). The average level of AWU per holding is 1.14, while this average per UAA is 0.19 AWU and per LSU is 0.33 AWU.

The total standard output of holding in Serbia is 5.34 billion EUR, with an average SO per farm of about 9,500 EUR annually.[60] However, income distribution is unequal – the most numerous category (28% of holdings) are holdings with the economic size under 2,000 EUR which produce only 3.7% of total SO; contrary to that, 1.5% of farms with the economic size of over 50,000 EUR contribute to the total standard output with 28%.

6.1.6. Legislative framework and institutional setup linked to the socio-economic aspects of climate change

The Law on Climate Change (Official Gazette of the Republic of Serbia, No. 26/21) regulates the system for the limitation of GHG and for adaptation to changed climatic conditions; adoption the strategy on low-carbon development and the programme of adaptation to changed climate conditions and monitoring and reporting on them; issuing permits for GHG emissions to the plant operator; issuing approvals to the aircraft operator's monitoring plan; monitoring, reporting, verification and accreditation of verifiers; administrative fees, supervision and other issues of importance for the limitation of GHG emissions and adaptation to changed climatic conditions. This law applies to GHG emissions caused by human activity and sectors and systems exposed to the impacts of climate

59 2017/2018 data.

60 According to the Agricultural Census 2012 results, the average SO per farm was about 5,900 EUR.

change. The aim of this Law is to establish mechanisms for timely, transparent, accurate, consistent, comparable and complete reporting and verification of information on the fulfilment of obligations under the Law on the Ratification of the UN Framework Convention on Climate Change, with annexes (Official Gazette of the Federal Republic of Yugoslavia – International Treaties, No. 2/97), the Law on the Ratification of the Kyoto Protocol (Official Gazette of the Republic of Serbia – International Agreements, No. 88/07), the Law on the Ratification of the Doha Amendments to the Kyoto Protocol to the UN Framework Convention on Climate Change (Official Gazette of the Republic of Serbia – International Agreements, No. 2/17) and the Law on Ratification of the Paris Agreement (Official Gazette of the Republic of Serbia – International Agreements, No. 4/17).

Other laws that create a common legal framework[61] regarding wider socio-economic aspects of climate change are the Law on Environmental Protection, the Law on Waste Management, the Law on Packaging and Packaging Waste, the Law on Waters, the Law on Chemicals, the Law on Energy, the Law on the Use of Renewable Energy Sources, the Law on Energy Efficiency and Rational Use of Energy, the Law on Air Protection, the Law on Integrated Prevention and Control of Environmental Pollution.

Climate change policy management is under the competence of the Ministry of Environmental Protection, while certain laws make up the legal framework on areas under the jurisdiction of other ministries (the Ministry of Agriculture, Forestry and Water Management, the Ministry of Economy, the Ministry of Mining and Energy, the Ministry of Health, etc.). The Environmental Protection Agency as part of the Ministry of Environmental Protection, performs tasks related to the national environmental protection information system, monitoring air and water quality, National Laboratory management, environmental data management, cooperation with the European Environment Agency (EEA) and the European Information and Observation Network (EIONET), etc.

6.1.7. Literature review on climate change linked to socio-economic aspects

In the Republic of Serbia, climate change has been monitored for more than ten years, including observed climate change and future change until the end of the 21st century under various scenarios of GHG emissions. Reporting under the UN Framework Convention on Climate Change is important for adaptation to climate change and it has been done in the form of national reports (national communications). Serbia has adopted two such reports (the First National Communication, 2010 and the Second National Communication, 2017). The Second National Communication presents an analysis of observed climate change up to 2012 while considering future climate change according to the IPCC SRES[62] scenarios of GHG emissions.

The selected scenarios for the analyses at that time were SRES A1B and A2, the so-called “medium” and “extreme” scenarios, considering that the assessments of future climate conditions under these two scenarios include the most likely outcomes of climate change for the purposes of adaptation planning. The assessment of future climate conditions was made for the periods 2011-2040, 2041-2070 and 2071-2100 in relation to the period 1961-1990[63], with changes in temperature and

61 The Law on Environmental Protection (Official Gazette of the Republic of Serbia, No. 135/04, 36/09, 36/09 – other law, 72/09 – other law, 43/11, 14/16, 76/18, 95/18 – other law), the Law on Waste Management (Official Gazette of the Republic of Serbia, No. 36/09, 88/10, 14/16, 95/18 – other law, 35/23), The Law on Packaging and Packaging Waste (Official Gazette of the Republic of Serbia, No. 36/09, 95/18 – other law), the Law on Waters (Official Gazette of the Republic of Serbia, No. 30/10, 93/12, 101/16, 95/18, 95/18 – other law), the Law on Chemicals (Official Gazette of the Republic of Serbia, No. 36/09, 88/10, 92/11, 93/12, 25/15), the Law on Energy (Official Gazette of the Republic of Serbia, No. 145/14, 95/18 – other law, 40/21, 35/23 – other law, 62/23), the Law on the Use of Renewable Energy Sources (Official Gazette of the Republic of Serbia, No. 40/21, 35/23), the Law on Energy Efficiency and Rational Use of Energy (Official Gazette of the Republic of Serbia, No. 40/21), the Law on Air Protection (Official Gazette of the Republic of Serbia, No. 36/09, 10/13, 26/21 – other law), the Law on Integrated Prevention and Control of Environmental Pollution (Official Gazette of the Republic of Serbia, No. 135/04, 25/15, 109/21).

62 Special Report on Emissions Scenarios – SRES.

63 Using the EBU-POM regional model.

precipitation on annual and seasonal levels and indices significant for extreme events analyzed using data from the network of meteorological stations managed by the Republic Hydrometeorological Institute of Serbia .

Estimates show that the Republic of Serbia is warming more and faster than the global average – while an increase in the global average temperature of 1.1°C has been recorded, Serbia is already at 1.8°C, and in the summer at even 2.6°C. By the end of the century (2071-2100), the expected temperature changes according to the "extreme" scenario will be 3.6-4.0°C, and according to the "medium" scenario 3.2-3.6°C. The most significant warming can be expected during the summer and autumn seasons, exceeding 4.0°C by the end of the century. The expected change in precipitation under both scenarios will decrease towards negative values until the end of the century. According to the "medium" scenario, the change in annual precipitation goes from +5% to-20%, and according to the "extreme" scenario from +20% to-20%, as the end of the century approaches. The deficit is most pronounced during the summer season.

These climate changes have a significant influence on hydrology and water resources, forestry, agriculture, health, etc. Regarding hydrology and water resources, expectations include reduced river flows, decline in groundwater availability and increased water temperature. The expected consequences of climate changes in forestry are related to forest fires and the appearance of pests and diseases. Agriculture would be affected by climate change the most, due to an increase in the vulnerability of crop production due to an increase in plant growth speed; expectations are focused on yield decrease, pests and diseases, water erosion, etc. Climate change affects human health too, causing death due to heat waves, endangering health due to deteriorated water quality, and the prevalence and increase in infectious diseases can be expected. Petrović et al. (2023) and Puškarić et al. (2010) have found evidence on negative effects on production and profitability in corn production in Serbia.

Estimates at the national level show that an increase in the average global temperature will significantly affect the value of GDP in the Republic of Serbia. Reduction in total GDP, depending on the global temperature increase scenario, without adjustment and compared to the case of the absence of global warming, is shown in Table 6.1.

Table 6.1. Expected impact of climate change on GDP: Reduction of total GDP compared to GDP in conditions without climate change (billion USD; %) 2020-2100.

T increase for	2020-2040	2040-2100	2020-2100
1 °C	15,465 (1.20%)	328,899 (4.74%)	344,364 (4.19%)
2 °C	58,124 (4.53%)	708,193 (10.20%)	766,317 (9.32%)
3 °C	59,107 (4.97%)	831,296 (12.88%)	890,403 (11.65%)
4 °C	97,536 (6.87%)	1,904,874 (18.46%)	2,002,410 (17.06%)

Source: UNDP (2019)

The primary impediment to conducting economic analyses of the impact of climate change on agricultural sectors is the scarcity of literature addressing the effects of climate change on production. To obtain dependable data, the establishment of test fields becomes imperative. These test fields should encompass experiments and demonstration plots focusing on the impacts of smart agriculture, alternative techniques to mitigate drought, and related measures. A specific recommendation is to create test fields within the Western Balkans economies, employing a standardized methodology to ensure consistency across the region.

6.1.8. Agricultural policies linked to climate change

Several strategic and programmatic documents in the Serbian strategic framework contain goals linked with climate change and its influence on agriculture and relevant sectors. One of the first documents that recognized the significance of climate change and proposed measures is the Strategy for Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024. Under five strategic goals, one goal is fully focused on climate change and environmental issues – Goal 3: Sustainable resource management and environmental protection. Achieving the strategic goals is aimed at 14 priority areas, two of which are relevant to climate change: Priority area 6 – Climate change adaptation and mitigation; and Priority area 9 – Protection and improvement of the environment and preservation of natural resources. Further, within priority areas, some operational goals have been defined. Under priority area concerning climate change adaptation and mitigation, the following operational goals have been defined: 6.1 Monitoring climate change, creation of adaptation measures; 6.2 Improvement and adaptation of technology; 6.3 Technical improvements of land, facilities and equipment; 6.4 Strengthening awareness of climate change, its consequences and the need to address them. Also, operational goals are defined regarding priority area protection and improvement of the environment and preservation of natural resources, as well. The majority of measures are implemented in the area of organic production (subsidies per area/animal and for certification), land management (implementation of the Code of Good Agriculture Practices) and conservation of plant and animal genetic resources (preserving autochthonous varieties and breeds).

The IPARD II Programme for the period 2014-2020 and the IPARD III Programme for the period 2021-2027 both contain Measure 4 – Agro-ecological-climatic measures and organic production. However, this measure was not implemented under the IPARD II Programme and its accreditation and implementation is planned within the IPARD III Programme, which is foreseen for the end of 2023. Also, Measure 4 will require the application of certain Good Agricultural and Environmental Conditions (GAEC), as a requirement to exercise the right on payment.

There are several documents as well that include a wider aspect of climate change influence, with an indirect effect on the sector of agriculture. The Economic Reform Programme (ERP) for the period 2023-2025 is the key Government programming document that defines economic goals and actions in a short-term period. Strategic reforms in the current ERP are largely based on the EU Green Deal, so one of the most important reforms is aimed at improving the conditions for increasing energy efficiency through the creation of conditions for the application of energy labelling and eco-design, as well as through subsidies for improving energy efficiency. This strategic reform includes key challenges – Greening of the energy sector and fully opening the energy market. In this sense, the measures aimed at achieving this goal are: 1) accelerate the transition to green energy, reduce CO_2 emissions, increase the share of renewable sources and save energy, and 2) carry out concrete activities with the aim to gradually eliminate the use of coal (establishment of the Directorate for Financing and Encouraging Energy Efficiency and Project Financing, adoption of by-laws). Some measures stated in the ERP have been already implemented – the Directorate for Financing and Encouraging Energy Efficiency and Project Financing was established in 2022 and allocated funds for subsidies at the amount of about 17 million EUR, while financing projects for energy efficiency has become a continuous activity.

The Strategy for Low Carbon Development of the Republic of Serbia for the period 2023-2030 states the goal of reduction of national GHG emissions by 13% by 2030 and at least by 55% to 69% by 2050 compared to 2010. According to the Strategy, this goal can be achieved through the implementation of certain measures aimed at the reduction of GHG emissions and the promotion of the transition to a climate-neutral economy and a society resistant to climate change.

The Programme for the Development of Circular Economy in the Republic of Serbia for the period 2022-2024 also includes goals and measures that are to a greater or lesser extent linked with climate change, but they are aimed at the creation of a business environment that can enable transformation to a circular business model, including enforcement of green public procurement as well.

The Strategy on Capital Market Development for the period 2021-2026 contains one of the newest financial instruments – the issuing of green municipal bonds for the financing of environmental projects, with a purpose of providing sufficient capital for financing (mostly) infrastructural projects linked to the environmental protection and mitigation of climate change. The first green Eurobond in the Republic of Serbia was issued in September 2021 in the amount of one billion EUR with a maturity of seven years and a coupon rate of 1% (the lowest so far achieved on the international market). Also, with this issue, the Republic of Serbia has joined the ranks with the few European economies that have issued green Eurobonds on the international financial market.

6.1.9. Existing data availability and quality for the analysis of climate change socio-economic issues

Annual surveys related to the crop production are conducted by the SORS in livestock farming, fishery, forestry, environmental protection and other fields of agriculture. Annual surveys are conducted on a defined stratified sample and cannot be implemented at the level of LAU (NUTS 4) with satisfactory reliability (which is in accordance with the Eurostat methodology). On the other hand, the Agricultural Census and Farm Structure Survey cover the entire population (Agricultural Census) or larger sample (FSS) and they provide data for all levels of territorial units. Nevertheless, some data are collected through these surveys only (number of holdings, UAA per holding, state of mechanization, etc.).

The official producer of statistics in the area of agriculture is the Statistical Office of the Republic of Serbia (SORS) and many governmental and state institutions are the administrative source for the data. The MAFWM is the administrative source for some statistical data too (organic production, delivered milk in dairies, pesticide statistics, subsidy payments, FADN data, etc.). Data are sent to Eurostat regularly following *acquis* requirements. Regarding climate and environmental issues, significant administrative sources of statistics are the Ministry of Environmental Protection and the Environmental Protection Agency.

There is a high level of harmonization of agricultural statistics with the *acquis*, ensuring data comparable with EU statistics, which provides satisfactory quality of these data. Data are available publicly in the SORS database (https://data.stat.gov.rs/), which contains data on SDGs, as well as an open data portal.

6.1.10. Conclusions with key recommendations and priorities referring to the socio-economic aspects of climate change

The agricultural sector in Serbia exhibits a remarkable level of resilience and stands out as a rare segment of the economy that consistently maintains a positive foreign trade balance. Despite its undeniable potential, the sector's further development is constrained by certain socio-economic factors. These factors primarily stem from the unfavourable farm structure prevalent in the economy, characterized by a predominance of small and economically fragile farms, which often operate independently without being part of cooperatives. These small-scale farms face challenges in achieving a competitive edge through economies of scale, particularly in the production of value-added products like organic and other environmentally-friendly agricultural goods. Regrettably, limited attention has been dedicated to supporting small agricultural producers, providing subsidies to associations, and establishing value chains for value-added products. Addressing these issues could significantly enhance the growth and

sustainability of the agricultural sector in Serbia.

In conclusion, the absence of regular data on NUTS (Nomenclature of Territorial Units for Statistics) and NUTS 4 levels for commodities presents a significant challenge for policymakers, researchers, and stakeholders in various sectors. The NUTS system is a vital tool for understanding regional economic and social dynamics within the European Union, and having detailed data at the NUTS and NUTS 4 levels is essential for informed decision making.

Lack of comprehensive and up-to-date data at these levels hinders the ability to accurately analyze and address regional disparities, plan targeted development initiatives, and assess the impact of policies on different geographical areas. This data gap not only limits our understanding of regional economic activities but also hampers efforts to foster regional development and cohesion.

The key recommendations include the following aspects:

Data Collection and Reporting: It is imperative to establish a systematic and regular data collection and reporting mechanism at the NUTS and NUTS 4 levels for commodities. This should involve collaboration between national statistical agencies, regional authorities and relevant stakeholders to ensure timely and accurate collection of data.

Standardization and Harmonization: Standardize methods and definitions used for data collection and reporting across regions to ensure consistency and comparability. Harmonizing data collection practices can facilitate a more comprehensive and meaningful analysis.

Capacity Building: Invest in capacities and training of individuals and organizations involved in data collection and reporting at the regional level. Ensuring that personnel have the necessary skills and resources is essential for improving data quality.

Transparency and Accessibility: Make collected data readily available and accessible to the public, policymakers, and researchers through user-friendly online platforms. This will promote transparency and enable a wide range of stakeholders to use the data for decision making.

International Cooperation: Collaborate with international organizations and neighbouring economies to harmonize data collection and reporting practices, particularly in border regions. Cross-border cooperation can help fill data gaps and provide a more accurate picture of regional dynamics.

Policy Impact Assessment: Encourage policymakers to assess the impact of their decisions on different regions, particularly at the NUTS and NUTS 4 levels, and to use this data in their decision-making processes. This can help ensure that policies are better tailored to regional needs and goals.

Regular Review: Periodically, review the effectiveness of data collection and reporting processes and adjust them as needed to meet changing demands and priorities.

In conclusion, addressing the lack of regular data on NUTS and NUTS 4 levels for commodities is essential for promoting regional development, economic cohesion, and informed decision-making. By implementing these recommendations, we can work toward a more comprehensive and accurate understanding of regional dynamics and, in turn, develop more effective policies to support these regions.

6.2. Status of soils linked to climate change in agriculture

6.2.1. Exposure and sensitivity of soils to climate change and its influence on overall soil health

Soils in Serbia are an essential natural resource base for biomass production, especially food, feed and fibre, and for safeguarding and enhancing ecosystem functions and services for environmental protection. However, they are under pressure from various threats. There is a significant influence of accelerated climate change on soils, and the pace of change outweighs the capacity for adaptation.

All the categories of climate hazards present in the territory of the Republic of Serbia have an impact on soil health. Data have shown that in the period 2020-2021, surface and groundwater flooded an area of 69,864 ha in 2020 and 14,728 ha in 2021. Over 70% of flooded areas are used agricultural soils. In the Morava River Basin in 2020, 21,352 ha of agricultural land was flooded, which amounts to 79.4% of the total used agricultural land. In 2021, southern Serbia was the most affected by the floods, and Fluvisols and Gleysols are the most affected soil types. Examples of the most intense floods in the previous period date from May 2014, when heavy rainfall led to a rapid increase of water levels in the main rivers of western, south-western, central, and eastern Serbia: Sava, Tamnava, Kolubara, Jadar, Zapadna Morava, Velika Morava, Mlava, and Pek (Serbia Floods 2014, 2014).

Over the last several decades, Serbia has seen increased frequency and severity of drought . Moisture conditions – drought monitoring is carried out by the Republic Hydrometeorological Service and estimated on the basis of the Standard Precipitation Index (SPI) for 1, 2, 3, 6, and 12 months for 28 locations (Map 1, baseline period 1961-2005). In response to the resulting changes, in 2020, Serbia prepared Recommendations for the development of the National Drought Plan of the Republic of Serbia (UNCCD, 2020). In 2021 there were 43, and in 2022, 409 climate events in the Republic of Serbia including large hail, heavy rain, severe wind gusts, tornadoes, damaging lightning strikes, and others (ESWD, European Weather Observer, 2023).

Number of people and/or enterprises (e.g. companies or farms) benefitting from measures to mitigate the consequences of floods and droughts included 110 farms in 2018; 259 farms in 2019; 454 farms in 2020 and 717 farms in 2021. Frost is monitored at 30 stations (Republic Hydrometeorological Service of Serbia), and Fluvisols and Leptosols are the most affected soil types. In 2021, damages caused by fire were registered on 834 ha (STAT.YEARB.SERB. 2022).

Soil erosion is the major form of soil degradation in Serbia. Soil erosion caused by wind, due to dry and hot weather and increased climate aridity, may further increase in the future in the case soil becomes devoid of vegetation cover and depleted of organic matter due to inadequate agricultural practices. In the period 2017-2021, the area of eroded soils ranged from 3,834 km^2 in 2018 to 6,090 km^2 in 2019, which makes up 7.8% of the territory of the economy (STAT.YEARB.SERB. 2022). Landslides occurred in 30% of the territory of the economy (SEPA, 2022), with Leptosol and Cambisols as the most affected soil types. The average soil organic carbon content in Serbia has decreased and reached the low category with a further tendency to decrease, and is mostly impacted by land use and climate change (SEPA, 2022).

In the period 2001-2020, 29% of the territory of Serbia was at moderate and 28% at higher risk levels of soil degradation considering climate and land-related degradation factors (aridity/water availability, extreme precipitation, soil and vegetation vulnerability without surfaces under managed soils, and terrain features) (14% at very and extremely high-risk levels). In the future period 2041–2060, 52%

will be at moderate and 42% at high-risk levels of soil degradation (25% at very and extremely high-risk levels) (Životić and Vuković Vimić, 2022). On average, Serbian territory could be considered a territory at high risk of degradation by mid-century. Research by the same authors further emphasizes that from the soil classification aspects, soil degradation considering climate and land-related degradation factors shows that the highest level (grade 5) of susceptibility to degradation, in the class of weakly developed soils, is shown by Lithosols, Sirozems – Regosols and Arenosols soil types and in the class of fluviatile soils, by Fluvisol soil type. The class of peats soils has also the highest level of susceptibility to degradation. In the class of acute saline and eluvial illuvial alkalized soils, the potential to reach the highest level of susceptibility to degradation is shown by Solonchaks and Solonetz soil types. Nine out of 20 soil mapping units from the National Soil Map have been determined as the first vulnerability group that has obvious constraints in current climate conditions. Together, they cover an area of 2,296,554 ha or 26.1% of the whole territory of the economy. Exposure of soils to climate change in Serbia is presented in Annex 6.1.

6.2.2. Overview of producers' adaptive capacities relevant for sustainable use of soils

The utilized agricultural area in Serbia encompasses 44.96% of the economy's entire territory (STAT. YEARB.SERB. 2023). The majority of agricultural holdings (99.71%) are comprised of family farms, and these farms own 66% of the total land. Within family farms, 84.74% of the land is owned, with an average property size of 5.75 hectares (Statistical Office of the Republic of Serbia, 2019). A survey was carried out to assess the implementation of sustainable adaptive practices and farmers' capacities for sustainable land use as part of the introduction of Measure 4 within the IPARD III Programme in 2023. Among the 150 farmers interviewed across 64 municipalities and cities, 75% acknowledged the impact of climate change on their agricultural production. Over the past 5 years, 94% of the farmers experienced adverse weather conditions, leading many to adopt measures for climate change adaptation. A significant portion (67.3%) participated in training courses in the last three years, reflecting a willingness among producers to enhance their knowledge. While there is openness to gaining new insights and improving production, sustaining and fostering this motivation requires specific educational workshops. In addition to Agricultural Advisory Services, there is a recognized need to involve educational, scientific, and research organizations in these initiatives (Ministry of Agriculture, Forestry and Water Management, 2023).

High level of dependence on the weather, which is a determinant of annual yield volatility, generates a constant risk to agricultural production. In agriculture, this indicates the need for stronger emphasis on support for hail suppression, hail nets, greenhouses, irrigation, and drainage, as well as the use of animal breeds and plant varieties more resistant to unstable weather conditions. Conventional cultivation techniques continue to dominate, leading to significant disruptions of the soil surface. Assessment of the implementation of sustainable adaptive practices in Serbia shows that reduced tillage is present on 10.06% of the territory of the economy, and no-tillage on 20,909 ha, in less than 1% of farms (Statistical Office of the Republic of Serbia, 2019). Organic fertilizers are used on 49% of farms (373,871 ha) (Statistical Office of the Republic of Serbia, 2013). According to expert opinion, soil laboratory testing schemes for improving fertilizer management were used by 70% of farms in 10 years, while precise agriculture (systems for agroecological zoning, thematic soil quality maps, online services) is present in less than 10% of farms.

The eAgrar information system has been developed to modernize and expedite the processes of registering and updating data in the Registry of Agricultural Holdings, along with facilitating the approval and disbursement of agriculture-related incentives. Examples of other available online

services are Geoportal of the Agricultural Land Administration and Prognostic Reporting Service on Plant Protection. The Geoportal gives quick and simple access to all data, maps, and applications necessary for the production of the annual programme of protection, management, and use of the state-owned agricultural land. Digital field book, crop observation through satellite images, precise weather forecast, calculation of production costs and expected profit, land sampling optimization, etc. are used by 11,000 farmers with 30,000 parcels.

Out of the entire UAA in 2022, 1.6% of the surface was irrigated. Out of the entire irrigated area, 91.8% was irrigated by fogging (STAT.YEARB.SERB. 2023). The utilized agricultural area covered by the drainage system was 1,723,000 ha in 2022, with over 7,881 km of drainage canals (STAT.YEARB.SERB. 2022).

Targeted training courses for farmers were attended by farmers from 3.1% of farms in 2012 (Statistical Office of the Republic of Serbia, 2012). According to the data from the Ministry of Agriculture, Forestry, and Water Management in 2022, farmers from 82,511 farms (24.67% of farms in Central Serbia) had consultations with extension services. According to expert opinion, lifelong learning programmes within universities and vocational training programmes related to soil were attended by less than 5% of farmers.

Of the total number of farm managers, 48.6% have gained experience through practice, 45.2% have completed high school, 6% have a university education, and 0.2% have completed courses in the field of agriculture. Analysis of the age structure of family farm owners shows that 42.5% are over 65 years old, and 27.9% are between 55 and 64 years old. The workforce could soon become a critical factor in the development of the agricultural sector since there is no indication of rejuvenating management staff on farms. Old agricultural machinery is presently used in Serbia, with 86% of tractors and 82.2% of combine harvesters over 20 years old (Statistical Office of the Republic of Serbia, 2019).

According to expert opinion, farmers in Serbia use land improvement practices which include liming (<1% in the Vojvodina Region where there is no need and 10-20% in Central Serbia when there are state subsidies) and on-farm erosion control practices (10-20% of farms) (Statistical Office of the Republic of Serbia, 2019). Producers' adaptive capacities relevant to sustainable use of soils are presented in Annex 6.1.

6.2.3. Outline of the existing gaps and challenges to meet the newly adopted EU strategic and legal documents on soil and adaptation

The main actions outlined in the EU Soil Strategy for 2030, which relate to adaptation to climate change, the implementation of which can be challenging for the Republic of Serbia, are particularly related to the set of 'sustainable soil management' practices and monitoring and reporting on their implementation. For the Republic of Serbia, the challenge is to develop support for sustainable growth of food production and greener farm practices through eco-schemes, particularly relevant to soils. Under these schemes, specific payments should be provided to farmers that adopt climate-sensitive and nature-sensitive practices in line with the European Green Deal objectives and the Soil Strategy for 2030. Examples of these actions include organic farming, crop rotation, and preservation of carbon rich soils. For the period 2021-2027, a total of 16,941,176.47 EUR was allocated for Agri-environment – climate and organic farming measures within the IPARD III Programme. Selected operations are highly relevant and complementary to the 5 Pillars of the Green Agenda for the Western Balkans.

The Nitrates Directive is not yet transposed in Serbia. Another challenge lies in the application of the Rulebook on the Code of Good Agricultural Practice (2023) which focuses on agricultural land,

and which contributes to soil protection and mitigation of degradation processes from the negative impacts of climate change.

It is worth mentioning that based on the results of the assessment conducted in 2020, the Republic of Serbia has set up a nationwide Land Degradation Neutrality target (LDN) to achieve land degradation neutrality by 2030 (UNCCD, 2020). The most promising and feasible measures have been identified. The implementation still represents a challenge for Serbia, in particular recognizing elements and targets of land degradation neutrality in legislation, spatial planning, and strategic documents, establishment and development of sustainable, systematic land monitoring, and establishment of appropriate, detailed national databases for the implementation of the LDN methodology.

The main identified gaps and challenges in the implementation of national strategies relevant to the EU Soil Strategy and EU adaptation strategy are low administrative capacities, development of decision-making tools by goals, development of institutional and personnel capacities for land and soil management on both national and local levels, improving cross-sector governance and support, mainstreaming green and low-carbon transition, including through public administration reform, public financial management, economic reform programme, mobilization of own resources, access to information, and awareness-raising. Gaps and challenges to meet the EU Soil Strategy and the Adaptation Strategy in Serbia are presented in Annex 6.1.

6.2.4. Outline of sustainable measures and best practices already applied for protection of agricultural land

There are several best practices for the protection of agricultural land already applied in Serbia related to cultivation: the total area on which organic production was applied in 2022 was 25,035 ha, which is 0.71% of used agricultural land (SEPA, 2023). Despite a growing trend, the proportion of land dedicated to organic production remains relatively small in comparison to the total utilized agricultural land. No-tillage is present on 0.83% of agricultural land, conservation of arable land in the winter period: winter crops are cultivated on 687,930 ha or 26.79% of agricultural land, growing crops for protection are present on 16,124 ha or 0.63% of agricultural land, and protection with plant residues (straw or stubble) is present on 122,054 ha or 4.75 % of agricultural land (Statistical Office of the Republic of Serbia, 2019). One of the best practices in fertilizer management already applied in Serbia is the application of organic fertilizers: solid manure is used by 49% of households on 373,871 ha, which is 11% of the total utilized agricultural land (Statistical Office of the Republic of Serbia, 2012). Soil fertility control is supported by the state and the local self-government (LSG) budgets. Precise agriculture is one of the best practices for the protection of agricultural land already applied in Serbia. Almost 10,000 farmers use the AgroSense platform – artificial intelligence, satellite images, meteorological data, and digital field records. Agricultural extension services play a crucial role in disseminating information, providing technical assistance, and offering training to farmers in Serbia. All those best practices mainly have a positive effect on soil organic matter maintenance, soil reaction, combating soil erosion, soil salinization, and water conservation.

To ensure good interaction of sectoral activities, the environment, and health, an excellent strategy in the implementation of measures of adaptation to climate conditions is the adoption of the concept of "Nature-based Solutions – NbS" (Vuković et al. 2021). Nature-based Solutions start with interventions implemented on the land cover and soil. Measures that can be applied in the Republic of Serbia, and that have an impact on the protection of soil health are forestation and restoration of forests, sustainable forest management, management of forest fires, implementation of agro-forestry, conservation agriculture, improved pasture management, restoration of abandoned agricultural

land, restoration of peatland, restoration of flooded areas, minimal land use in urban planning, etc. An important measure is the planned forestation of the most developed agricultural region of the Republic of Serbia – Vojvodina, with an extremely low forestation rate of 6.4 %, which makes it one of the least forested regions in Europe.

The Republic of Serbia has officially adopted the Low Carbon Development Strategy for the period from 2023 to 2030, with projections extending until 2050. The Strategy outlines specific measures within the agricultural sector, including the implementation of winter cover crops, which also play a role in soil protection.

Some of the adaptation measures offered in the Draft Climate Change Adaptation Programme with Action Plan (2023) are measures directly related to soil: solving regulatory issues related to intended land use for mitigation and prevention of degradation. There is a measure aimed at increasing the resilience of meadows and pastures and their capacity to adapt to climate change. This measure entails mapping vulnerable meadows and pastures that need adapting to climate change based on Nature-based Solutions, with an emphasis on conservation agriculture, management of nutrients by ensuring a permanent vegetation cover (cultivating legumes as fertilizers), sowing grass mixtures and expanding areas with drought-resistant species. The programme looks at the interconnections between climate, soil, and water (the so-called nexus approach). While the Draft Climate Change Adaptation Programme acknowledges the importance of soil, there appears to be a gap in adequately representing adaptation measures for this critical natural resource. This oversight could potentially exacerbate pressures on the soil, hindering effective climate resilience.

Best practices related to managing risks of the harmful influence of water include a preliminary flood risk assessment, producing flood hazard maps and flood risk maps, as well as creating and implementing plans for flood risk management. Flood hazard maps and flood risk maps are produced by the public water management enterprise for a 6-year period. Maps are produced for important flood-prone areas identified by the preliminary flood risk assessment (Map 2). These maps will assist public water management companies Vode Vojvodine and Srbijavode as well as LSGs in managing floods in large and small rivers. Sustainable measures and best practices already applied for the protection of agricultural land in Serbia are presented in Annex 6.1.

6.2.5. Overview of the already adopted mechanisms and opportunities for effective adoption of adaptation measures for soil health protection

Subsidies (IPARD and direct payments) present a good mechanism of support provided to the implementation of good agricultural practices for soil conservation, as they involve principles of the EU Common Agricultural Policy (CAP) and environmental protection through direct support and rural development measures for farmers. In addition to continuous work on the process of harmonization of national regulations with EU standards, additional programmes and measures are needed, as well.

According to the annual programme, subsidies are distributed by regulation and by types of subsidies. Subsidies that are fully financed from the national budget include direct payments, rural development measures, credit support, and special subsidies. IPARD subsidies are only partially financed from the national budget, and mostly from EU financial funds. One of these subsidies contributing towards the protection and improvement of land and soil as a natural resource is for organic production. The use of subsidies has increased over the years: 110 farms in 2018, and 1,086 in 2022. Subsidies are limited to 20 ha. In 2022, subsidies were increased by 250% compared to the original subsidies for plant production and amounted to around 270 EUR/hectare.

Subsidies related to investing in the physical assets of agricultural estates include investments in the purchase of new machinery and irrigation equipment for crop production, frost protection equipment/ mechanization, meteorological stations and IT equipment (hardware, software, equipment for monitoring, controlling and managing production and storage processes).

The Agri-environment-climate measure in the IPARD III Programme for the Republic of Serbia (2021-2027) consists of four operations that aim to enhance cultivation methods adapted to the environment and the features of landscapes and enhance the biodiversity and ecosystem services, promote water conservation and water quality improvement, and contribute to climate change adaptation and mitigation principally by sustainable input use and improving soil management. Supporting more sustainable practices and management of agricultural land in rural areas will contribute to the maintenance of a favourable landscape and environment for enhanced public goods. The 4 operations consist of the following: Operation 1 – Crop rotation on arable land; Operation 2 – Grassing in the inter-row area in permanent cropland; Operation 3 – Establishment and maintenance of pollinator strips; Operation 4 – Sustainable management of meadows and pastures. These operations are directly relevant to the achievement of the vision and strategic goals of the National Agriculture and Rural Development Strategy which underlines the importance of a more responsible and sustainable use of resources and agricultural practices.

When it comes to informing agricultural producers about adaptation mechanisms, the Agriculture Advisory Service is a key instrument for the transfer of knowledge in agriculture through non-formal education. Since 2013, the number of advisory services has risen almost every year. In Central Serbia, advisory services were provided by 158 providers in 2013, and in 2022, there were 208 service providers.

6.2.6. Analysis of the current institutional and legal setup for effective adaptation of soils to climate change

Institutional framework: The Ministry of Environmental Protection is in charge of climate change at the national level. The Republic Hydrometeorological Institute (RHMZ) is a separate organization in charge of affairs related to meteorological, meteorological-radar, agri-meteorological, and hydrological observation, and analytical forecasting systems. Environmental Protection Agency is an authority under the auspices of the Ministry of Environmental Protection that is in charge of the collection and monitoring of environmental protection indicators, including those that are relevant to adaptation to climate change. The National Climate Change Council is one of the important instruments for achieving a social consensus on the matters of climate change. After the adoption of the Climate Change Adaptation Programme, the Ministry of Agriculture, Forestry and Water Management will be in charge of the implementation of adaptation measures in the area of agricultural production.

Educational and scientific capacities related to adapting soil to the negative impacts of climate change are primarily concentrated in research and education centres. However, it is essential to ensure that these capacities are effectively used and accessible to a broader audience.

Strategic framework:

- Low Carbon Development Strategy for the period 2023-2030 with projections until 2050
- Nature Protection Programme of the Republic of Serbia for the period 2021-2023
- Strategy on Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024
- Water Management Strategy on the territory of the Republic of Serbia until 2034 with Action Plan for the implementation of the Water Management Strategy on the territory of the Republic of Serbia for the period from 2021 to 2023

Draft Spatial Plan of the Republic of Serbia for the period 2021-2035 has been largely harmonized with the requirement of adaptation to climate change, which makes it exceptional in the overall strategic planning documents in Serbia. One of the six objectives of the Plan is increased resilience of space to change and pressures, achieved by sustainable use and protection of natural resources, the environment, biodiversity, natural and cultural heritage, and by development and management of landscape and green areas.

Legislative framework: The Law on Climate Change establishes the basis for planning, updating, and implementing of policies, measures, and activities in the area of adaptation to climate change. In order to ensure systematic implementation of climate change adaptation, endorsed by the Republic of Serbia by signing the Paris Agreement (ratified in 2017), the Law envisages drafting a Climate Change Adaptation Programme accompanied by an Action Plan. Drafting of the Programme in accordance with the principles of the EU climate change strategy is in progress.

Law on Disaster Risk Reduction and Emergency Situation Management – regulates reduction of risk from disasters and management of emergency situations; in this context, disaster risk reduction entails climate change monitoring and adaptation of the society to expected consequences. According to this Law, RHMZ has coordinated the drafting of a weather-related disaster risk assessment of the Republic of Serbia. Observed and forecasted climate change (scenarios) have not been included in the risk assessment. The national disaster risk assessment was adopted in March 2019 and is being updated every three years.

The Law on Agriculture and Rural Development sets out the basic definitions, rights, and responsibilities of agricultural producers, enforcing a duty of protecting the environment, animal health, animal welfare, and soil.

6.2.7. Soil data availability and quality, data constraints and data gaps

In Serbia, there is no structured soil monitoring. However, through a combination of statistical and environmental data sources, considerable information is available or at least possible to collect at the national level (Vidojevic et al, 2022). Data on the state of soil are published in the Report on the State of the Environment (SEPA, 2022) and the Soil State Report in the Republic of Serbia (Vidojevic, 2021). Even though relevant data exist, the existing data sets related to specific pressures are outdated and they need to be updated. Additional data is needed related to soil management and environmental conditions affecting soil quality. The Land Parcel Identification System (LPIS) is under development in Serbia.

Soil and land data relevant for the design of soil adaptation measures and measuring of their effects, available in GIS format are Soil maps, Land Use and Land Cover maps, Soil physical properties, Soil chemical properties, Soil organic carbon content, Contamination, Soil sealing, Salinization, Acidification, Drought, Floods (Vidojevic et al, 2022). Although soil erosion affects about 90% of the total area of Serbia, data are outdated and are available only in hard copy.

A major form of degradation of agricultural soils in the Republic of Serbia comes from the loss of organic matter. In the context of recent research studies and papers, the content and stocks of soil organic carbon were assessed and analyzed. Vidojević (2015) has investigated in detail the spatial distribution of soil organic carbon (SOC) and SOC sequestration potentials in the soils of the Republic of Serbia. However, there is no monitoring of soil organic carbon in accordance with the soil sampling protocol, required for certifying any change of SOC stocks in mineral soils. Overall peat areas in Serbia cover less than 1% of the soils and their impact is not investigated in terms of SOC content and the potential for carbon sequestration.

Further action at the national level is the improvement of the quality and availability of soil data: collection, analysis, verification, reporting, monitoring, and integration with other disciplines.

For planning national and local adaptations, which would serve as an overview and to download relevant data necessary for monitoring climate impact on soils, a web portal, Digital Climate Atlas of Serbia, has been developed, containing relevant climate data required for the analysis of climate change and impacts. This is a web platform that provides the integration of climate change adaptation into mid-term and long-term planning of activities of legal entities and other stakeholders. This portal offers a range of climate data used for specific risk and vulnerability assessments, including the observed climate change and future climate projections, both at the national and local levels.

6.2.8. Conclusions with key recommendations and priorities referring to soil adaptation to climate change

Soils play a crucial role in achieving the ambitious target of the European Green Deal on a climate-neutral EU by 2050. Implementation of a soil protection framework to ensure healthy soils is a priority for the implementation of the Green Agenda for the Republic of Serbia. This requires coherent action across a broad policy base. It is crucial to integrate a more comprehensive set of adaptation measures specifically focusing on enhancing soil health in the Climate Change Adaptation Programme.

Monitoring farming practices and the effectiveness of adaptation measures for soil health protection needs to be further developed. Generally, there is a low level of awareness of climate change impact among farmers. Agricultural Advisory Services have a very important role in farmer education and implementation of agro-environmental and rural development measures.

The highest priority is set on the issues of capacity building, awareness raising, and improvement of data availability and transparency. It is necessary to emphasize the importance of the development of an integrated system for monitoring the impact of climate change, associated with obligations to report on the effects of climate change mitigation and adaptation measures. The low level of awareness is one of the biggest obstacles to proper implementation of sustainable land management practices, and it is essential to demonstrate the benefits of improved soil and land management. Building human and technical capacities is further needed. Capacity building should be conducted for all stakeholders from policymakers to farmers. It is necessary to harmonize the goals set within national strategic documents with the requirements set in the new EU Soil Strategy for 2030 and measure progress toward the goals. There is an urgent need to establish inter-institutional arrangements and protocols in the process of exchange of existing data and access to databases between institutions, and setting in place functional monitoring, reporting, and verification systems for soils, as well as develop a long-term programme to support the implementation of sustainable land management practices in all sectors acting as drivers of land degradation. Planning preventive measures for soil and land degradation is necessary and urgent. Assessment of the soil and land degradation risk should be downscaled to the local level. Risk assessment at the national level should be considered as a guiding reference for the selection of priority areas and a time schedule should be developed for addressing differently vulnerable areas.

6.3. Status of water resources and their importance for agricultural production

From the territory of Serbia, waters gravitate towards three seas: the Black Sea (rivers of the Danube Basin), the Adriatic Sea (Drim and Plavska Rivers) and the Aegean Sea (Lepenac, Pčinja and Dragovištica Rivers). The largest part of the territory of Serbia belongs to the Black Sea Basin (about 92% with and about 98% without the territory of Kosovo* and Metohija).

The Directorate for Waters, an administrative division of the Ministry of Agriculture, Forestry and Water Management, is responsible for managing Serbia's water resources. Two Public Water Authorities named Srbijavode and Vode Vojvodine carry out engineering tasks and provide technical advice in relation to water resources.

Water management is performed at the level of water areas (VP), (Annex 1). The Danube water area is divided into two districts (MP) Upper Danube (northern part of the water area) and Lower Danube (southern part). The Sava water area is divided into MP Srem, Kolubarski MP and Gornje Drinsko MP, and the Morava Basin into MP Velika Morava, MP Južna Morava, MP Zapadna Morava, MP Ibar-Lepenac and MP Beli Drim [Water Master Plan, 2001]. The flows of international rivers are significant and dominant in relation to the domestic rivers with flows generated on the territory of Serbia. On the territory of the Republic of Serbia, about $63.7 \cdot 10^9$ m^3 of water precipitates annually, about $16 \cdot 10^9$ m^3 runs off, while the rest returns to the atmosphere through evapotranspiration.

Water flows for domestic use are relatively modest, averaging just below 500 $m^3 \cdot s^{-1}$ during the year, and 60 $m^3 \cdot s^{-1}$ during the low flow period (95% confidence level). Due to the modest amount of domestic water, the water demand can be met by water from international rivers according to international agreements (about 5,000 $m^3 \cdot s^{-1}$ during the annual average or about 1,500 $m^3 \cdot s^{-1}$ during the low water period). The total reservoir storage (28 reservoirs with a volume of more than $10 \cdot 10^6$ m^3) is about $6 \cdot 10^9$ m^3. In addition, a large number of smaller reservoirs have been built. The Danube-Tisa-Danube water system holds 326 $m^3 \cdot s^{-1}$ of water for service purposes. Estimated total capacity of groundwater is about 67.1 $m^3 \cdot s^{-1}$.

The total water needs in the economy are estimated at 5.32 billion m^3 per year. Predominantly, water is used for industry (production and distribution of electricity and other industry 4.25 billion m^3 (75.5%), followed by agriculture $0.71 \cdot 10^9$ m^3 (12.62%), and municipal water use $0.69 \cdot 10^9$ m^3 (11.9%), irrigation only $68 \cdot 10^6$ m^3 (<1%). Total internal renewable water resources per capita are only 958 m^3/capita/year. Taking into account transitional water, total annual renewable water resources per capita are 18,490 m^3 (FAO Aquastat database, 2020).

The normal annual precipitation is 896 mm. The amount of precipitation increases with altitude. Drier areas with precipitation below 600 mm are located in the northeast of the economy, as well as in the valley of the Južna Morava River and in the part of the autonomous province of Kosovo* and Metohija (AP KiM). Annual precipitation totals 650 mm in the water area of the Danube, the MP Velika Morava and its continuation towards Vranje and Dimitrovgrad. The areas of Serbia with the highest precipitation are located in the west and southwest of the economy, where the annual precipitation ranges from 850 mm to 1,000 mm. Precipitation increases with altitude from 850 mm to 1,000 mm per year and exceeds 1,000 mm on some mountain peaks in southwestern Serbia. The spatial distribution of annual precipitation is shown in Annex 6.2.

6.3.1. Brief analysis of irrigation and drainage status in the Republic of Serbia

Agriculture is a very important economic sector in Serbia, as its share in gross national income, together with forestry and fisheries ranges from 6 to 6.8%. Primary agriculture is mainly based on small family farms (a total of 631,552 households with 1,442,628 workers), which account for about 20% of the population, only 12% of whom are engaged in additional activities such as food processing or rural tourism. The average size of farm holdings is only 5.4 hectares, composed of an average of 6 plots. The average size of parcels is about 1 hectare. Such an unfavourable ownership structure increases the vulnerability of agriculture and can slow down its development.

Irrigation schemes as public property were built on an area of 182,252 hectares with AP KiM, or 117,928 ha without AP KiM, in the 1980s (Table 6.2). The utilization of irrigation systems varied from 9.8% in 1999 to 95% in 2012 (http://www.stat.gov.rs/sr-cyrl/publikacije/; Water Master Plan, 2001).

Table 6.2. Hydro-ameliorative systems in Serbia and their use in agricultural production

Hydro-ameliorative systems in the economy		Irrigated area in ha according to project documents	Real irrigated area in ha
		~1970-80	**2018**
1	**Watershed Dunav**	**97,168**	
	Bačka	57,846	
	Banat	36,264	
	Gornji Dunav	3,058	
2	**Watershed Sava**	**9,560**	
3	**Watershed Morava**	**75.524**	
	Northern Serbia		82,588
	Southern Serbia		76,999
	Total	**182,252**	**159,587**

According to the Agricultural Census (2012), 71,947 farms irrigated a total of 99,773 hectares. Therefore, the average irrigated area per farm was only 1.4 hectares. Evenly throughout the economy, farmers mostly irrigated vegetables, watermelons and strawberries (63.8%), followed by sugar beets (13.3%), fruit orchards (13.4%) and other crops (9.5%), e.g. for seed production, such as corn, soybean, sunflower hybrids, etc. (Table 6.3).

Table 6.3. Irrigated land by group of crops in 2012 in Serbia

Regions	Total irrigated area (ha)	Cereals, maize for fodder	Industrial crops	Other crops (fodder crops, pods, etc.)	Vegetables	Orchards	Vineyards	Meadows	Other permanent crops
Serbia	99,773	36,154	9,863	18,976	19,865	13,344	215	602	754
Vojvodina	58,251	22,062	9,047	12,043	9,755	5,050	89	22	183
Belgrade	6,109	2,395	760	495	931	1,438	8	12	70
Šumadija and Western Serbia	21,173	6,093	6	3,727	5,205	5,254	70	368	450
Southern and Eastern Serbia	14,241	5,604	49	2,712	3,974	1,603	48	200	51

Survey carried out by the Statistical Office of the Republic of Serbia (SORS) in 2018, indicated that the total irrigated area was 159,587 ha. For irrigation purposes, $68.12 \cdot 10^6$ m^3 of water was withdrawn (probably for irrigation systems as public property), although the actual amount of water withdrawn is much higher, because users who irrigate less than one hectare do not have to register or pay for the water withdrawal. A realistic estimate is that about $262 \cdot 10^6$ m^3 of water is withdrawn annually, which is about 5.7% of the total amount of water withdrawn. The average irrigated area per farm has been decreasing and amounts to only 0.85 hectares. Although the number of irrigated hectares under vegetables, orchards and strawberries has almost doubled, the percentage share of these crops has changed in relation to the others, and amounts to 31.3% of the total irrigated areas. The areas under fruit trees and berries have increased two and a half times, so the percentage share has increased to 20%. Maize is irrigated on 17.1% and cereals on 8.8% of the total irrigated areas. The area under sugar beet is represented at 3.2% and is irrigated only on large estates (95 farms irrigate 5,182 ha). Potatoes are irrigated on 3.7%, fodder crops on 1.8%, legumes on 1.2%, sunflower on 1.3%, rapeseed on 1%, vineyards on only 0.4%, and the remaining crops are irrigated on 10.1% of the area.

Farmers predominantly use surface (furrows) irrigation systems (60.6%), followed by drip irrigation (27.2%) and sprinkling (12.2%), such as rangers, pivot devices, typhoon, and rain wings. Water source for irrigation is mostly groundwater (51.6%), then surface water outside the farm (31%), surface water on the farm (6.7%), water from the public water supply (6.5%), and 4.2% are other water sources.

Drainage systems cover 2,013,872 hectares, with around 390 drainage systems and 24,138 km of canal network, 210 larger and several dozen smaller pumping stations, with a total capacity of 543 $m^3 \cdot s^{-1}$ and 252 gravity outlets, 260 inlets, 426 cascades and 13 siphons. Horizontal pipe drains water around 62,008 ha (Water Master Plan, 2001; Strategy on Water Resources Management on the Territory of the Republic of Serbia, 2015). The largest number of drainage systems (70% of the total systems) were built in the Danube Basin, MP Upper Danube. According to the latest SORS data, the total area covered by drainage systems is 2,536,000 ha (Statistical Yearbook 2022). The Government of the Republic of Serbia has intensified investments in drainage and flood control systems over the last two decades, and recently about 100 million EUR have been invested or allocated in the development of irrigation, and several new systems and expansions of existing systems are currently being actively considered.

Table 6.4. Drainage systems in the Republic of Serbia

Drainage systems in the economy		Drainage area in the economy according to project documents (ha)	Area in the economy covered by drainage systems (%)	Cleaned canal network (km)*	Main recipient
1	**Danube watershed**	**1,453,598**			Danube River
	Gornji Dunav	1,423,076			
	Donji Dunav	30,522			
2	**Sava watershed**	**513,354**			
	Sremski	353,433			Sava River
	Podrinjsko-kolubarski	159,921,000			Drina River
	Gornje Drinsko"	-			
3	**Morava watershed**	**115,060**			Velika Morava River
	Velika Morava	26,730			
	Južna Morava	8,500			
	Zapadna Morava	8,700			
	Ibar-Lepenca	30,000			
	Beli Drim	41,130			
	Total	**2,082,010**	**67-85**	~4,500	

*Recently cleaned canals (2017-2019)

6.3.2. Drought risk assessment and crop water requirements

Observed data from meteorological stations in the period 1961-2017 indicate significant climate change trends in Serbia, which may have caused numerous negative impacts (increase in air temperature >1°C; increase in dry periods and drought intensity; extreme heat waves; increased precipitation variability >7 mm/decade; floodings), although some positive impacts on agriculture are also expected (prolonged growing season). All this indicates an increased vulnerability of agricultural production and needs for adaptation to climate change (Group of authors, NAP 2015; Stričević et al., 2019).

Average values of potential evapotranspiration for the territory of Serbia is 824 mm for the period 1991-2020. For the same observed period, the average climatic water deficits amount to 280 mm (Figure 6.4). Spatial climate deficits vary significantly across the territory of Serbia – they are the smallest in the MP Gornje Drinsko (<100 mm) and the highest in the northeast and southeast, where values exceed 400 mm. In most of the economy, the climatic deficit is in the range of 260-370 mm.

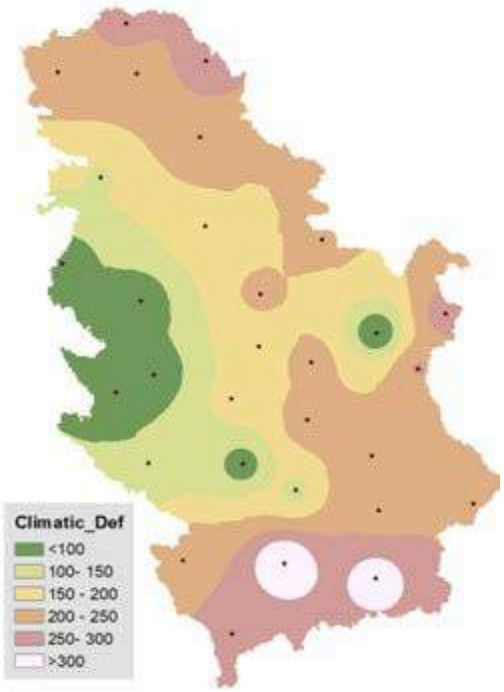


Figure 6.4. Climatic water deficit in Serbia (1991-2020)

According to de Martonne's drought index (IM) (Figure 6.5) calculated for the period 1991-2020, irrigation is not required in western areas (IM > 30), while in the remaining areas supplementary irrigation is needed (IM 20-30). The areas of northeast and southeast of Serbia are the most critical because the values are approaching the limit for irrigation to become mandatory for successful crop production. The months of July and August are especially critical, since IM value is in the range of 16-20, which indicates that irrigation is indispensable in the southeast of Serbia, especially for perennial crops, crops with long growing cycle, orchards and vineyards (Figure 6.6).

Crop water requirements and irrigation needs vary depending on the year, crop variety/hybrids, crop structure, growing conditions, etc. Table 6.5 shows the results of the irrigation water demand in Serbia (Group of Authors, 2015; Group of Authors, 2023). The highest irrigation requirements should be provided by fruit crops (on average 355 ± 85 mm per year), followed by sugar beet (300 ± 60 mm). An average of 200-230 mm of water should be provided for the irrigation of corn, fodder plants, potatoes, a little less is needed for sunflowers (160 ± 35 mm) and vegetables due to the shorter growing season (130 ± 60 mm). The least water is required for vineyards (76 ± 40 mm) and cereals (±40 mm), usually due to drought in the period of sowing and sprouting, and less in spring. Greater than average seasonal irrigation norms (+) should be provided in the eastern (Negotin) and southern parts of Serbia (MP Južna Morava and Donje Podunavlje) and less (–) in MP Gornje Drinsko. There are average water deficits in the MP Zapadna Morava and MP Velika Morava. Irrigation is urgent in southern and northern parts of the economy, and on shallow soils.

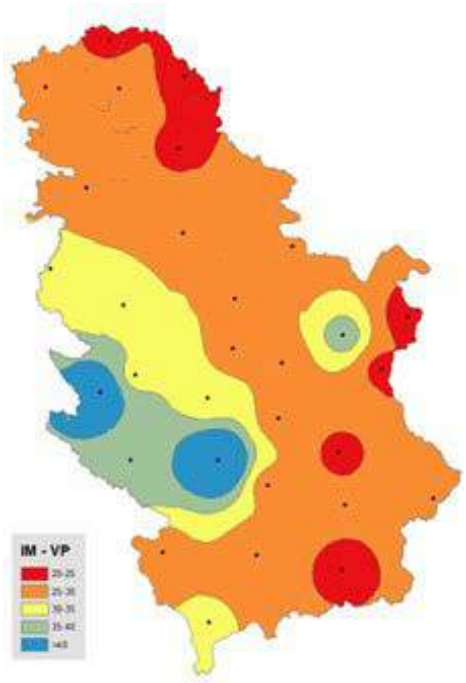


Figure 6.5. Dryness index by De Martonne for the growing season (April-September)

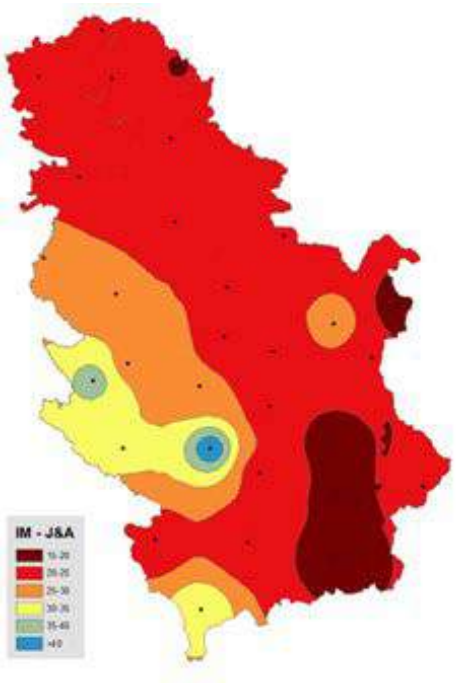


Figure 6.6. Dryness index by De Martonne for the July and August season

Table 6.5. Evapotranspiration (ETP) and irrigation water requirement, applied irrigation techniques and irrigation regime by groups of crops

Crops	ETP by season (mm)	Irrigation water requirements by season (mm)	Applied irrigation techniques	Irrigation efficiency	Irrigation application rate (mm)	No. of applications during the season
Cereals	340±40	±40	Sprinkler		20-40	0-3
Maize	492±55	210±70	Sprinkler		20-40	0-8
Industrial crops (sugar beet)	650±55	300±60	Sprinkler		20-40	0-8
Industrial crops (sunflower)	430±35	160±35	Sprinkler		20-40	0-5
Fodder crops, alfalfa	595±70	195±100	Sprinkler		20-40	0-8
Pods/Legumes, soybeans	490±45	190±70	Sprinkler		20-40	0-10
Vegetables	300±32	130±60	Sprinkler/ drip/ furrow	~70 %		>20
Orchards (apple, pear, cherry)	640±75	355±85	Drip irrigation	~70 %		>21
Orchards (apricots, plums, peaches)	545±60	295±80	Drip irrigation	~70 %		>22
Vineyards	377±30	76±40	Drip irrigation			
Meadows/clover	483± 50	203±58	Sprinkler			
Potato	465±50	230±60	Sprinkler/ drip/ furrow			

An assessment of yield decline due to lack of water found that the biggest reduction occurs in sugar beet and corn (from 5 to 70%, and in extreme years even up to 80%). Sunflower and soybean tolerate drought a little better, so sunflower yields vary from 0 to 40%, and soybeans from 5 to 50% (Group of authors, 2014-18; Stričević et al., 2019; Kresović et al., 2014). Greater damages from drought occur on shallow and sandy soils, and especially on hydromorphic soils where it is not possible to plough the soil and sow in optimal terms.

In the opinion of farmers (Stričević et al., 2020a; Stričević et al., 2020b), damages due to climate change in farming and vegetable growing in the open field were assessed as significant (30-50% of the average profit). The variation from moderate to significant damages can be interpreted as long-term observed damages, which are really variable from year to year, because almost all agricultural production and part of vegetable production (beans, peas, potatoes, onions, garlic) is carried out in conditions without irrigation, while losses in viticulture are moderate (10-30% damage). Producers involved in fruit growing suffer the most damage in the amount of 30-50%. This opinion is not surprising, because extremely high temperatures and drought are highlighted as the strongest impact of climate change, which must certainly cause damage to fruit growing in rainfed conditions. In addition, the quality of fruit and price are affected by the occurrence of hail and late spring frosts, which is also an important impact according to farmers' perceptions. The impact of drought on fruit plantations has a double effect. Namely, a drought episode from one year has a decisive influence on the yield of the following year as well.

6.3.3. Overview of farmers' existing adaptive practices for proper water use under climate change

In Serbia, numerous practices and methods are used to mitigate the effects of climate change in agriculture. Based on research conducted throughout Serbia (Stričević et al., 2020b), it can be concluded that both experts and farmers agree that the following measures are very important for climate change adaptation: irrigation, anti-hail nets, anti-frost irrigation systems, agro-technical measures (optimal sowing dates, use of hybrids with shorter vegetation, monitoring the occurrence of pests and diseases and timely application of spray treatments, sowing density, reduced tillage, application of mulch, etc.), use of multipurpose reservoirs for water supply, use of drainage canals for irrigation, construction of anti-hail nets, drainage and improvement of practices for protection against water erosion. Other recognized measures (27 in total), while important, are rated as less important and are therefore given secondary priority for implementation (Annex 6.2).

Figure That this research is realistic is shown by the fact that irrigation systems have been considerably expanded, localized irrigation (drip method) is used mainly in new locations, reservoirs are built on the properties themselves, especially to protect them from frost, and vegetable gardens are protected from cold waves and late spring frosts. In orchards, in addition to irrigation, anti-hail nets are used, which also serve to lower the air temperature, protecting the fruit from intense irradiation and thus reducing water consumption (Picture 1).

According to expert assessment, fertigation is applied to about 80% modern irrigation systems (especially on larger estates), with constant monitoring of water and nutrient consumption. In the last few decades, subsurface drip irrigation systems have been increasingly installed in order to save water. The irrigation regime is generally observed on properties where experts for irrigation are employed. According to expert judgment, up to 50% of irrigation systems use irrigation scheduling, and up to 30% of irrigation systems have sensors for measuring soil moisture. Tensiometers are used to the same extent. Many experts use reference evapotranspiration (ETo) data for the previous 5 days from the Republic Hydrometeorological Institute (RHMZ), as well as forecasts for the next 10 days and the

occurrence of rain in order to coordinate the start of watering and determine irrigation depts (Annex 2). Agricultural producers who irrigate small areas are generally guided by empirical norms. There are no official data on the efficiency of water use.

Lifelong learning in the field of irrigation is organized in Serbia, both for experts and for farmers (https://www.psss.rs). The commercial advisory service, organized by companies selling mineral fertilizers and irrigation equipment, is expanding more and more.



Picture 6.1. Some applied adaptive practices in Serbia – anti-frost irrigation system, anti-hail nets, irrigation, shadowing nets, mulch

Photo: Stričević R.

Possible limitations preventing the introduction of sustainable practices. Research throughout the economy has revealed that the majority of farmers, regardless of education and age, believe that the implementation of climate change adaptation measures in agriculture largely depends on financial support provided by the government. They also believe that support of advisory services and application of new technologies are necessary (Stričević et al., 2019; Stričević et al., 2020b). Government of Serbia provides subsidies every year (https://subvencije.rs) for irrigation equipment and other forms of technical support, which can promote water saving, anti-hail protection, precision agriculture, etc. Some of the tasks of the IPARD III Programme for Serbia are to contribute to mitigating climate change and encourage sustainable management of natural resources, and support investments in material assets and technical improvements in agriculture.

6.3.4. Summary of national strategies and adaptation plans for water use in agriculture

The Directorate for Waters, a bureau within the Ministry of Agriculture, Forestry and Water Management is responsible for managing water resources on the territory of the Republic of Serbia. The Law on Waters (Official Gazette of the Republic of Serbia, No. 30/2010, 93/2012, 101/2016, 95/2018, and 95/2018) controls the legal status of waters, integrated water management, management of infrastructure, sources and ways of financing water activities, supervision over the implementation of this Law, as well as other crucial water management concerns.

The strategic approach to water management is determined by the Strategy on Water Management in the Territory of the Republic of Serbia until 2034 (Official Gazette of the Republic of Serbia, No. 3/2017), while the broader context of agriculture is included in the Strategy on Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 (Official Gazette of RS, No. 85/2014). In the framework of these documents, investment and regular maintenance of drainage systems, construction of new drainage systems and construction of irrigation systems, transfer of knowledge, technical and technological development, conservation of land resources (prevention of degradation), financing of agriculture (incentives), etc. are foreseen. The dynamics of irrigation development will be based on economic and ecological principles, in accordance with the needs and possibilities of the society, both at the local level (small farms) and at the regional level (construction of regional irrigation systems). Given that agriculture is extremely vulnerable to climate change, the Ministry of Agriculture, Forestry and Water Management of Serbia has begun developing the Irrigation and Drainage Development Strategy 2023-2032 in 2022, in collaboration with FAO, and it is in its final stages.

Currently, 37 legal regulating provisions are in place to more strictly control matters relating to water protection, watercourse regulation, protection from adverse effect of waters, water use for various purposes, financing methods, etc. Regulation on the Water Management Programme, 2020; Ordinance on the Operational Plan for Flood Defence, 2020; and Regulation on the General Plan for Flood Defence are some of the current laws crucial for the inclusion of aspects of climate change and adaptation (Annex 2). A detailed description of all legal regulation provisions concerning climate change is provided in the document *Overview and assessment of the existing policy, regulatory and institutional framework for adapting to climate change with recommendations for the development and improvement of a special policy and regulatory framework – Report 3*, and the *Report on climate change impact on agriculture with a proposal for adaptation measures*, in draft version, available at: https://adaptacije.klimatskepromene.rs/dokumenta/.

6.3.5. Data availability and quality, data constraints and data gaps

The Republic Hydrometeorological Institute carries out all duties associated with the national hydrometeorological service, including data collection, processing, and quality control. It also represents the Republic of Serbia in international organizations, conventions and protocols related to meteorology and hydrology. The required information is readily available on the website www.hidmet.gov.rs. There are some data constrains regarding water withdrawal for irrigation.

6.3.6. Conclusions with key recommendations and priorities referring to proper water use and adaptation to climate change

Over the last two decades, the temperature and precipitation regime has changed, leading to less favourable conditions for plant and fruit production. Damage caused by climate change varies between zero and 30 to 50% (occasionally 100% due to hail or extreme drought) of the average profit. The need for irrigation and other climate change adaptation measures is becoming increasingly important. Drought occurs most frequently in July and August, so supplemental irrigation is required. The eastern and southern parts of Serbia are more prone to drought. Irrigation is not well developed, but there is an increasing trend towards the construction of modern irrigation systems. Water for irrigation will be limited, so multipurpose water reservoirs should be planned and the dynamics of irrigation development should be based on economic and ecological principles. The existing irrigation and drainage systems should be renovated and modernized where possible. Investment and regular maintenance of drainage systems are essential, as is the construction of new drainage systems, as severe storms have become more frequent in recent years and are predicted for the future. Farmers are aware of climate change and are willing to adopt adapted practices if supported by advisors. Continuous subsidies for the acquisition of new techniques and technologies should be facilitated, as well as knowledge transfer through extension services to farmers. Capacity building of extension services should be strengthened to meet adaptation demands.

6.4. Crops production analysis linked to climate change in agriculture

6.4.1. Analysis of meteorological data availability and accessibility

In Serbia, the Republic Hydrometeorological Institute of Serbia (RHMZ) is responsible for climate monitoring. The number of active meteorological stations is rapidly reducing, for example, in the period 2011-2018 the number of active meteorological stations went down from about 100 to about 65, measurements of precipitation from 550 to about 250, and significant reduction happened also in number of phenological and agrometeorological observations. According to RHMZ annual report on measurements, 56 meteorological stations were active in 2022, 29 of which with hourly observations and data in the international exchange system. Three stations had shorter period of observations than 20 years. It is notable that that all stations, with the exception of the main stations, do not necessarily have full data sets for all years in the past. Forecast capacities are also reduced, because of old computer equipment.

For both reasons, the Programme highlights the need to strengthen technical capacities to enable proper monitoring and improved forecast systems. For the purpose of zoning in agriculture, spatial interpolation was done with a 1 km resolution of daily data, using all available data, but those datasets are not available for other use. RHMZ participated in a project related to the development of spatially interpolated data with neighbouring economies (http://www.carpatclim-eu.org/), but the latest data are for 2010. For the V&R assessment, and the Digital Climate Atlas of Serbia, because of these gaps in data availability for national level assessments, EOBS database (https://www.ecad.eu/download/ensembles/download.php), which regularly updates data, and station data sent to international exchange are used. To enable better assessments in the future, it is planned in the Programme to develop portal with spatially interpolated climate monitoring with downloadable data.

Digital Climate Atlas of Serbia (atlas-klime.eko.gov.rs) was developed for the Republic of Serbia, which enables a wide range of users to use climate data, with the possibility to download images, graphs and data. Data are available from the national to the local level. In addition to standard climate indices, it includes over 20 different indices with possible use in different sectors. If needed, the portal can be updated with other relevant indices. Data encompass observed and future climate data.

6.4.2. Analysis of the most common agrometeorological indices available and used in the national context

For climate change analysis, SPEI6a (Standardized Precipitation Evapotranspiration Index for 6months, ending with August) values are used as drought indicators, but different indices are used for vulnerability and risk assessments, depending on the needs of crops in different phenophases. Phenophase occurrences are determined with thresholds of consecutive daily temperatures above some value, and using GDD values. Other indices used include average annual temperature, average growing season temperature, growing season start and duration, frost free period duration, frequency of hot days (above 35°C), frequency of frost in the growing season, frequency of days with extremely low temperatures, indices proposed by OIV for viticulture (Winkler, Huglin, etc.), etc.

6.4.3. Analysis of phenological monitoring

Phenological observations are performed as part of RHMZ and agricultural advisory services' activities , but databases are not integrated and easily accessible. The quantity and quality of these data is unknown. One of the actions in the Climate Change Adaptation Programme of the Republic of Serbia for the period 2023-2030 (draft), is to revise and integrate such observations, if possible. Phenological observations could be available if they are systematically collected from the producers that have such records, and from the academia.

6.4.4. Analysis of crop models used for estimating crop response to climate change

Crop models have not been used for national-level assessments, but rather they have been used in the past to prove sensitivities of production under specific conditions. Use of crop models is avoided because of the inability to properly use them without significantly more input data and calibration. After learning about the sensitivities, codes were developed for the latest V&R assessments, with newly defined indices specific to varieties. Regarding crop models, for example, AquaCrop was used for the assessment of irrigation needs in some locations (Stričević et al., 2019; Stričević et al., 2021), DSSAT (Jancic Tovjanin et al., 2015).

6.4.5. Analysis of extreme weather events

Drought most probably causes largest impacts in agriculture, compared to other climate hazards (Đurđević, 2020). In only two years, 2012 and 2017, with more severe drought in Serbia, loss in agriculture is assessed to be 3.5 billion USD. Also, the producers confirmed that the largest threat is drought, followed by high temperatures, hail, etc. (Stručević et al., 2019, 2020; Vuković Vimić et al. 2022). Frequency of extreme events is shown in the Annex 6.2, along with other information on climate change (performed using IPCC AR6 2021 methodology, 2022). The impact assessment of extreme events on agriculture on the national level is not performed. There is a database on damages (DesInventar) from which such data could be extracted, but the tool is under development. Nevertheless, data on impacts on agriculture are not systematically collected (not all damages and losses were recorded). From experience, literature, media, it is known that, besides floods, high precipitation and hail, increased frequency of frost during the growing season and high summer temperatures (perennial crops), increasing water deficit combined with high temperatures (annual crops) have the highest impacts. Water deficit in growing perennial crops has also been common in the past climate, and fruit growing regions are usually equipped with irrigation systems.

In addition to extreme events, impacts on crop production are also caused by changes in general climate characteristics, average temperature increase, changes in the annual distribution of precipitation and distribution by intensity, increase in the level of aridity of climate characteristics (impacted mostly by the increase of temperature, and the consequence of higher evapotranspiration rates). It is not possible to obtain a list of extreme events in the past period, because there are too many different cases, some had at the scale of national and broader domain, and some very local. Analysis of extreme weather events is provided by their frequency at the national level within the climate periods and can be extracted on the level of municipality or on local level from the Digital Climate Atlas.

6.4.6. Information on the most important crops sensitive to climate change, vulnerable regions and their combination

In the National Communications of the Republic of Serbia, vulnerability of agriculture (mostly plant production) to climate change has been analyzed over a decade, and regularly updated with new methodologies and knowledge (MZZS, 2010; MZZS, 2017; Stričević et al., 2019). A new vulnerability and risk assessment has been done for the Climate Change Adaptation Programme of the Republic of Serbia (detailed results are presented in the Programme, which is waiting for adoption by the Government). Examples of such analysis are given in Annex 6.2. Observed changes in extreme weather indices related to fruit production can be found in Vujadinović Mandić et al. (2022).

In fruit production, V&R is done for almond, apricot, peach, strawberry, currant, walnut, plum, sour cherry, cherry, raspberry, blackberry, apple, pear, quince, and blueberry (for these types of production, zoning of areas favourable for growing is performed). Vine growing is also considered as important, even though vineyards do not occupy large surfaces. For annual crops, the following types of production are common: maize, sunflower, winter wheat, soy, and sugar beet.

Total UAA in Serbia is 3,475,894 ha. Areas under maize production are the most represented in Serbia, with 900,048 ha. Approximately 640,000 ha is under wheat production, 239,794 ha under sunflower, 196,902 ha under soy, and 44,898 ha under sugar beet. Around 182,923 ha is under fruit production, and 20,466 ha under vineyards. In fruit production, plum is cultivated on 72,116 ha, raspberry on 26,360 ha, apples on 25,281 ha, sour cherry on 18,956 ha, etc. Approximately 84% of used agricultural areas is under family ownership. Data are from 2017 and 2018.

Average yield (t per ha) for the period 2018-2022 for selected types of production is the following:

- Annual crops: maize 6.7 t/ha, wheat 4.9 t/ha, sunflower 3 t/ha, soy 2.7 t/ha, sugar beet 51.3 t/ha
- Perennial crops: plum 6.8 t/ha, raspberry 5.4 t/ha, apples 18.5 t/ha, sour cherry 4.1 t/ha, grape 7.9 t/ha

Currently, the most sensitive to climate change conditions is maize (hybrids with late longer growing season), under increasing risk are sunflower and soy, whereas for sugar beet adaptive capacities are higher (the majority of production is owned by legal entities), so this production is less sensitive except for the fact that sugar beet is very sensitive to the current climate change conditions. In fruit production, early varieties are the most sensitive to frost during the growing season, and late varieties to extreme summer heat. Fruit production requires irrigation in general. Both viticulture and fruit growing are very much affected by increasing damages from hail.

An analysis has not been done for specific types of cropping systems, in relation to whether they are traditional or indigenous, except for some vine varieties (Prokupac, Smederevka, etc.).

In plant production, vulnerability and risk assessment include assessment of climate change in areas which can sustain growing of different crops and changes of identified climate risks, meaning that climate hazards have been specifically defined in agricultural production. Assessments have been done for the entire area of Serbia, resolution of approximately 10 km, and summarized with identified risk level to administrative regions (25 administrative regions). Methodologies, i.e. criteria for risk assessment differ among types of crop production. A summary of identified impacts and consequences is provided in Annex 6.3.

Water deficit in fruit growing has been a long-term problem in Serbia, and irrigation systems are commonly present. In annual crop production the risk of water deficit is high, especially for maize. Taking into consideration the distribution of all types of production and meteorological data, the

largest requirements for water (irrigation) overall are in Vojvodina, and south of Sava and Danube in the following administrative regions: Braničevski, Zaječarski, *Šumadijski*, etc. Average requirements for water for irrigation in case similar distribution of production remains, will increase by 18% under climate change in the period 2041-2060, compared to the end of 20th century. In case of RCP8.5, at the end of the century requirements will increase by 44-48%.

Risk of hail (significant for fruit growing and viticulture) is rapidly increasing (currently it is high in central and western Serbia, and will spread by mid-century over major part of Serbia). Frost risk in growing season tends to increase because of the increasing frequency of heat waves in the colder part of the year, which triggers early growing season start, and affects the most almond and apricot (in all areas), followed by peach, strawberry, currant, walnut (in regions south of Danube and Sava). Risk of extreme temperatures is high for pear, apple, quince, raspberry, and blackberry. Lower, but increasing risk, coming from longer periods with high risk of extreme temperatures, is for plum, sour cherry and cherry.

6.4.7. Information on practices used by the farmers to protect their crops from damages caused by weather variability (hot weather, drought, excessive water, hail, intensive sun etc.)

Selection of hybrids (in maize production shift to FAO groups with earlier ripening), selection of varieties (late varieties to avoid frost risk and ones more resistant to drought), implementation of different agrotechnical measures according to weather conditions in the upcoming period (season). Use of nets for hail protection and protection from sunburns. Implementation of irrigation. There are many practices implemented, also using timely information provided by advisory services.

There is no systematic monitoring of implemented practises and their performance. Data could be collected from academic work.

On the other hand, climate change causes change in weather variability and extremes, which are beyond the current experience and require rapid increase in the knowledge of advisory services and farmers.

6.4.8. Information on climate change adaptation measures and practices already tested/promoted in the economy or established in national documents related to climate change and agriculture

Measures planned for adaptation to climate change in agriculture, at the national level, are provided in the Climate Change Adaptation Programme for 2023-2030, with Action Plan for 2024-2026 (waiting for adoption by the Government). This document includes vulnerability and risk assessments for different sectors, which are done in most detail for agriculture, including recommendations for the implementation of adaptation measures at the national level. Recommendations are provided in Annex 6.2 are given, and the measures presented below have been selected as priority and relevant for adaptation of crop production.

Protection of perennial crops from extreme weather – increasing investments from the national budget in subsidies for anti-hail and shading nets, and for anti-frost systems.

Optimization of irrigation according to needs and resources – development of studies on the potential to use atmospheric water for irrigation, including micro-irrigation ponds, and study on the potential to use water from existing large irrigation ponds in case of rehabilitation of related irrigation systems.

Build capacities and raise knowledge on adaptation of agricultural production to climate change – development of manuals for adaptation in fruit production, viticulture, annual crops production, and

their introduction in education for the certification of advisors within the system of Agricultural Advisory Services of Serbia, development and implementation of methodology for zoning of production under climate change conditions.

Improvements of agrometeorological services in order to provide on-time and necessary information required for increasing the resilience of agricultural production to climate change – increase of measurement stations, development of operational new and adjusted forecast products and their efficient dissemination.

In addition to the listed measures, where agriculture is identified as priority beneficiary, there are also other measures with benefits for crop production.

- Establishment of the system for monitoring climate change, impacts, implementation of adaptation measures and their success – building a portal with high-resolution interpolated observed data, regularly updated; development of methodology for monitoring damages and losses caused by climate change and monitoring system implementation; building a reporting system on the implementation of adaptation measures.
- Improvement of the national methodology for disaster risk assessment, including information on climate change.
- Development of methodology for monitoring drought as a multidimensional hazard.
- Building capacities to enable fulfilling increasing demands for timely information dissemination on weather extremes and climate change – building capacities of the Republic Hydrometeorological Institute of Serbia.
- Increase citizens' preparedness for weather and climate extremes – improve forecasts of different scales, improve tools for information dissemination.
- Solve regulatory issues in land use – identify unused and degraded agricultural land and determine options to implement sustainable land management.

Specific measures for adaptation of crop production, which provide knowledge to producers on how and when to act to reduce damage, are specific to location, type of production, and depend on producers' capacities and development of new information. Such measures (and guidelines) will be included in educational materials, manuals, and will be regularly updated. Effective knowledge sharing, by priority, will be implemented through agricultural advisory services.

Currently, national agricultural policy explicitly related to adaptation to climate change is regulated through the Adaptation Programme (above-listed measures). This document considers measures that will systematically include climate change adaptation through national policy documents. There are measures already implemented by the Ministry of Agriculture, Forestry and Water Management, which can be linked to support for combating climate change, but the measures are designed to implement actions which consider already existing problems (also in past climate conditions), not considering future needs caused by climate change. Such measures are, for example, subsidies for different equipment, education, etc. For this reason, systematic implementation of climate change would reshape investments in measures, and tailor measures according to the needs imposed by climate change.

6.4.9. Brief analysis of the current infrastructure and systems for preventing and mitigating the negative effects of weather extremes on crop production

The Republic Hydrometeorological Institute of Serbia (RHMZ) issues short-term and seasonal forecast, which is used by the agricultural advisory services (https://www.psss.rs/), which operate at the level

of municipality and issue advisories according to the forecast (dissemination also through social media). RHMZ also performs monitoring for agriculture and issues bulletins for agriculture, drought monitoring of (using SPI), etc. (https://www.hidmet.gov.rs/ciril/meteorologija/agro.php). RHMZ also issues special warnings for upcoming extremes. Under the Adaptation Programme, the plan is to invest in upgrading RHMZ technical capacities to improve monitoring, forecasting and dissemination of information, as well as to provide special forecast products for different sectors. Current capacities cannot meet the needs for disaster risk reduction and adaptation. Analysis of the use of seasonal forecast in agriculture is done under the project Integrated Agrometeorological Prediction System (Vuković Vimić et al. 2022).

6.4.10. Existing data availability and quality, data constraints and data gaps

Meteorological data are explained above. Regarding phenological data, they are not publicly available, monitoring is performed by RHMZ and by agricultural advisory services. One of the activities in Adaptation Programme is to perform a revision of those databases, to check reliability and availability of phenological data and to find a way to integrate existing databases. Systematic monitoring of pests and diseases is recommended in the Adaptation Programme, but actions for its implementation are not explicitly planned through this programme, so they could be implemented through other strategic documents and provide input for further improvement of knowledge on vulnerability to climate change.

6.4.11. Conclusions with key recommendations and priorities referring to crop production and adaptation to climate change

Measures are already listed in above derived from the Draft Climate Change Adaptation Programme of the Republic of Serbia for the period 2023-2030 with Action Plan for the period 2024-2026. The Programme implements the key principles of EU Adaptation Strategy: adaptation should be smart (based on science), systematic (introduced through policy documents) and fast (immediate investments in most urgent needs for damage reduction).

It is recommended for the region (group of economies) to develop common methodology for zoning of suitable areas for growing different crops (at least for climate conditions), including mapping of risk level (it has been done in Serbia for fruit growing and viticulture, and has enabled large improvements in the methodology for vulnerability and risk assessment). Methodology for zoning only exists for viticulture, according to OIV methodology (International Organization of Vine and Wine, 2012), but it does not include dynamics of change of climatic conditions. Large gaps in knowledge exist for zoning of fruit growing areas, and especially for annual crops.

In adaptation planning in agriculture, it is highly recommended to use the nexus approach with water resources and soil (climate-water-soil nexus), to avoid maladaptation. In this sense, V&R assessment and adaptation planning should be done if impacts on all components are known. For Serbia, in addition to the analysis of climate change impact on water availability (study performed for the needs of the Third National Communication and Adaptation Programme), also an assessment of climate change impact on soil degradation is performed (Životić and Vuković Vimić, 2022). According to recommendations of the EU Adaptation Strategy, the concept on Nature-based Solutions should also be implemented in adaptation planning where possible, because of the sustainability of such solutions (Vuković Vimić et al., 2021).

6.5. Livestock farming analysis linked to climate change in agriculture

6.5.1. Overview of livestock farming in Serbia

Livestock farming is the cornerstone of agricultural production in Serbia and accounts for over 40% of its total value (Popović, 2014). Cattle, pig and poultry production are of central importance in the sector, while sheep and goat production play a somewhat lesser role.

Cattle production is at the top of the Serbian livestock sector and accounts for around 40% of its value (Popović, 2014). This branch has a long tradition and is based on small- and medium-size family farms, although the number of larger farms is increasing, especially in agriculturally intensive areas. The landscape of cattle production systems covers a broad spectrum, ranging from extensive systems on small farms to semi-intensive systems on medium-size farms and highly intensive systems on large farms. The Serbian cattle herd consists predominantly of the Simmental breed and Simmental-type cattle, which account for 75 to 80% of the total cattle herd. Holstein-Friesian (together with European black and white cattle) makes up about 15%, while the remaining 10% includes beef and local breeds as well as various industrial crossbreeds (Bogdanović, 2014, Bogdanović et al., 2014).

The pig production segment accounts for about 17.2% of total livestock farming. Within the Serbian meat industry, pig farming is the most important, with a share of over 55% in the meat sector. White breeds, particularly Large White and various landrace breeds, dominate the Serbian swine industry, while Duroc, Hampshire and Pietren are the most prominent terminal breeds. On the other hand, local breeds such as Moravka and Resavka are endangered or threatened with extinction, while the Mangulitza breed has a relatively stable status. Intensive and semi-intensive production systems predominate in pig farming, although there are also semi-extensive systems, especially on smaller family farms.

Poultry farming, which includes broiler and egg production, accounts for 11.8% of the total value of livestock farming. It is the most industrialized branch not only of animal husbandry, but of agriculture as a whole. Intensive production relies almost exclusively on imported line hybrids combined with advanced rearing techniques, typically characterized by closed systems, a high concentration of animals per unit area, complete feed mixtures and the adoption of intensive know-how systems from foreign companies. On the other hand, family farms that do not focus primarily on poultry farming exhibit a range of production intensities, from extensive rearing of small numbers of poultry to semi-intensive methods where poultry farming serves as a side business.

Sheep farming is widespread in the hilly and mountainous regions of Serbia, with extensive, semi-extensive and semi-intensive production systems predominating. The majority of sheep farms, over 95%, are small- and medium-sized. The autochthonous Pramenka (or Zackel) breed, which includes various Pramenka strains, is the predominant breed in Serbia and accounts for around 80% of the sheep population. In Vojvodina, Cigaja (or Tzigai) breed is also represented in larger numbers. Among the exotic breeds, Merino Landschaf (or Wuerttemberger) and various, mainly industrial crosses predominate. The Il-de-France, Texel and Suffolk breeds are also represented, but in much smaller numbers than the Wuerttemberger.

In contrast to sheep farming, goat keeping in Serbia is far less common, although natural conditions are favourable for this type of livestock farming. Goat farming in Serbia is mainly organized in small farms, where extensive and semi-extensive production systems prevail. However, an increasing number of

new farms are emerging, employing intensive production systems and exotic breeds. Among the native breeds, the Balkan and Serbian White goats are the most common, including various crosses, while among the exotic breeds, the Alpine and Saanen breeds are the most numerous.

6.5.2. Analysis of meteorological data availability and accessibility

The Republic Hydrometeorological Institute of Serbia (RHMZ) (www.hidmet.gov.rs) is the main source of meteorological data in Serbia. This organization serves as the authority for creating and sharing weather and water forecasts, and issuing alerts for severe meteorological and hydrological events. Through a network of 25 meteorological stations and 3 observatories, key meteorological factors such as air temperature, humidity and pressure, wind speed and other parameters are continuously monitored.

RHMZ provides publicly available data within its domain; however, the practical use of this data remains considerably limited. Some of the meteorological information collected is made available to the public in the form of yearbooks, which are published on RHMZ website in the middle of the following year and cover the previous calendar year (www.hidmet.gov.rs/latin/meteorologija/klimatologija_godisnjaci.php). These yearbooks contain daily meteorological observations for the six most important (synoptic) stations and average monthly observations for other stations in the network. However, these yearbooks lack data from precipitation stations; they only contain data from the main and ordinary weather stations. Data in the yearbooks are presented in tabular form, but the entire document is in PDF format, making it challenging to automate data download. Scanned yearbooks are the only option for the period from 1949 to 1991, and the visibility of data is remarkably poor, making practical use even more difficult. The daily observed data is stored in RHMZ internal database, which can be accessed at a fee (https://adaptacije.klimatskepromene.rs/wp-content/uploads/2022/10/NAP_Report-1_Analiza-dostpunosti_za-sajt_21.09.2022-1.pdf).

In addition to the meteorological and climatological observations, agrometeorological and phenological observations are also carried out at some stations. The historical phenological data are partly digitized and are located in the RHMZ internal database, which is not publicly available. There are also several publicly available databases with daily meteorological observations (E-OBS, DanubeClim, CarpathClim), which generally have a resolution of about 10 km, but only E-OBS database is regularly updated (https://adaptacije.klimatskepromene.rs/wp-content/uploads/2022/10/NAP_Report-1_Analiza-dostpunosti_za-sajt_21.09.2022-1.pdf).

6.5.3. Analysis of extreme weather events

The frequency of extreme weather events has increased in Serbia in recent years. Compared to the period between 1961 and 1990, temperatures in Serbia have risen by more than 1°C. The rise in temperature, in combination with other factors, has contributed to an increase in extreme weather events, which have caused considerable damage in Serbia over the last two decades, amounting to several billion EUR (https://klima101.rs/ekstremni-vremenski-dogadjaji-srbija/).

The Republic Hydrometeorological Institute of Serbia (RHMZ) maintains a catalogue of early announcements and records of extreme climatic events and anomalies. Since 2016, they have been publicly accessible in the form of a weekly Bulletin for Early Warning of Extreme Climatic Events and Anomalies. The Bulletin aims to inform the public about the likelihood and severity of impending climatic events, facilitating the implementation of mitigation plans and minimizing the consequences of hazardous events. Structured in PDF format, the bulletin provides weather and hydrological forecasts for the upcoming week but does not provide information on extreme weather events that occurred in the previous week (https://www.hidmet.gov.rs/latin/meteorologija/klimatologija_produkti.php).

Reliable data on the number of livestock farms affected by extreme weather events or anomalies is currently unavailable. These data are not even gathered by breeders' associations. Consequently, information regarding the impact of extreme weather events on livestock farms and/or livestock farming can only be obtained through direct contact with farmers.

6.5.4. Heat stress risk assessment for ruminants, pigs and poultry

To assess the degree of heat stress on domestic animals, mathematically derived indicators are used, the most commonly used of which is the Thermal-Humidity Index (THI). Most THI formulas are calculated based on two factors: temperature and relative humidity. The emphasis on these two factors stems from the fact that it is important that both variables are easily measurable or publicly available through various weather services.

The Republic Hydrometeorological Institute of Serbia (RHMZ) currently lacks a systematic approach to recording THI to evaluate heat stress risks or develop heat stress mitigation measures for domestic animals. Although RHMZ conducts agrometeorological and phenological observations, it does not make these data publicly available. Instead, RHMZ periodically releases agrometeorological bulletins, overviews, and analyses, including a seven-day agrometeorological bulletin, a ten-day agrometeorological overview, a monthly agrometeorological information (bulletin) for the previous month, and an annual agrometeorological analysis for the previous production year. However, these publications, all in PDF format, primarily analyze the conditions affecting the growth and development or winter dormancy of major agricultural crops, rather than aspects relevant to livestock farming.

Official data regarding microclimates in farms housing ruminants, pigs or poultry are notably absent in Serbia. However, steps have been made to address this issue, particularly concerning milk production, through the implementation of an R&D project, titled Optimization of Technological Procedures and Zootechnical Resources on Farms to Enhance the Sustainability of Milk Production. This research has been carried out since 2014 by the Faculty of Agriculture in Belgrade. The project focuses on monitoring and recording temperature and relative humidity on 12 representative dairy farms across six administrative districts in Serbia – Mačvanski, Šumadijski, Dunavski, Moravski, Banatski, and Bački.

The selected dairy farms reflect typical family farms in Serbia, which vary in size. Despite the project's completion in 2019, the monitoring and recording of microclimatic parameters on these farms continues to date. The database is not publicly accessible and is used internally either for scientific and research work (e.g. Bogdanović et al., 2016; Bogdanović et al., 2015; Mićić et al., 2022) or for the education and training of farmers. Preliminary analyses show a loss of around 18 million kilograms of milk due to heat stress during the study period, resulting in direct production losses of more than 5 million EUR, not including indirect losses due to deterioration in animal health or impaired reproduction.

Climate change not only influences the frequency of heat stress, but also the spread of atypical animal diseases. As a result of climate change, temperate regions are becoming increasingly suitable for the survival of vectors and reservoirs of atypical diseases, facilitating the spread of numerous tropical diseases. Through numerous complex interactions with hosts, vectors and the environment, climate change has facilitated the spread of pathogens and the occurrence of atypical diseases in domestic animals in Serbia, such as bluetongue, lumpy skin disease, African swine fever, or West Nile Disease. The Ministry of Agriculture, Forestry and Water Management periodically issues instructions for monitoring various atypical diseases of domestic animals, such as West Nile Disease.

6.5.5. Overview of farmers' existing adaptive practices for mitigating impacts of climate change

Farmers acquire the knowledge about the impact of heat stress on livestock primarily through interactions with advisors from the Agricultural Advisory and Expert Service of Serbia (PSSS) (www.psss.rs). These interactions usually include direct on-farm consultations or professional training and education. In addition, PSSS advisors occasionally publish short technical articles on heat stress in diverse livestock species in the PSSS Professional Bulletin (PSSS Vranje, 2019; PSSS Jagodina, 2020; PSSS Kragujevac, 2021). Farmers can also receive important information on how to avoid heat stress through trainings organized by breeding organizations, agricultural colleges and faculties. Finally, fostering horizontal links among farmers and promoting exchange of experiences play a crucial role in disseminating knowledge about heat stress management.

On cattle farms, particularly dairy farms, farmers strive to prevent or mitigate heat stress by implementing various measures. While biological adaptation strategies remain underutilized, technological optimization measures are widely adopted. These include adjustments in feeding practices, adequate access to fresh water, regulating temperature and humidity in barns, utilizing THI monitoring applications, ventilating, cooling, and aerating barns, thermally insulating roofs, providing natural shading for barns, directly cooling animals through spraying or watering, minimizing animal relocation or transport, and implementing insect control measures. Notably, larger and medium-sized farms adopt varied strategies compared to smaller farms with lower production capacities, which often implement simpler or no measures at all to mitigate heat stress.

Biological adaptation strategies to mitigate heat stress in cattle, such as modifying breeding programmes for the selection of heat-resistant traits, utilizing sires with favourable breeding value estimates for heat stress tolerance, implementing genomic selection, or keeping heat-tolerant breeds (e.g. Jersey), are not yet widely accepted. The use of sires with positive breeding value estimates for heat stress tolerance is exceptionally rare and primarily limited to large-scale farms.

To prevent the occurrence of heat stress during the summer months in sheep, farmers usually keep sheep outdoors, providing shade and adequate amounts of fresh water. On medium-size and especially large-size goat farms, measures similar to those used for dairy cows are applied.

The approach to reducing heat stress on pig farms depends on farm size. Larger farms implement diverse measures, from adapting buildings to high outside temperatures (e.g. installing water walls) to roof cooling systems and changing feeding practices. Medium-sized farms use simpler methods (e.g. ventilation buildings or adapting feeding practices), while smaller farms use the simplest measures such as natural ventilation or feeding corrections.

The most common measures to prevent or alleviate heat stress in poultry include determining the optimal population density in the poultry house, using appropriate fans or cooling systems, providing an adequate amount of fresh water with electrolyte supplementation, adjusting the feeding time to the times of day (early morning or evening), while reducing the amount of protein and increasing the energy content, painting outer walls in lighter colours, and pouring cold water during peak heat periods.

It should be noted that there is still room for improvement in the application of artificial intelligence and IT solutions as well as in biological adaptation to prevent or mitigate the occurrence of heat stress at farm level. However, the limits to greater use of modern IT solutions at farm level lie in the unsatisfactory education and age structure of farmers.

6.5.6. Summary of national strategies and adaptation plans in the livestock sector, including reports, R&D, projects and communications of the international CC (adaptation) framework (UNFCCC)

In Serbia, there are several strategic documents that deal with the effects of climate change on the livestock sector. One of the fundamental documents is the Climate Change Adaptation Programme for the period 2023-2030 with Action Plan. This Programme outlines the key characteristics of the impact of climate change on livestock farming and the necessary measures to ensure sustainable livestock farming. Two other relevant documents are the Strategy on Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 and the Low Carbon Development of the Republic of Serbia for the period 2023-2030 with projections until 2050.

On the other hand, the implementation of specific projects has led to the creation of numerous documents, primarily reports that provide in-depth analyses of the impact of climate change on livestock farming. The comprehensive analysis relies on three reports developed during the implementation of the project Advancing Medium and Long-Term Adaptation Planning in the Republic of Serbia, funded by the Green Climate Fund (GCF) and implemented by the United Nations Development Programme (UNDP) in collaboration with the Ministry of Agriculture, Forestry and Water Management. All reports are available at https://adaptacije.klimatskepromene.rs/, including: (1) Report on the impact of climate change on the agriculture sector, with proposed adaptation measures, Activity 1: Risk and vulnerability assessment – observed occurrences, impacts and levels of affectedness within; (2) Report on the impact of climate change on the agriculture sector, with proposed adaptation measures, Activity 2: Assessing the impact of climate change on the agricultural sector in the future and (3) Report on the impact of climate change on the agriculture sector, with proposed adaptation measures, Activity 3: Proposed adaptation measures.

6.5.7. Overview of the political and institutional setup, and legislative framework for adaptation activities relevant to the sector

The Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia is responsible for developing strategies and policies for agricultural development, as well as managing agricultural resources such as land, water and forests. The Ministry has formed a Group for Monitoring the Impact of Climate Change on the Agricultural Sector to coordinate activities related to adaptation and mitigation to climate change. Additionally, the Minister of Agriculture, Forestry and Water Management, who is responsible for the sectors most affected by climate change (agriculture, forestry, and water management), has been appointed as the national focal point (NFP) for cooperation with the Green Climate Fund.

The Law on Climate Change ("Official Gazette of the Republic of Serbia, No. 26/2021) is the primary legislation that regulates Serbia's national policy on climate change. However, this Law uses the term "agriculture" only in two places, while "livestock" or "animal husbandry" is not mentioned at all. While the Law on Climate Change directly addresses the impact of climate change on various sectors, the Strategy on Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 also recognizes the threat of climate change to food production. In addition, climate change issues are also addressed in the documentation of the IPARD Programme, which describes adaptation measures both for individual producers/farms and for the agricultural sector as a whole.

Finally, within the context of harmonizing regulations with the new Common Agricultural Policy of the European Union, the draft version of the National Programme on Agriculture for the period 2022-2024 (www.minpolj.gov.rs/nacionalni-program-za-poljoprivredu-za-period-2022-2024-godine/?script=lat) addresses the interconnectedness between climate change and agricultural production, and this issue is specifically discussed in the section concerning regulation harmonization.

Agricultural Advisory and Expert Services (PSSS) or the Agricultural Extension Service, operating under the auspices of the Ministry of Agriculture, Forestry and Water Management and the Provincial Secretariat for Agriculture, Forestry and Water Management, constitute a network of institutions dedicated to transferring knowledge to farmers, encompassing areas such as good agricultural practices and environmental protection. However, this Extension Service is not yet fully prepared to provide services specifically tailored to implementing agricultural practices to prevent or mitigate the effects of climate change on livestock farming. On the other hand, leading higher education institutions in the field of agriculture, namely the agricultural faculties in Belgrade and Novi Sad, have updated their curricula across all educational levels and enriched them with content on climate change and sustainable use of agricultural resources. In addition, academic staff is actively involved in the knowledge transfer system through cooperation with PSSS and participation in training projects for advisors.

6.5.8. Data availability and quality, data constraints and data gaps

Current databases and historical records of local weather disasters and other climate-related risks lack adequate organization and standardization. These data are not consolidated into unified databases, hindering the extraction of essential indicators for valid and data-driven decision making. Although meteorological data are publicly available, they are in a format that is not suitable for direct analysis, making additional analysis difficult and sometimes even impossible. This data accessibility issue poses an increasingly grave threat, demanding prompt attention as the impacts of climate change, particularly extreme weather events and anomalies, are anticipated to intensify in the coming years. It is imperative that forthcoming sectoral documents use reliable data regarding climate change impacts and anticipated alterations in both the broader agricultural sector and specific branches of agricultural production, such as livestock farming. Therefore, the adequate public availability of these data is of paramount importance for effective decision making and policy formulation.

6.5.9. Conclusions with key recommendations and priorities in livestock adaptation to climate change

Despite the livestock sector's strong dependence on weather conditions in Serbia, there is scarcity of scientific data on the impact of climate change and extreme weather events on livestock farming and economic outcomes. Even less information is available for specific farm types, production types, regions, and products. Monitoring the impact of climate change on the livestock sector in the future requires a holistic approach that considers both monitoring direct effects of microclimatic changes within animal housing facilities and monitoring indirect effects on feed production and quality, including monitoring of animal health, reproduction and welfare. This requires a systematic approach through the first two pillars of agricultural support, i.e., market price support measures, direct production support measures, and structural and rural development measures, including capacity-building programmes for livestock breeders through various types of training and education.

Correcting and adapting livestock breeding programmes is also crucial, as selecting for heat stress tolerance in livestock and enhanced production efficiency stands as one of the primary biological adaptation measures. Resources required for this measure are already in place, as subsidies are provided for acquiring high-quality breeding animals for all types of domestic livestock.

Agricultural extension services, in collaboration with scientific institutions, are a key player in disseminating knowledge and information on climate change and adaptation measures to farmers and livestock producers. However, their capacities to fulfil this role are relatively limited, considering both available staff and limited technical capabilities. Therefore, there is need to strengthen the agricultural extension service so that it can respond to the growing challenges of climate change.

Finally, swiftly adopting practical actions and guidelines for applying technological optimization and biological adaptation measures to cope with climate change in the livestock sector is essential. The future economic and zootechnical sustainability of livestock farming hinges significantly on the sector's resilience and ability to withstand the challenges posed by climate change. Unless the livestock sector adapts to climate change, long-term sustainability of the entire sector remains questionable.

6.6. References

Bogdanović, V. (2014). Stanje i mogućnosti optimizacije primarne proizvodnje mleka u Srbiji: farmske i zootehničke karakteristike. U monografiji: „Optimizacija tehnoloških postupaka i zootehničkih resursa na farmama u cilju unapređenja održivosti proizvodnje mleka", urednik V. Bogdanović, Univerzitet u Beogradu – Poljoprivredni fakultet, Beograd, 1-26.

Bogdanović, V., Đedović, R. & Stanojević, D. (2015). Variability of temperature-humidity index on simmental dairy farms. Proceedings and Abstract Book of the International Symposium on Animal Science (ISAS) 2015 and 19th International Congress on Biotechnology in Animal Reproduction (ICBAR). 09-11.09.2015. Novi Sad, Serbia, 76-82.

Bogdanović, V., Đedović, R., Perišić, P., Stanojević, D., Topisirović, G., Petrović, D.M. & Mijić, P. (2016). Monthly and daily variation of temperature-humidity index (THI) on dairy cattle farms. Proceedings of the International Symposium on Animal Science 2016 (ISAS). 24-25.11.2016. Belgrade-Zemun, Serbia, 25-31.

Bogdanović, V., Đedović, R., Perišić, P., Stanojević, D., Zarić, V. & Petrović, M., D. (2014). An assessment of efficiency and prospects for the cattle sectors in Serbia. In: Abele Kuipers, Andriy Roztalnyy and Gerry Keane (Eds.), Cattle husbandry in Eastern Europe and China: Structure, development paths and optimization. (pp. 201-211). EAAP Scientific Series, Wageningen Academic Publishers, The Netherlands.

Digital Climate Atlas of Serbia. https://atlas-klime.eko.gov.rs/

Draft Spatial Plan of the Republic of Serbia for the period 2021-2035. accessed September 20, 2023. https://www.mgsi.gov.rs/sites/default/files/PPRS%20Nacrt.pdf

Đurđević, V., (2020) Drought Initiative–Republic of Serbia, UNCCD. Available online: https://www.unccd.int/sites/default/files/ country_profile_documents/NDP_SERBIA_2020.pdf

ESWD, European Severe Storms Laboratory, European Weather Observer, accessed on 13 September 2023 (https://www.eswd.eu/ESWD/).

Farm Structure Survey (FSS) (2018). Statistical Office of the Republic of Serbia.

Geoportal of the Agricultural Land Administration. https://gisportal.gdi.net/portal/apps/sites/#/upravapz

International Organization of Vine and Wine, Guidelines for Vitiviniculture Zoning Methodologies on a Soil and Climate Level, Resolution OVI-VITI 423-2012; International Organization of Vine and Wine: Paris, France, 2012; p. 19.

IPARD III programme for the Republic of Serbia for the period 2021 – 2027 (2022). The Republic of Serbia, Ministry of agriculture, forestry and water management. Available at: http://www. minpolj.gov.rs/download/IPARD-III-Programme-for-the-Republic-of-Serbia-for-the-period2021-2027-CLEAN-21-Jan-2022.pdf

IPCC (2021). Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3–32, doi:10.1017/9781009157896.001.

IPCC (2022). Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, doi:10.1017/9781009325844.001.

Jančić Tovjanin, M., Lalic, B., Mihailovic, D., Jacimovic, G. (2015). Impact of climate change and carbon dioxide fertilization effect on irrigation water demand and yield of soybean in Serbia, The Journal of Agricultural Science 153(8):1-15, doi: 10.1017/S0021859615000179.

JRC, Joint Research Institute (2015) Remediated sites and brownfields. Success stories in Europe; EUR 27530 EN; doi 102788/406096.

Klima 101. Srbija je od 2000. pretrpela preko 7 i po milijardi evra štete od ekstremnih vremenskih događaja (2020). https://klima101.rs/ekstremni-vremenski-dogadjaji-srbija/ [Accessed on 10 September 2023].

Kovačević, V., Brenjo, D., Cvetković S. & Rainović, Lj. (2022). Comparative analysis of foodstuff geographical indications in the Western Balkans, Economics of Agriculture, Vol 69, No. 1, pp. 163-178, DOI: 10.5937/ekoPolj2201163K.

Law on Agriculture and Rural Development (Official Gazette of the Republic of Serbia, No. 41/2009, 10/2013, 101/2016-other law, 101/2016, 67/2021-other law and 114/2021).

Law on Climate Change (Official Gazette of the Republic of Serbia, No. 26/2021). https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/skupstina/zakon/2021/26/1/reg

Law on Disaster Risk Reduction and Emergency Situation Management (Official Gazette of the Republic of Serbia, No. 87/2018). https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/skupstina/zakon/2018/87/1/reg

Low Carbon Development Strategy for the period 2023-2030 with projections until 2050 (Official Gazette of the Republic of Serbia, No. 46/2023).

Low Carbon Development Strategy for the period 2023-2030 with projections until 2050 (Official Gazette of the Republic of Serbia, No. 46/2023). https://www.ekologija.gov.rs/sites/default/files/2023-06/strategija_niskougljenicnog_razvoja.pdf

Mićić, N., Stanojević, D., Samolovac, Lj., Petričević, V., Stojiljković, N., Gantner, V. & Bogdanović, V. (2022). The effect of animal-related and some environmental effects on daily milk production of dairy cows under the heat stress conditions. Mljekarstvo : Journal for Dairy Production and Processing Improvement, 72 (4), 250-260.

Ministry of Agriculture, Forestry and Water Management. (2023). Report on the results of the survey of agricultural producers – potential beneficiaries of Measure 4 of the IPARD III Programme in the Republic of Serbia, Project: Strengthening the Resilience of the Agricultural Sector to Natural Disasters – FAO. Unpublished.

Ministry of Environmental Protection, Draft Climate Changed Adaptation Programme with Action Plan (2023). RADNA VERZIJA_Program prilagodjavanja na izmenjene klimatske uslove_Akcioni plan.pdf (ekologija.gov.rs, accessed on 24 August 2023).

MZŽS (2010). Prvi izveštaj Republike Srbije prema Okvirnoj konvenciji Ujedinjenih nacija o promeni klime, Ministarstvo zaštite životne sredine i prostornog planiranja.

MZŽS (2017). Drugi izveštaj Republike Srbije prema Okvirnoj konvenciji Ujedinjenih nacija o promeni klime, Ministarstvo zaštite životne sredine i prostornog planiranja.

Nature Protection Programme of the Republic of Serbia for the period 2021-2023 (Official Gazette of the Republic of Serbia, No. 53/2021).

NRC. National Research Council (1971). A guide to environmental research on animals. Natl. Acad. Sci., Washington, DC, USA.

Petrović, G., Ivanović, T., Knežević, D., Radosavac, A., Obhođaš, I., Brzaković, T., Golić, Z. & Dragičević Radičević, T. (2023). Assessment of Climate Change Impact on Maize Production in Serbia. Atmosphere, 14(1), p.110.

Popović, R. (2014). Popis poljoprivrede 2012. Poljoprivreda u Republici Srbiji. STOČARSTVO U REPUBLICI SRBIJI. Beograd: Republički zavod za statistiku.

Popović, R. (2014). Popis poljoprivrede 2012. Stočarstvo u Republici Srbiji. Republički zavod za statistiku, Beograd.

Prognostic reporting service of plant protection (https://www.pisvojvodina.com/Preporuke_BD/).

Projekat: "Unapređenje srednjeročnog i dugoročnog planiranja mera prilagođavanja na izmenjene klimatske uslove u Republici Srbiji – NAP" (2019-2022). Izveštaj: „Izveštaj o uticaju klimatskih promena na sektor poljoprivrede, sa predlogom mera adaptacije – Aktivnosti 1, 2 i 3". https://adaptacije.klimatskepromene.rs/wp-content/uploads/2022/03/Poljoprivreda-1.-Procena-rizika-ranjivosti.pdf [Accessed on 18 September 2023], https://adaptacije.klimatskepromene.rs/wp-content/uploads/2022/03/Poljoprivreda-2.-procena-uticaja-klimatskih-promena-u-buducnosti.pdf [Accessed on 18 September 2023], https://adaptacije.klimatskepromene.rs/wp-content/uploads/2022/03/Poljoprivreda-3.-Predlozene-mere-adaptacije.pdf [Accessed on 18 September 2023].

Projekat: "Unapređenje srednjeročnog i dugoročnog planiranja mera prilagođavanja na izmenjene klimatske uslove u Republici Srbiji – NAP" (2019-2022). Izveštaj: „Analiza dostupnosti klimatskih i socio-ekonomskih informacija, uključujući klimatske podatke, podatke o rizicima i procenama pogođenosti i informacije o merama adapatacije". https://adaptacije.klimatskepromene.rs/wp-content/uploads/2022/10/NAP_Report-1_Analiza-dostpunosti_za-sajt_21.09.2022-1.pdf [Accessed on 18 September 2023].

Projekat: "Unapređenje srednjeročnog i dugoročnog planiranja mera prilagođavanja na izmenjene klimatske uslove u Republici Srbiji – NAP" (2019-2022). Izveštaj: „Izveštaj o kapacitetima i potrebama jačanja kapaciteta na nacionalnom i nivou lokaalnih samouprava za adaptaciju na izmenjene klimatske uslove". https://adaptacije.klimatskepromene.rs/wp-content/uploads/2021/04/Institucionalni-kapaciteti-za-CCA-1.pdf [Accessed on 18 September 2023].

Projekat: "Unapređenje srednjeročnog i dugoročnog planiranja mera prilagođavanja na izmenjene klimatske uslove u Republici Srbiji – NAP" (2019-2022). Izveštaj: „Pregled i procena postojeće politike, regulatornog i institucionalnog okvira za prilagođavanje klimatskim promenama sa preporukama za razvoj i unapređenje posebne politike i

regulatornog okvira". https://adaptacije.klimatskepromene.rs/wp-content/uploads/2021/04/Postojeca-politika-regulatorni-i-institucionalni-okvir-1.pdf [Accessed on 18 September 2023].

PSSS Jagodina. Bilten Jul 2020. (2020). https://www.psss.rs/download/psss-jagodina-bilten-jul-2020/ [Accessed on 28 August 2023].

PSSS Kragujevac. Bilten 3 2021. (2021). https://www.psss.rs/download/psss-kragujevac-bilten-3-2021/) [Accessed on 28 August 2023].

PSSS Vranje. Bilten Jun 2019. (2019). https://www.psss.rs/download/psss-vranje-bilten-jun-2019/ [Accessed on 28 August 2023].

Puskarić, A., Potrebić, V., & Jeločnik, M. (2010). Condition of crop farming and vegetable production in Republic of Serbia and impacts of global climate changes on its future development. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.10(1). https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=c52a6f22fc4f0e7c4087fc8bd02367a098487b4b#page=177 [Accessed on 3 August 2023].

Regional Rural Development Standing Working Group – SWG (2020). Food Quality Policy: Schemes of Geographical Indications and Traditional Specialities in Southeast Europe. Retrieved from: seerural.org/wpcontent/uploads/2020/09/Food-Quality-Policy-Assessment.pdf

Pravilnik o kodeksu dobre poljoprivredne prakse (Official Gazette of the Republic of Serbia, No. 23/2023).

SEPA (2022). State of the Environment Report in the Republic of Serbia for 2021. Ministry of Environmental Protection, Environment Protection Agency. http://www.sepa.gov.rs/download/IZVESTAJ_2021.pdf

Serbia Floods (2014). The Recovery Needs Assessment, 2014: United Nations, European Commission, World Bank Group, Government of the Republic of Serbia, Belgrade 2014.

STAT.YEARB.SERB. (2022). Statistical Yearbook of the Republic of Serbia, 2022, Statistical Office of the Republic of Serbia, Belgrade.

STAT.YEARB.SERB. (2023). Statistical Yearbook of the Republic of Serbia, 2023, Statistical Office of the Republic of Serbia, Belgrade.

Statistical Office of the Republic of Serbia (2013). Census of Agriculture 2012, Agriculture in the Republic of Serbia. ISBN 978-86-6161-077-6, ISBN 978-86-6161-076-9. https://pod2.stat.gov.rs/objavljenepublikacije/popis2012/pp-knjiga1.pdf

Statistical Office of the Republic of Serbia (2019). Survey on the structure of agricultural holdings 2018. https://publikacije.stat.gov.rs/G2019/Pdf/G201922002.pdf, https://publikacije.stat.gov.rs/G2019/Pdf/G20196007.pdf

Statistical Office of the Republic of Serbia (2019). Survey on the structure of agricultural holdings 2018 – Land. ISBN 978-86-6161-183-4. https://publikacije.stat.gov.rs/G2019/Pdf/G20196003.pdf

Strategy on Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 (Official Gazette of the Republic of Serbia, No. 85/2014). https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/strategija/2014/85/1

Stričević, R., Prodanović S., Đurović N., Petrović Obradović O. i D. Đurović (2019). Climate change impacts on Serbian agriculture, UNDP, ISBN: 978-86-7728-263-9.

Stričević, R., Vujadinović Mandić, M., Djurović N., Lipovac, A. (2021). Simulacija primene dve mere adaptacije na klimatske promene na prinos pšenice, kukuruza i suncokreta modelom AquaCrop, Zemljiste i biljka 70(1):41-59, doi: 10.5937/ZemBilj2101041S.

Stričević, R.; Lipovac, A.; Prodanović, S.; Ristovski, M.; Petrović Obradović, O.; Djurović, N.; Djurović, D. (2020). Vulnerability of agriculture to climate change in Serbia–Farmer's assessment of impacts and damages. J. Agric. Sci, 65, 263–281.

The Economic Reform Programme for the period 2023-2025. Government of the Republic of Serbia. https://rsjp.gov.rs/wp-content/uploads/Program-ekonomskih-reformi-2023-2025-.pdf

The IPARD II Programme for the Republic of Serbia for the period 2014-2020. The Republic of Serbia, Ministry of agriculture, Forestry and Water Management. https://uap.gov.rs/wp-content/uploads/2021/02/ipard-ii-monitoring-report-vi-mc-serbia.pdf

The Programme for the Development of the Circular Economy in the Republic of Serbia for the period 2022-2024 (Official Gazette of the Republic of Serbia, No. 137/2022).

The Strategy for Capital Market Development for the period 2021-2026 (Official Gazette of the Republic of Serbia, No. 102/2021).

UNCCD (2020). Drought Initiative – Republic of Serbia. Recommendations for development of the National Drought Plan of the Republic of Serbia https://www.unccd.int/sites/default/files/country_profile_documents/NDP_SERBIA_2020.pdf

UNCCD (2020). Report on the applied methodology and identification of targets to achieve land degradation neutrality in the Republic of Serbia, 2020. https://www.unccd.int/sites/default/files/ldn_targets/2020-03/Serbia%20LDN%20TSP%20Country%20report%20%28English%29.pdf

UNCCD (2023). Report from Serbia to the United Nations Convention to Combat Desertification (UNCCD). https://reporting.unccd.int/api/country/SRB/report/official/pdf/

UNDP (2020). Nature-based solutions for climate change mitigation and adaptation. United Nations Development Programme.

UNDP (2019). The Study on socio-economic aspects of climate change in the Republic of Serbia. United Nations Development Programme. http://www.fao.org/state-of-food-security-nutrition/ [Accessed on 10 December 2023].

Vidojevic, D. (Edt) (2021). Soil State Report in the Republic of Serbia – Indicator based report 2018-2019, Ministry of the Environmental Protection, Environmental Protection Agency, ISSN 2466-2968 (Online).

Vidojević, D., Manojlović, M., Đorđević, A., Nešić, Lj. & Dimić, B. (2015). Organic carbon stocks in the soils of Serbia. Carpathian Journal of Earth and Environmental Sciences, November 2015, Vol. 10, No 4, p. 75–83.

Vidojević, D., Zdruli, P., Civic, H., Markovic, M., Milic, S., Mukaetov, D., Knezevic, M. & Sharku, A. (2022). Soil management in the Western Balkans – gaps and recommendationas – Skopje: Standing Working Group for Regional Rural Development (SWG), 2022. ISBN 978-608-4760-41-2.

Vidojević, D., Zdruli, P., Civic, H., Markovic, M., Milic, S., Mukaetov, D., Knezevic, M. & Sharku, A. (2022). State of the art of soil management in the Western Balkans – Skopje: Standing Working Group for Regional Rural Development (SWG), 2022. ISBN 978-608-4760-42-9.

Vujadinović Mandić, M., Vuković Vimić, A., Ranković-Vasić, Z., Đurović, D., Ćosić, M., Sotonica, D., Nikolić, D., Đurđević, V., (2022). Observed Changes in Climate Conditions and Weather-Related Risks in Fruit and Grape Production in Serbia, Atmosphere 13, no. 6: 948, https://doi.org/10.3390/atmos13060948.

Vuković Vimić, A., Djurdjević V., Ranković-Vasić, Z., Nikolić, D., Ćosić, M., Lipovac, A., Cvetković, B., Sotonica, D., Vojvodić, D., Vujadinović Mandić, M. (2022). Enhancing Capacity for Short-Term Climate Change Adaptations in Agriculture in Serbia: Development of Integrated Agrometeorological Prediction System, Atmosphere 2022, 13, 1337. https://doi.org/10.3390/atmos13081337

Vuković Vimić, A., Petrović, N., Weinreich, A. & Pistorius, T. (2021). Nature-based Solutions for climate change and potential for their implementation in Serbia, UNDP, Belgrade, Serbia, ISBN 978-86-7728-303-2.

Vuković Vimić, A., Petrović, N., Weinreich, A., Pistorius, T. (2021). Rešenja zasnovana na prirodi za klimatske promene i potencijal za njihovu primenu u Srbiji, UNDP, Beograd, Srbija, ISBN: 978-86-7728-304-9 (also available in English).

Water Law (Official Gazette of the Republic of Serbia, No. 30/2010, 93/2012, 101/2016, 95/2018, 95/2018 – other law).

Water Management Strategy of the territory of the Republic of Serbia until 2034 (Official Gazette of the Republic of Serbia, No. 3/2017). https://www.paragraf.rs/propisi/strategija-upravljanja-vodama-u-srbiji-do-2034.html

Životić, Lj. & Vuković Vimić, A. (2022). Soil degradation and climate change in Serbia, UNDP, Belgrade, Serbia, ISBN 978-86-7728-356-8.

The Law on Climate Change (Official Gazette of the Republic of Serbia, No. 26/2021).

ANNEXES



Ievgenii Meyer/shutterstock.com

Annex 1.
Albania climate change adaptation in agriculture – additional materials

Annex 1.1. Additional materials – socioeconomic analysis linked to climate change

Table A.1.1. Sources of gender-disaggregated indicators by type of source institution

Indicator	Are data available at:				Is the quality of data satisfactory:	Main source of data:	Are data accessible:
	NUTS-1 level:	NUTS-2 level:	NUTS-3 level:	NUTS-4 level:			
GDP (at current prices)	Yes	Yes	Yes	No	No	INSTAT	Yes
Value added (at current prices)	Yes	Yes	Yes	No	No	MoFE	Yes
GDP per capita	Yes	Yes	To some extent	No	No	World Bank	Yes
External trade balance	Yes	Yes	No	No	No	UNCOMTRADE	Yes
Unemployment rate	Yes	Yes	To some extent	No	No	Labour force survey, INSTAT	Yes
Food, beverages and tobacco in total household expenditures	Yes	Yes	No	No	No	Data from National Accounts (expenditure method)	Yes
GVA of agriculture (at current prices)	Yes	To some extent	No	No	Yes	MoFE	
Share in AgGVA in all activities	Yes	To some extent	No	No	Yes	MoFE	
Number of employed in agriculture	Yes	Yes	No	No	Yes	INSTAT	Yes
Share in total employment	Yes	No	No	No	Yes	INSTAT	Yes
Export of agri-food products	Yes	No	No	No	Yes	UNCOMTRADE	Yes
Share in export of all products	Yes	No	No	No	Yes	UNCOMTRADE	Yes
Import of agri-food products	Yes	No	No	No	Yes	UNCOMTRADE	Yes
Share in import of all products	Yes	No	No	No	Yes	UNCOMTRADE	Yes
Trade balance in agri-food products	Yes	No	No	No	Yes	UNCOMTRADE	Yes
Share of crops in total agricultural output	No	No	No	No	Yes	INSTAT	Yes
Share of livestock in total agricultural output	No	No	No	No	Yes	INSTAT	Yes
Total agricultural land	Yes	No	No	No	To some extent	INSTAT	Yes
- Arable land	Yes	No	No	No	To some extent	FAOSTAT	Yes
(of which fallow and uncultivated land)	Yes	No	No	No	To some extent	FAOSTAT	Yes
- Land under permanent crops	Yes	No	No	No	To some extent	FAOSTAT	Yes
(of which orchards)	To some extent	No	No	No	To some extent	SSO, Regular statistics and Farm Structure Survey	Yes
(of which vineyards)	Yes	No	No	No	To some extent	FAOSTAT	Yes
- Permanent grassland	Yes	No	No	No	To some extent	FAOSTAT	Yes

Indicator	Are data available at:				Is the quality of data satisfactory:	Main source of data:	Are data accessible:
	NUTS-1 level:	NUTS-2 level:	NUTS-3 level:	NUTS-4 level:			
(of which meadows)	No	No	No	No	To some extent		
(of which pastures)	No	No	No	No	To some extent		
Utilized agricultural area (UAA)	No	No	No	No	To some extent		
Number of agricultural holdings	To some extent	No	No	No	To some extent	SSO, Farm Structure Survey	Yes
UAA per holding	No	No	No	No	To some extent		
Cattle	Yes	Yes	Yes	Yes	Yes	INSTAT	Yes
(of which dairy cows)	Yes	Yes	Yes	Yes	Yes	INSTAT	Yes
Pigs	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
(of which breeding sows)	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Sheep and goats	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
(of which breeding ewes/goats)	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Poultry	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Beehives	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Average yields	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Wheat	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Maize	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Potatoes	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes
Average yield	Yes	Yes	Yes	Yes	To some extent	INSTAT	Yes

Source: Albania StatDatabase (2022), SSO

Annex 1.2. Additional materials – soils linked to climate change

Table A.1.2. Summary of land use/land cover for Albania as of 2020 (population 2.8 million, territory 28,748 km²)

Agricultural land[1] (share of total territory)						**Organic farming**[2] (share of total agricultural land)		**Forest and areas with forestry biomass including shrubs** (share of total territory)		**Permanent meadows and pastures** (share of total territory)		**Other areas**[3] (share of total territory)	
Cropland		**Permanent crops**		**Total** (cropland and permanent crops)									
ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
614,350	21.37	84,650	2.94	696,000	24.31	653	0.10	1,077,113	37.46	478,080	16.63	623,607	21.60

Table A.1.3. Summary of soil health indicators and their pressures on agriculture land for Albania (agricultural land 696,000 ha)

Soil health indicators: pressures on agricultural land											
Excess use of Nitrogen[1] Kg/ha/yr^{-1} ha	**Soil Organic Carbon losses from**[2]		**Compaction** ha	**Erosion**		**Pollution** ha	**Salinization**/ sodification magnesial soils (Smonitsa) ha	**Soil Acidity**: ≤5pH topsoil ha	**Soil sealing** and land take (2000 2020) ha	**Deserti fication** % of total area	Pressures on **soil biodiversity** %
	Mineral soils	Organic soils		Water >10t/ ha/yr[1]	wind						
	ha	ha		%	%						
N/A	595,900	100	N/A	93	N/A	N/A	42,000	90,000	50,000	25	N/A

Table A.1.4. Legislation dealing with land and soil related protection in Albania

Issue	**Name of national acts (laws and by-laws)**	**Year**	**Harmonized with EU regulation (Yes/ No/Partly)**
Law 9244	Law on Land Protection	1994	Partly
Regulation 80	on the establishment, functioning, tasks and responsibilities of the agricultural land protection authorities	2005	Partly
Regulation 59	on the analysis of agricultural land indicators	2005	Partly
Law No. 69/2013	Amending and Supplementing Law No. 9244 on Agricultural Land Protection	2013	Partly
Law No. 131/2014	Amending and Supplementing Law No. 9244 from 2001 on Agricultural Land Protection	2014	Partly

All Laws and Regulations are published in the Official Gazette

Table A.1.5. Exposure of soils to climate change

Processes	Units	Location	Area affected	Data availability	Data format	Period (events/year)	Soil types affected	Land productivity potential affected	Comments
Floods	Ha	Shkodër Lezhe Kruje Durres Lushnjë Fier Vlorë Berat	On average 16,000 ha were affected	Rather good	Municipal records and Institute of GeoSciences[64]	1980 – 2022 Many flood events recorded in this period	Fluvisols, Cambisols Gleysols Vertisols Luvisols Gleysols Stagnosols	Heavily affected	
Heavy rainfall (storms)	Ha	Throughout the economy	In the range of several ha	Limited	Institute of GeoSciences[65]	Continuous	All types	Heavily affected	
Drought	Km^2	Certain areas mostly in the lowland coastal plains	In the range of several km^2	Limited	Institute of GeoSciences	1952-2022 with duration between several days and 5 months	All types	Heavily affected	
Frosts	Ha	Typical for the mountain regions	In the range of several ha	Limited	Institute of GeoSciences	Frequent during winter	Cambisols Regosols	Minor effects	
Land slides	%	Sloping areas	9 % of the economy	Moderate	Albanian Geological Survey	Continuous	Cambisols Regosols Luvisols	Major effects	
Forest fires	Ha	Throughout the economy	Hundreds of ha	Rather good	Municipalities	Data availability for the last 30 years	All types	Heavily affected	
Other extreme events									Hail

64 Institute of GeoSciences, https://www.geo.edu.al/.
65 Institute of GeoSciences, https://www.geo.edu.al/.

Table A.1.6. Producers' adaptive capacity

Indicator	Management practices	Area ha	# of farmers	# of farms	Expert opinion	Confidence level (H, M, L)
Cultivation	Reduced tillage (sporadic cases)	N/A	N/A	N/A	Some areas	L
	No-tillage	None	None	None	Not applied	H
	Contour tillage	Limited	N/A	N/A	Scarce	M
	Strip cultivation	N/A	N/A	N/A	Not applied	M
Fertilizer management	Soil laboratory testing schemes	100k	Many	Many	Increasing	M
	Organic fertilizer	250k	Many	Many	Spreading	M
	Exclusive use of chemical fertilizers	50k	Unknown	Unknown	Same	L
Fertigation	Pressurized systems	30k	Unknown	Unknown	Limited	L
	Pressurized systems with irrigation scheduling	Limited	N/A	N/A	Scarce	L
	Overhead irrigation (drip irrigation)	20k	N/A	N/A	Scarce	M
	Furrow irrigation	250k	Many	Many	Increasing	H
Precision agriculture	Systems for agro-ecological zoning	None	None	None	Not applied	H
	Thematic soil quality maps	450k	Many	Many	Increasing	H
	Online soil services	450k	Many	Many	Increasing	H
Training programmes	Lifelong training programmes	Limited	N/A	N/A	Scarce	M
	Vocational training related to soils	Limited	N/A	N/A	Scarce	M
	Targeted training courses for farmers	Limited	N/A	N/A	Scarce	M
Land improvement practices	Liming	none	N/A	N/A	Not applied	H
	Erosion control	50k	N/A	N/A	Increasing	M
	Salinity management	500	1	1	Scarce	H

Table A.1.7. Best practices in place

Indicator	Best practice in place	Area affected (ha)	Soil organic matter maintenance	Soil reaction pH	Soil erosion control	Soil salinization	Water conservation	Other
Cultivation	Reduced or no-tillage	100k	Some interventions	None	Some interventions	Minimal interventions	Increasing	
	Strip and contour farming	10k	Limited extent	None	Minimal interventions	None	Minimal interventions	
Fertilizer management	Organic fertilizers	250k	Improving	None	Not relevant	Minimal interventions	Not relevant	
	Chemical fertilizers	450k	Impacted	Impacted	Not relevant	Impacted, especially in the greenhouses	Not relevant	
Irrigation	Pressurized and drip irrigation	50k	Impacted	None	No impact	Improving	Improving	
	Furrow irrigation	250k	Impacted	None	Strongly impacted	Improving, unless of poor water quality		
Precision Agriculture	Not applied							
Training programmes	Vocational farmer training	Little						

Annex 1.3. Additional materials – water resources linked to climate change

Table A.1.8. Water resources in the economy

Economy	Hydrological characteristics					
ALBANIA	Surface water in M m3/year (average values)	%	Average precipitation in mm (average values for the economy for minimum 30 years)	%	Ground water potential in M m3/ year	%
River basin						
Drin-Bune	NA	NA	NA	NA	NA	NA
Mat	NA	NA	NA	NA	NA	NA
Ishem-Erzen	NA	NA	NA	NA	NA	NA
Shkumbin	NA	NA	NA	NA	NA	NA
Seman	NA	NA	NA	NA	NA	NA
Vjose	NA	NA	NA	NA	NA	NA
TOTAL	39.22 billion m^3/ year					
Total annual discharge	1,300 m^3/s					

Table A.1.9. Data for selected regions in Albania as of 2014

Region	Agricultural land (ha)	Potential irrig. capability (ha)	Actual irrig. capability (ha)	No. of farms	No. of machines
Berat	52,908	13,760	8,830	24,176	1,910
Dibër	41,056	23,128	16,504	25,658	809
Durrës	40,568	19,736	11,866	28,770	1,733
Elbasan	72,872	34,906	22,243	31,326	2,645
Fier	121,961	83,604	46,772	52,169	7,158
Gjirokastër	45,111	18,989	8,332	18,918	799
Korçe	90,909	35,652	24,610	29,500	2,472
Kukës	25,292	11,412	8,130	10,108	864
Lezhë	34,736	17,163	10,758	25,585	1,462
Shkodër	50,625	34,220	16,126	38,812	2,301
Tiranë	56,609	26,980	11,652	34,454	1,974
Vlorë	62,873	34,179	23,530	32,839	1,775

Table A.1.10. Irrigated areas in 2021, by district

District	Irrigated area (ha)
Berat	11,849
Bulqizë	1,794
Delvinë	7,105
Devoll	9,741
Dibër	12,904
Durrës	13,629
Elbasan and Peqin	20,766
Fier	30,119
Gjirokastër	10,759
Gramsh	4,185
Has	1,943
Kavajë	11,603
Kolonjë	4,834
Korçë	19,001
Krujë	7,962
Kuçovë	3,661

District	Irrigated area (ha)
Kukës	5,152
Laç	7,265
Lezhë	14,339
Librazhd	4,645
Lushnjë	31,866
Malesia e Madhe	8,235
Mallakastër	4,378
Mat	4,689
Mirditë	3,392
Përmet	4,122
Pogradec	5,288
Pukë	2,891
Sarandë	8,048
Shkodër	19,333
Skrapar	2,617
Tepelenë	2,975
Tiranë	14,565
Tropojë	5,425
Vlorë	18,920
Albania Total	340,000

Note: these data show a lower amount of potentially irrigated areas that are estimated at 360,000 ha.
Source: Ministry of Agriculture and Rural Development

Drainage systems in the economy

Data are not available, overall drainage area should be in the range of about 50,000 ha

Table A.1.11. Producers' adaptive capacity

Indicator	Lists	Yes	No	If yes, please note used area (e.g. in ha or in % of total irrigated area in the economy, number of farmers, number of farms, etc.)	Expert opinion	Comments
Micro-irrigation	Drip irrigation Micro-sprinkler Drip fertigation	Yes Yes Yes		About 30,000 ha in more than 10,000 farms About 10,000 ha 1992 ha		
Irrigation scheduling practices	Irrigation programmes Sensors and data loggers Tensiometers Meteo stations	Yes Yes	No No	Limited in certain areas, water user associations, no sensors and data loggers or tensiometers, except for experimental sites 125	Programmes have limited impact	
Soil moisture conservation methods	Organic mulch materials Inorganic mulch materials	Yes	 No	100,000 ha in thousands of farms		
Training programmes	Lifelong training programmes within universities Vocational training programmes related to water Targeted training courses for farmers and young professionals	 Yes	No No	Very limited programmes In some areas training has been conducted to farmers located in the most intensive agriculture areas		
Other	UV nets Cover crops		No			

Documentation

Albania has not signed the EU Water Directive and is not legally binded to it. For more detailed information on national legal issues please read the text of the chapter.

Annex 1.4. Additional materials – crop production linked to climate change

Table A.1.12. Most important crops, area planted and yield in last 5 years in Albania

Most important crops	Average area in the last 5 years, ha	Average yield in the last 5 years, t/ha
Wheat	59,791	4.3
Maize	56,467	7.1
Alfalfa	140,000	38.5
Tomato	6,660	45.2
Watermelon	5,790	46.9
Dried onion	5,433	20.8
Apple	4,342	24.2
Grapevine*	10,426*	18.9
Olive	54,726	2.4

*Pergolas are not included

Maize. Changes in average temperature during the growing season of maize (April to October) reveal an increase of about 1°C to 2°C from 1992 to 2020. Maize yields and climatic mean and weather extreme variables are strongly correlated. Higher values of all temperature variables were associated with higher yields.

Changes in precipitation for the same period have been mainly negative (-100 to 300 mm) during the growing season and particularly in the most productive region.

Some coastal regions of the economy have had more days with excessive heat above 35°C in the last 20 years but many more night heat events (nights with minimum temperatures above 20°C). The latest can result in faster heat unit (growing degree days, GDD) accumulation that can lead to earlier corn maturation. However, maize plants are sensitive to heat stress (>30 °C) and there is a strong decline in grain yield as plants face heat stress above this threshold for a prolonged duration.

Maize yields have increased remarkably in the last 20 years (1992-2020), which can be related to technology but also climatic changes (increased heat accumulation, less frost events during the growing season, etc.). However, studies on adaptation to climate change in agriculture foresee that the effects on maize yields will vary by region, with increases in the southern highlands and decreases in other regions, probably because current temperature is the most moderate in the mountainous southern highlands and so increases can enhance yields. Effects of climate change on maize yields may also be linked to effects on livestock due to the effects of climate change on forage crops, like rainfed alfalfa and grassland yields.

Winter Wheat. Changes in average temperature for wheat growing period (October to July) have been slightly less pronounced than those for the growing period of maize, but some important production areas in the southeast have had hotspots of temperature increases. In general, wheat yield is positively correlated with minimum, average and maximum temperatures. Minimum temperature is positively related to the yields of winter wheat.

Changes in total precipitation show similar spatial patterns for the growing period of winter wheat as for maize but lower in absolute values (-150 mm). Again, the largest decreases occurred in northern Albania. Considering the phenological stage of wheat, this reduction in precipitation does not have a major impact on yield. Notwithstanding, there are more events of heavy precipitation during the growing period of winter wheat causing frequent damages. Wheat production enjoys a significant comparative advantage because of the widespread accessibility of irrigation capacity in Albania.

Night heat events increased during the period when winter wheat is grown. Night heat positively influences wheat yields in Albania. The significant global loss of crop yield is primarily due to heat-related damage during the reproductive phase. Terminal heat stress causes morphophysiological alterations, biochemical disruptions, and reduction of genetic potential.

The number of frost events also decreased during the growing period of winter wheat in the last 20 years. However, some areas in the southeast have received more frost with a negative effect on wheat yields and sometimes very late frosts just before harvesting.

Climate change is projected to have the potential to improve yields of winter wheat (if pest damage does not increase). Yield increases can result as climate change will likely result in an extended growing season, more moderate autumn and winter temperatures, and greater precipitation and water availability during the wheat growing season. Some experts have noted, however, that the recent decline in wheat yields might be attributable to increased incidence of pest damage to this crop. In highland areas, winter wheat is cultivated at temperatures below the optimal temperature, and so climate change can enhance yields and extend the growing season.

Alfalfa. Climate change is projected to have the potential to improve yields of irrigated alfalfa in most regions. Such potential is high under all scenarios, due to beneficial effects of higher temperatures and a longer growing season.

Tomato. Tomato is cultivated mainly in the western lowlands, especially intensive production destined for export. Given that tomatoes are mostly an irrigated crop in Albania, the main potential climate factor for tomatoes is temperature stress. Analysis of climatic data has shown that in the last 20 years, the number of days with excessive heat above 35°C and night heat events (nights with minimum temperatures above 20°C) has increased strongly in that region. High night temperatures over 24°C damage the production of pollen, causing most of the fruit to remain very small and seedless, including deformations in the fruit shape. Heat stress caused by days with excessive heat can also change the sink-source association among roots and shoots, which affects the vegetative and the reproductive growth in tomato plants leading to reduced yield and fruit quality.

Tomatoes will need substantially increased amounts of water. The low-impact scenario forecasts more rainfall, including during the cropping period, which results in a slight decrease in water demands.

Tomato yields outside of greenhouses with climate controls may fall modestly under the scenarios of climate change. There is potential for more substantial effects on tomatoes, which could suffer from heat and drought stress, particularly during critical periods of growth. Notwithstanding, under climate change scenarios, more tomatoes should move to greenhouses, expanding the use of plastic greenhouses for tomato cultivation. In some regions, tomatoes are produced throughout the winter without heating, getting a very high price. That was not possible 20-30 years ago because of the cold winter temperatures.

Even if a good share of tomatoes is already cultivated in protected culture, storms have damaged greenhouses which are virtually all in high tunnels, without a strong structure. Another major concern is heavy hails and snow but exposure to such risks varies by region.

Some negative impacts are related to the incidence and severity of different greenhouse pests by becoming a major setback to vegetable cultivation (Table 4). This is due to influences on pest and disease occurrences, host-pathogen interactions, distribution and ecology of insects, time of appearance, migration to new places and their overwintering capacity.

Watermelon. The effects of climate change on watermelon could be substantial, which could suffer from heat and drought stress, particularly during critical periods of growth. One reason for the relatively modest effects is the widespread use of irrigation. To the extent that irrigation infrastructure is in poor repair, water may not be available at critical times of the growing season of watermelon, which would mean that the severity of effects of future climate change for watermelon may be underestimated.

Watermelon has a strong export orientation and the climate change effects for these value chains may adversely affect export performance considering that the export markets are more demanding and competitive than the local markets in terms of volumes, quality and timing. In some years, low tunnels prepared early for the cultivation of watermelons have been damaged by floods due to heavy rains.

Apple. Apples have been damaged almost every season by late frosts or hail requiring the installation of hail nets. The cost of hail nets is very high, especially if orchards do not have a supporting system, but is becoming an obligatory cost to avoid complete loss of production.

Expected increase in temperature will affect the phenology of apples, altering their patterns for sprouting, flowering, giving and ripening the fruit. The changing climate make fruit trees susceptible to common and new pests, fungal diseases and more.

Grapevine. Vineyards are adversely affected by heavy rains or hails during the blossoming period, which can affect yields and cause diseases and reduced input efficiency. Due to frequent rains, farmers have to repeat several sprays of pesticides that result in bad quality of grapes and wine. For example, the year 2023 was denominated 'Annus horribilis' for grapevine production. Moreover, the quality of wine depends on many physiological processes and enzymatic activities that are temperature dependent, and are going to be largely affected by climate change.

Studies on the adaptation to climate change in agriculture demonstrate that grapes will be the most affected by climate change, particularly affected in the lowland agroecological zone. This is particularly because grapevine is mostly rainfed.

Olives. Olives are particularly characterized by strong year-to-year changes in yields, and also quality is largely affected by climate conditions, and such oscillations may get worse due to climate change. Although olives are very well adapted to Mediterranean conditions, the combined action of lack of rain and high temperatures in autumn and early spring determines the flowering period and its intensity. Earlier flowering reduces the percentage of fruit set and, therefore, production. Another factor reducing fruit set is lack of sufficient chilling units accumulated during very mild winters.

Studies on the adaptation to climate change in agriculture demonstrate that olives will be the most affected, being a rainfed crop. Specifically, areas under marginal rainfed production will have less adaptive capacity than areas that are more productive and irrigated agricultural land. Here the variety plays a crucial role – old traditional varieties tend to resist better than some new imported varieties. Most olive orchards, even new ones, are planted on wild rootstocks that resist better to drought.

Table A.1.13. Number of meteorological and phenological stations in Albania

Climatological	Pluviometrics	Thermometric posts and simple meteorological	Total weather stations	Phenological station
23	23	74	120	13

Table A.1.14. Meteorological data available in Albania required for measuring climate change

Parameter	Daily Max T	Daily Min T	Daily RH	Daily precipitation	Average daily wind speed	Daily sunshine duration	Data recording on extreme events*
Period covered	1949-present	1949-present	1949-present	1949-present	1949-present	1949-present	1949-present
Number of stations	74	74	29	29	29	29	29
Coverage	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy

Table A.1.15. Extreme weather events recorded in Albania

Extreme event	Date reported	Region affected	Affected area in ha	Crops affected and impact
Drought	2018	Whole economy	400,000	All crops, drastic reduction on yield and crop failure
Flood	November 2022	Shkodra, Lezha	1,220	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood	March, 2018	Shkodra, Lezha	4,704	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood	February and October 2015	Fier, Vlora	11,400	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood	November 2010	Shkodra, Lezha	11,400	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood	February 2005	Southeast	3,000	Wheat, maize, fodder crops, field crops collapsed, perennials affected
Flood	22-30 September 2002	Milot, Lezha, Torovica, Zadrima, Shkodra	16,000	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood	1995- 1996	Shkodra, Lushnja, Kruja, Laçi, Durrësi, Lezha	30,000	All crops, field crops collapsed, perennials affected
Flood	December 1962-January 1963	Shkodra, Lezha, Berati	70,000	All crops, field crops collapsed, perennials affected

Table A.1.16. New crop pests and diseases recorded in Albania

Crop/disease (Latin name)	**Crop/disease (English name)**	**First recorded**	**Crops/cropping system affected**	**Level of spreading**	**Risk for production and productivity**
Frankliniella occidentalis, Perg.	Western flower thrips	2001	Greenhouse	Nationwide	Mean
Bemisia tabaci, Gennadius	Tobaco witefly	2001	Greenhouse	Nationwide	High
Aphis illinoiensis, Shimer	Grapewine aphid	2011	Vineyard	Nationwide	Low
Tuta absoluta, Meyrick	Tomato moth	2009	Greenhouse	nationwide	High
Ceratitis capitata, Weidemann	Mediterranean fruit fly	2007	Citrus trees, Persimnon	Partly distributed	High
Tomato brown rugose fruit virus	ToBrRFV	2022	Greenhouse	Nationwide	High
Tomato yellow leaf curl	TYLCV	2022	Greenhouse	Nationwide	High
Tobacco mosaic tobamovirus	TMV	2022	Greenhouse	Nationwide	High

Table A.1.17. Most vulnerable regions and crops to climate change in Albania

Most vulnerable regions	Crops
Lowlands	Wheat, vegetables (open field and protected culture), olive, grapevine
Southern highlands	Wheat, dried onion, apple, sweet cherry

Table A.1.18. Climate change adaptation practices used or tested in Albania

	Best adaptation practice in place	Farms affected	Tested
Heat stress	Overhead irrigation	Small	To some extent
Heat stress	Shading	Small	Low
Heat stress	Mulching	Small	High
Drought	Drip irrigation	Large	High
Drought	Tolerant varieties	Small	Low
Insolation	Shading	Small	To some extent
Changes in season and growth stages	Change ripening period of varieties	Large	To some extent
Hail	Hail nets	Large	High
Training programmes	Various donors and public institutions delivering trainings on climate change adaptation		

Annex 1.5. Additional materials – livestock farming linked to climate change

Table A.1.19.Extreme events of heavy rains during last years

Year	Event description
2022	Heavy rains in southern Albania caused flooding and mudslides, which killed livestock and destroyed agricultural crops.
2021	
2019	
2017	
2015	

Table A.1.20. Some of the floods that occurred in Albania during the last years

Year	Event description
2020	A flood occurred in the Shkumbin River basin, affecting the districts of Elbasan, Durrës, and Tirana. The flood caused damage to infrastructure and agricultural land, and displaced thousands of people.
2017	A flood occurred in the Devoll River basin, affecting the districts of Korçë and Pogradec. The flood caused damage to infrastructure and agricultural land, and displaced thousands of people.
2015	A flood occurred in the Vjosa River basin, affecting the districts of Gjirokastra and Tepelena. The flood caused damage to infrastructure and agricultural land, and displaced thousands of people.
2014	A flood occurred in the Drin River basin, affecting the districts of Shkodër and Lezhë. The flood caused damage to infrastructure and agricultural land, and displaced thousands of people.
2010	A flood occurred in the Mat River basin, affecting the districts of Dibër and Krujë. The flood caused damage to infrastructure and agricultural land, and displaced thousands of people.

Table A.1.21. Some of the extreme cold events in Albania

Year	Event description
February 2022	The temperature in the city of Durrës dropped to-15°C, the coldest temperature in Albania in 2 years.
January 2021	The temperature in the city of Tirana dropped to-16°C, the coldest temperature in Albania in 4 years.
January 2017	The temperature in the city of Elbasan dropped to-20°C, the coldest temperature in Albania in 5 years.
February 2012	The temperature in the city of Korçë dropped to-22°C, the coldest temperature in Albania in 30 years.
January 1985	The temperature in the city of Shkodër dropped to-25°C, the coldest temperature ever recorded in Albania.

Table A.1.22. Some the dates of extreme heat in Albania

Year	Event description
2020	A heat wave occurred in July, with temperatures reaching up to 39°C in some parts of the economy. The heat wave caused a number of deaths, and also led to forest fires and crop damage.
2019	A heat wave occurred in July, with temperatures reaching up to 40°C in some parts of the economy. The heat wave caused a number of deaths, and also led to forest fires and crop damage.
2018	A heat wave occurred in August, with temperatures reaching up to 41°C in some parts of the economy. The heat wave caused a number of deaths, and also led to forest fires and crop damage.
2017	A heat wave occurred in July, with temperatures reaching up to 42°C in some parts of the economy. The heat wave caused a number of deaths, and also led to forest fires and crop damage.
2012	A heat wave occurred in July, with temperatures reaching up to 44°C in some parts of the economy. The heat wave caused a number of deaths, and also led to forest fires and crop damage.

Annex 2. Bosnia and Herzegovina climate change adaptation in agriculture – additional materials

Annex 2.1. Additional materials – soils linked to climate change



Map A.2.1. Flood hazard map-AVP Sava-APSFR-areas with potentially significant risk



Map A.2.2. Map of flooding in B&H



Picture A.2.1 Flooding in B&H

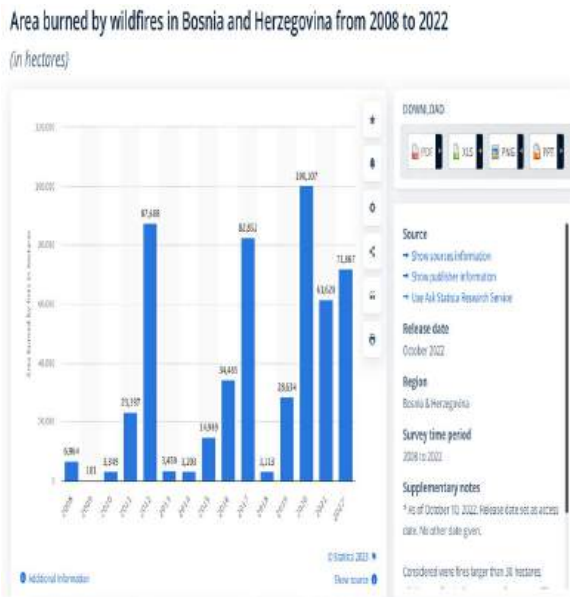
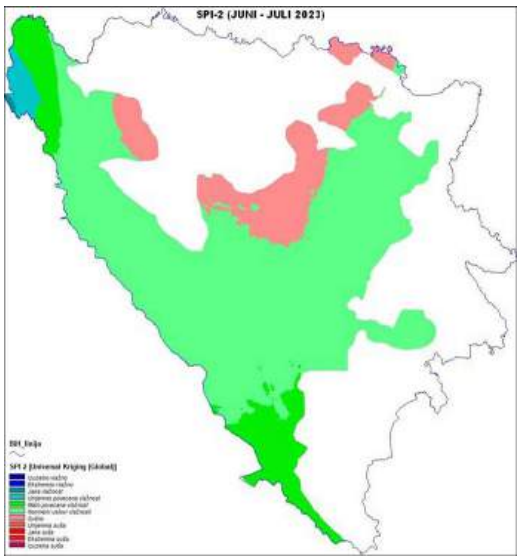
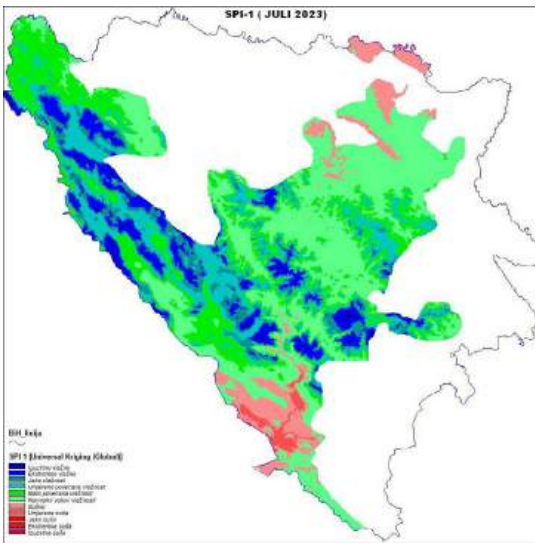


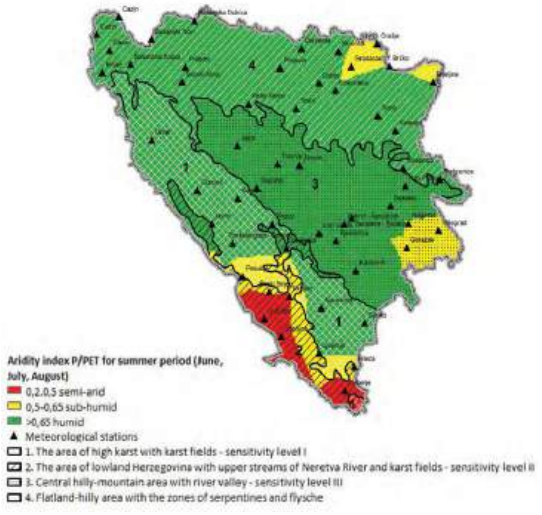
Figure A.2.1. Area burned by wildfires in Bosnia and Herzegovina from 2008 to 2022

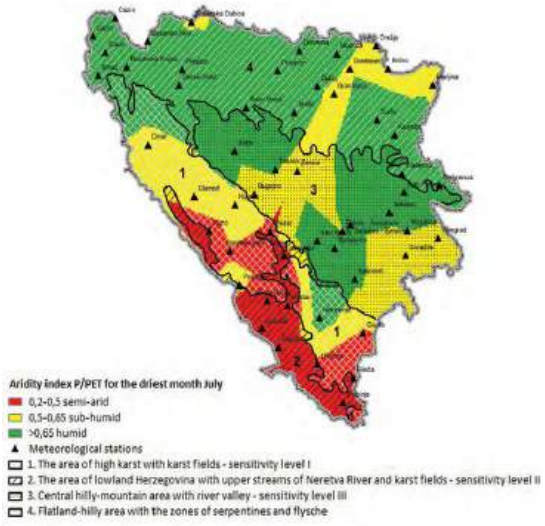


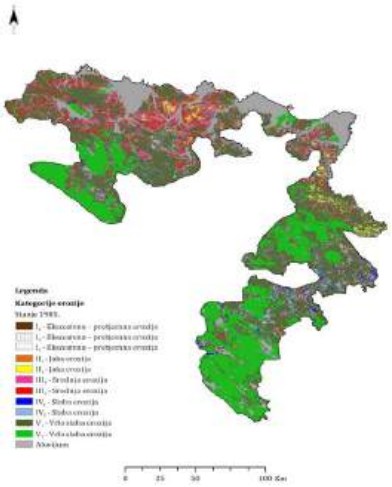
Map A.2.3. Map of drought assessment based on bimonthly precipitation index (SPI-2) in FB&H



Map A.2.4. Map of drought assessment based on one month precipitation index (SPI-1) in FB&H







Map A.2.5. State of erosion from 1985 in RS



Picture A.2.2. Landslide in B&H (Ze-Do Kanton 2014)

Annex 2.2. Additional materials – crop production linked to climate change

Table A.2.1. Most important crops in B&H

Rank	Most important crops	Average area in last 5 years ha or number of trees	Average yield in last 5 years t/ha
1	Maize (grain)	193,980	6.00
2	Wheat	70,680	4.18
3	Clover and mixtures	64,660	3.43
4	Maize (green)	33,620	19.50
5	Potatoes	35,780	11.02
6	Lucerne	29,320	4.12
7	Barley	21,340	3.71
8	Plums (trees)	12,473.04	-
9	Apples (trees)	7,207.12	-
11	Soya	8,960	2.50
12	Bean grain	7,620	1.45
13	Grapes	4,500	8.40
14	Onion	5,020	8.16
15	Cabbages	4,720	15.07
16	Raspberries	3,020	7.36
17	Tomatoes	3,740	12.97
18	Peppers	3,420	13.51
19	Strawberries	1,240	8.42

Table A.2.2. Number of meteorological and phenological stations in B&H

Type of the Station	Meteorological	Phenological station
Number of locations	31	20

Table 3. Meteorological data available in B&H required for implementing climate change

Parameter	Daily Max T	Daily Min T	Daily RH	Daily precipitation	Average daily wind speed	Daily sunshine duration
Period covered	1961-present	1961-present	1961-present	1961-present	1961-present	1961-present
Number of stations	31	31	31	31	31	31
Coverage	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy

Note: The data gap, depending on the location, varies from January 1992 to December 1999.

Table A.2.4. Extreme weather events recorded in B&H

Extreme event	Date reported	Region affected	Affected area in ha	Crops affected and impact
Flood event	2001	North B&H (Posavina, Tuzla, Zenica-Doboj) and Central Bosnia Canton	20,000 ha of farmland was affected	All crops, drastic reduction on yield and crop failure
Flood event	2004	Tuzla, Zenica-Doboj (central), Posavina (north), Bosna-Podrinje (east) and Herzegovina-Neretva Canton	13,455 hectares of agricultural land	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood event	2014	Zenica-Doboj, Tuzla, Brčko District, Semberija and Posavina		Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood event	17 May 2014	Bosanski Šamac	Not measured	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood event	17 May 2014, 8 March 2017	Brčko	Not measured	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood event	23 May 2014	Doboj	Not measured	Wheat, maize, fodder crops, field crops collapsed, perennials affected
Flood event	02 December 2010	Goražde	Not measured	Wheat, maize, fodder crops, grapevine, fruit trees, field crops collapsed, perennials affected
Flood event	1 December 2010, 15 May 2014	Ilidža	Not measured	All crops, field crops collapsed, perennials affected
Flood event	15 May 2014, 25 February 2017	Kakanj	Not measured	All crops, field crops collapsed, perennials affected
Flood event	14 May 2014	Kladanj	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	20 September 2010, 16 May 2014	Ključ	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	10 January 2010	Konjic	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	15 May 2014	Lukavac, Maglaj, Modriča, Olovo, Visoko, Zavodovići, Zenica	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	2 December 2010, 31 March 2013	Mostar	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	18 May 2014	Odžak	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	16 May 2014	Sanski Most	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	2 March 2010, 15 May 2014	Žepče	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	2009	B&H	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	2019	B&H	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Flood event	2021	Canton Sarajevo	Not measured	Flood impacts on infrastructures and agricultural objects and areas
Drought events	2000	B&H	Not measured	Extreme food insecurity, forest fires
Drought events	2003	B&H	Not measured	Extreme food insecurity, forest fires
Drought events	2007	B&H	Not measured	Extreme food insecurity, forest fires
Drought events	2011	B&H	Not measured	
Droughts and heatwaves	2012	B&H	Not measured	Extreme food insecurity, forest fires
Droughts and heatwaves	2013	B&H	Not measured	
Drought events	2015	B&H	Not measured	
Droughts and heatwaves	2016	B&H	Not measured	
Droughts and heatwaves	2017	B&H	Not measured	
Drought events	2018	B&H	Not measured	

Extreme event	Date reported	Region affected	Affected area in ha	Crops affected and impact
Droughts and heatwaves	2019	B&H	Not measured	
Hail	2003	B&H	Not measured	
Hail	2007	B&H	Not measured	
Hail	2009	B&H	Not measured	
Hail	2010	B&H	Not measured	

Table A.2.5. Most vulnerable regions and crops to climate change in B&H

Most vulnerable regions	Crops
High karst area with karst fields (south)	These areas are generally not utilized for agricultural production, soils exposed to intensive erosion and forest fires
Lower Herzegovina area including the upper Neretva and karst fields	Orchards, cherries, sour cherries and berries (strawberries, blackberries, raspberries)
Central hilly-mountainous area with river valleys (central B&H)	Smaller family farms along with meadows and pastures
Lowland hilly area (north-west)	Plums, apples, pears, as well as raspberries and strawberries, corn, wheat, barley

Table 6. Climate change adaptation practices used or tested in B&H

Extreme event	Best adaptation practice in place	Farms affected	Tested
Heat stress	Planting resistant varieties	All	Low
Drought	Irrigation	All	High
Insolation	Protective nets	All	High
Hail	Hail nets	All	To some extent
Training programmes	Raising awareness about CC	All	High

Table 7. National documents providing information on crop production vulnerability and adaptation to climate change

Title of the document	Year
Strategy on Agriculture Development and Rural Areas for Brčko District for period 2021-2027	2022
Strategy on Agriculture and Rural Development of the FB&H for period 2021-2027	2022
Strategy on Agriculture Development and Rural Areas of Republic of Srpska for period 2021- 2027	2021
Fourth National Communication of B&H under UNFCCC	2021
Bosnia and Herzegovina National Adaptation Plan – NAP with proposed measures	2021
Climate Change Adaptation and Low-Emission Development Strategy for B&H for the period 2020-2030	2020
Environmental Performance Reviews B&H – Third Review	2018
Nationally Determined Contributions of B&H 2020-2030	2016
Third National Communication of B&H under UNFCCC	2016
Action Plan for flood protection and river management 2014-2017	2014
Risk assessment of FB&H regarding natural and other disasters	2013
Climate Change Adaptation and Low-Emission Development Strategy for B&H	2013
Second National Communication of B&H under UNFCCC	2013
FB&H Water Management Strategy 2010-2022	2012
Integrated Water Management Strategy of Republic of Srpska	2012
Environmental Performance Review B&H	2012
Initial National Communication of B&H under UNFCCC	2009

Table A.2.8. Measures from national systems for support to agriculture that can be related to climate change adaptation

Measure	Necessary funds	Implementation period
Earlier planting and selection or breeding of tolerant species and varieties, resistant to high temperatures, drought, floods, but also to diseases and pests (30 million BAM)	15 million EUR	2021-2027; 2020-2030
Focusing more on production of winter crops	-	2021-2025
Improving cultivation techniques: soil conservation for erosion protection, conservation agriculture and agroforestry, organic agriculture, ecosystem-based approaches, crop rotation adjustment, change of plant species (growing modern orchards, vineyards)	1.25 million EUR	2021-2023
Construction/reconstruction of new irrigation and drainage systems	1 million EUR	2021-2027; 2020-2030
Prepare plans and projections for the construction of micro-reservoirs in hilly and mountainous areas	100,000 EUR	2021-2027
Better solution for agricultural water management, such as good examples of Water User Association from Herzegovina (Trebinje)	-	2021-2027
Higher use of organic matter (manure) to preserve soil fertility	-	2021-2027
Development of an early warning system for meteorological and climatic extremes, with special focus on floods and drought	-	2021-2027
Establish communication-linked hail protection systems in the entities and the Brčko District of B&H	0.75 million EUR	2021-2025
Construction/reconstruction of flood, erosion and torrent protection facilities in endangered areas/settlements and roads, including rainwater drainage	-	2021-2027
Support for application of Smart Agriculture practices (drones, remote sensing, software, sensors as well as automatization and digitalization)	-	2021-2027
Increased scientific research and extension services can enhance the capacity and delivery of information to the agricultural sector, with particular reference to climate change and the implementation of adaptation options	-	2021-2027
Awareness raising and education on the need to adapt to climate change	222,000 EUR	-
Focusing more on the production of winter crops	250,000 EUR	2020-2023
Strengthen the professional and technical capacity to implement research, applied and operational activities in important disciplines dealing with climate change, which include the field of climate modelling and predictive technologies for forecasting weather and environmental conditions, and promote and adopt a more associated approach to multi- and interdisciplinary economic, environmental and social research to assess sensitivity to climate change	250,000 EUR	2020-2025

Annex 3. Kosovo* climate change adaptation in agriculture – additional materials

Annex 3.1. Additional materials – policy measures linked to climate change

Sector	Forestry
Title of policy measure	Enhancement of forest resources
Timeframe	Forestry Strategy 2020-2030
Main objective of policy measure	Enhancement of forest resources through: Specific Objective 1: Entire public forest area is administered with management plans 2: Improve of forests through silviculture measures
Measures to be implemented	Alignment of the forestry sector legislation with the EU Acquis. Forested areas covered by long-term management plans. Forest areas covered by multipurpose integrated forest management plans in five pilot sites. Forest and forest land area inventoried. Regulation of titled holders and owners of public forests and their registration in the Cadastre. Identification and registration of usurpation of forests and forest lands, as well as legal property disputes. Registration of forest land by function. Increase (expansion) of forest areas.

Sector	Forestry
Title of policy measure	Protection of forest resources
Timeframe	Forestry Strategy 2020-2030
Main objective of policy measure	Protection of forest resources
Measures to be implemented	Protection of forest resources through reduction of illegal logging, consolidation of forest lands, protection and monitoring of forests health, forest biodiversity conservation, and protection of forests from fires

Sector	Forestry
Title of policy measure	Sustainable and multipurpose use of forest resources
Timeframe	Forestry Strategy 2020-2030
Main objective of policy measure	Sustainable and multipurpose use of forest resources
Measures to be implemented	Simplify technical and administrative procedures for forest use; Regulate the issue of long-term logging permits; Define national sustainable forest management criteria and indicators; Capacity building of NWFP collectors and operators; Define potential areas for ecotourism and digitize and mark ecotourism paths

Sector	Agriculture
Title of policy measure	Agri-environment and climate schemes (local breeds, organic farming, extensive grassland management)
Timeframe	Agriculture Strategy 2022-2028
Main objective of policy measure	Strategic Objective 2: Sustainable management of natural resources (land, forests and water); Specific Objective 2.1: Support in mitigation and in adaptation to climate change, like the use of renewable energy
Measures to be implemented	1. Introduce good agricultural and environmental practices aimed at improving carbon sequestration (for example, not burning incinerators) 2. Prioritize grants for farmers with investments in renewable energy 3. Afforestation of open areas 4. Preparing management plans

Sector	Agriculture
Title of policy measure	Agri-environment and climate schemes (local breeds, organic farming, extensive grassland management)
Timeframe	Agriculture Strategy 2022-2028
Main objective of policy measure	Strategic Objective 2: Sustainable management of natural resources (land, forests, and water); Specific Objective 2.2: Promoting sustainable and efficient resource management (land, water, air)
Measures to be implemented	Measure 1: Grants for investments in physical assets of agricultural holdings. Prioritization of grants for farmers with investments in fertilizer depots for manure management.

Sector	Agriculture
Title of policy measure	Agri-environmental schemes for biodiversity protection.
Timeframe	Agriculture Strategy 2022-2028
Main objective of policy measure	Strategic Objective 2: Sustainable management of natural resources (land, forests, and water); Specific Objective 2.3: Biodiversity protection, improvement of ecosystem services and conservation of habitats and landscapes/nature
Measures to be implemented	1. Extensive pasture management for high biodiversity lands in areas with proven biodiversity values, such as protected areas 2. Preparation of guidelines for farmers and pasture users for the use and management of value-added pastures

Sector	Agriculture
Title of policy measure	Agri-environmental schemes for biodiversity protection.
Timeframe	Agriculture Strategy 2022-2028
Main objective of policy measure	Strategic Objective 3: Development of businesses in rural areas and increase of employment and social infrastructure Specific Objective 3.2: Improve societal requirements for food and health, including safe, nutritious and sustainable food, reduction of food waste, and animal welfare
Measures to be implemented	Organic farming – subsidizing/compensating for farmers who follow the rules of organic farming, as their production is usually lower because of the ban on chemical fertilizers and pesticides

Annex 3.2. Additional materials – soils linked to climate change

Digital data sets produced by the EULUP Project

Agricultural Land Suitability (ALS)	This system is based on a visualization technique of mapping land use areas for land taxation purposes. Specific land use types are associated with particular land quality classes. However, such a methodology does not take account the influence of physical land properties on land use, land ownership or the quality of land management.
Construction Zoning Planning (CZP)	According to the Law on Spatial Planning (Article 17) the construction of houses in Kosovo* is only allowed in designated and officially declared construction areas (zones). These areas are defined in the Municipal Development Plan (MDP) and as such they form a legal basis for issuing building permits.
Estimated Biodiversity Value (EBV)	The proposed model is a quick reconnaissance screening process that indicates areas that may be rich(er) in biodiversity. EBV is not a direct measure of biodiversity but a best estimate in the absence of data.
Groundwater Sensitivity (GWS)	Groundwater sensitivity depends on those natural characteristics of a site that determine the amount and speed of vertical (downward) movement of pollutants. Groundwater sensitivity is assessed on the physical, chemical and biological properties of the soils and rocks beneath a site as these properties control the movement of pollutants to the water table. The factors which together define the sensitivity of groundwater resources include nature of geological strata (consolidated and unconsolidated) in the unsaturated zone; depth to groundwater; presence and nature of overlying soil.
Integrated Land Suitability (ILS)	The ILS method comprises two separate assessments: agricultural land suitability and environmental land sensitivity. ILS map is produced by applying an algebra formula within the MapAlgebra GIS tool.
Land Use Intensity Plan (LUIP)	The model has been built from data derived from the Land Assessment models. The agriculture class and forest/nature classes of integrated oLUP+CLC map have different modelling structure and different data.
Optimized Land Use Plan (OLUP)	The first task within the Rural Land Management Plan (RLMP) framework is to derive a map identifying the optimum land user across the varying landscapes of Kosovo*. Its implementation will ensure a more efficient use of land resources in terms of economics and environmental protection.
Soil Erosion Sensitivity (SES)	The mechanical stability of surface soils is a major consideration of this model. SES assessments will increase the awareness of soil erosion which should influence land management practices and help minimize the instances of erosion in sensitive areas.
Flood Risk (FLR)	The FLR identifies all cells that carry an increased flood risk. These are cells that lie close to larger rivers and in a plain
Groundwater Risk (GWR)	Groundwater is contained naturally within underground water-bearing strata (aquifers) of various types across Kosovo*. It is likely to be less polluted than surface waters though it is difficult to verify this. Groundwater in Kosovo* is important for small scale water supply, for agricultural use and for industry as well as sustaining the baseflow (summer flow) of rivers.
Rural Environment Action Plan (REAP)	Structure of this rEAP conceptual model comprises two decision trees (DTs) that are based on two major CLC 1st level categories and five LUIP land management types. It also integrates data describing: surface water bodies; Flood Risk areas (FLR); Groundwater Risk (GWR); Soil Erosion Risk (SER); and Estimated Biodiversity Value (EBV).
Soil Erosion Risk (SER)	The SER model has been set up specifically for assessing the risk of soil erosion on agricultural land within the Environmental Action Plan for rural areas (rEAP). SER provides a realistic assessment of contemporary soil erosion risk across the whole of Kosovo* as it incorporates the effects of current land cover.
Irrigated Areas (IRA)	All available information about man-made irrigation structures available to EULUP is collected in these datasets.

Annex 3.3. Additional materials – water resources linked to climate change

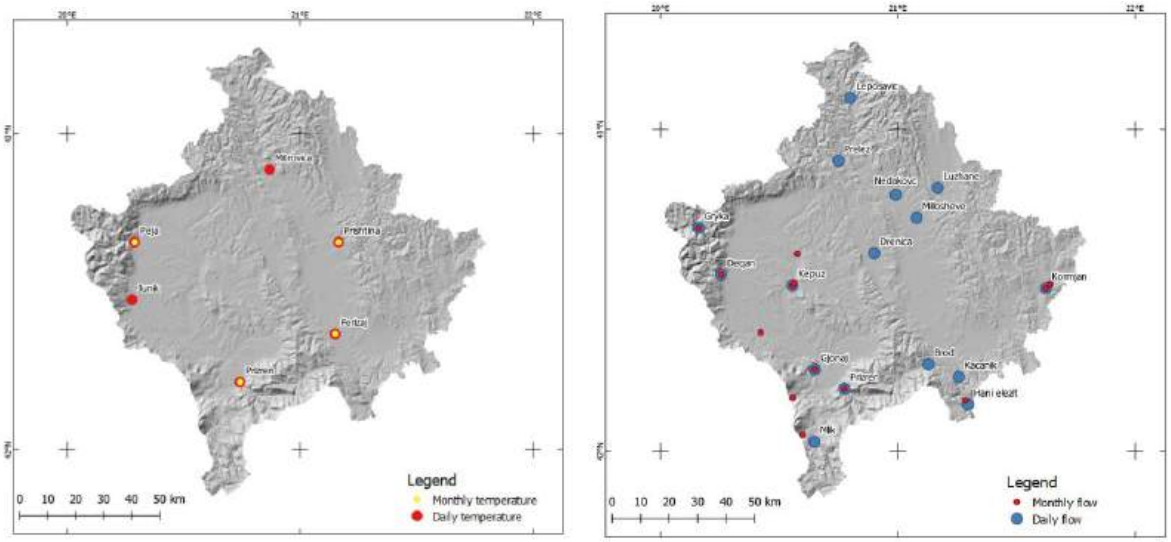


Figure A.3.1. Daily and monthly available temperature stations and available flow stations (HMIK)

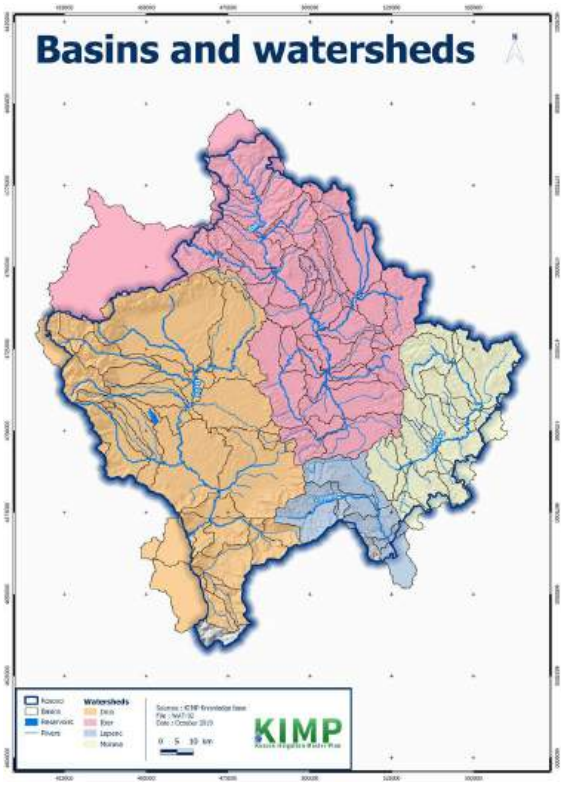


Figure A.3.2. Kosovo* river basins and watersheds

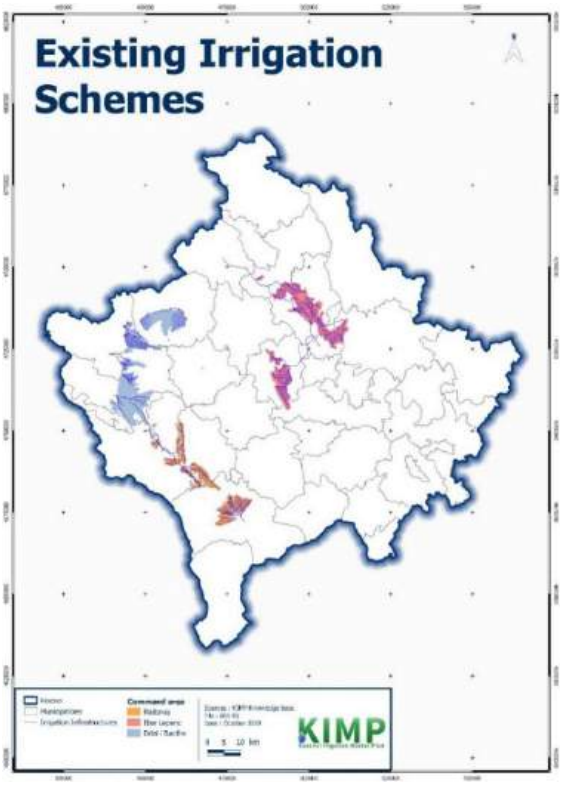


Figure A.3.3. Irrigation schemes in Kosovo*

Table A.3.1. Observed precipitation monthly average values

Station	Start	End	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pejë	2001	2018	69	68	79	51	73	66	41	43	55	71	91	84	791
Prishtinë	2001	2018	52	38	55	51	73	56	53	47	51	69	64	53	662
Ferizaj	2001	2018	51	40	59	60	81	70	57	49	57	78	65	62	731
Mitrovicë	1992	1998	26	40	50	44	49	39	49	41	61	46	62	47	552
Desivojce	2005	2018	83	76	89	72	90	66	46	43	51	77	93	77	863
Kotline	2005	2018	60	58	91	75	107	80	42	36	59	83	105	79	874
Prizren	1983	2018	50	68	66	60	50	55	58	50	68	75	76	48	722
Radoniq	2004	2018	91	102	112	58	90	67	41	23	55	90	103	86	916
Kijev	2005	2018	59	59	66	51	59	53	40	30	49	71	71	84	692
Malisheve	2005	2018	61	54	77	51	68	67	42	32	62	81	76	69	740
Budakov	2005	2018	65	52	79	67	96	77	63	37	52	83	76	68	816

Table A.3.2. Observed temperature monthly average values

Station	**Start**	**End**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Pejë	2002	2018	-0.2	2.2	6.7	11.1	14.7	19.6	22.2	22.1	16.3	11.5	6.3	0.9
Prishtinë	2001	2018	-0.1	3.6	7.4	11.8	16.0	20.6	23.4	23.4	16.6	11.7	6.8	2.1
Ferizaj	2001	2018	-0.7	1.7	6.0	10.8	15.1	19.0	21.3	21.4	16.2	10.8	5.7	1.0
Prizren	2005	2018	0.3	5.0	8.0	13.5	17.1	21.2	23.6	22.6	18.3	12.2	5.7	0.9

Table A.3.3. Observed precipitation monthly average values (Kosovo* Water Master Plan from 1983)

Station	**Start**	**End**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Bostani	1948	1978	54	51	48	62	84	74	55	48	53	82	84	61	756
Çallapek	1948	1978	94	78	62	64	74	65	53	34	62	83	106	95	870
Nëntë Jugoviqët	1948	1978	39	40	37	54	72	67	53	41	46	60	68	56	633
Dolci	1948	1978	72	56	52	54	65	54	57	42	55	68	90	85	750
Domorovci	1948	1978	43	44	52	46	67	63	49	33	49	51	63	57	617
Dulë	1948	1978	44	48	44	66	71	64	50	37	54	67	80	68	693
Gjakovë	1948	1978	108	90	78	74	75	47	52	43	75	90	123	127	982
Gllogjan	1948	1978	84	69	52	61	59	44	50	38	56	77	101	95	786
Gjilan	1948	1978	39	36	36	45	73	63	47	41	43	55	64	51	593
Janjevë	1948	1978	43	45	42	56	32	69	46	38	45	56	63	57	592
Junik	1948	1978	158	142	113	107	94	83	64	46	88	140	194	183	1412
Kjiev	1948	1978	54	47	39	50	79	54	49	40	57	60	81	70	680
Kamenica	1948	1978	44	40	40	39	58	61	49	38	43	51	58	49	570
Mitrovicë	1948	1978	42	40	40	46	60	68	48	41	44	54	67	58	608
Leshan	1948	1978	42	43	42	46	73	65	55	41	46	50	56	52	611
Nadakovc	1948	1978	47	42	38	49	63	65	50	45	48	55	70	37	609
Rahovec	1948	1978	59	58	53	58	69	65	54	40	67	68	84	77	752
Orllan	1948	1978	42	45	50	57	76	66	51	38	61	63	77	62	688
Pejë	1948	1978	97	71	71	64	76	63	53	42	53	85	114	101	890
Podujevë	1948	1978	39	42	37	51	70	68	52	40	49	56	67	51	622
Ponoshec	1948	1978	105	112	95	82	85	51	58	42	82	115	168	146	1,141
Prishtinë	1948	1978	35	35	34	51	72	73	47	43	48	54	62	51	605
Prizren	1948	1978	65	56	59	61	72	59	58	38	65	62	79	73	747
Suhareka	1948	1978	49	47	50	57	76	66	48	41	59	59	67	65	684

Station	Start	End	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Ferizaj	1948	1978	49	45	49	52	80	71	62	49	51	60	68	55	691
Vushtrri	1948	1978	45	41	35	45	61	62	50	48	48	56	67	57	615
Jazhinc	1948	1978	87	72	81	85	114	93	81	53	75	78	97	91	1,007
Kaçanik	1948	1978	80	66	69	68	94	70	63	43	59	77	90	79	858

Table A.3.4. Observed flow monthly average values in m3/s (elaboration of MESPI data)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Deqan	2.6	2.8	3.5	7.7	13.2	8.0	3.1	1.8	2.1	3.4	4.1	3.3	4.6
Domorovoc	5.0	7.7	8.6	6.6	5.5	3.9	1.8	1.1	1.2	1.8	2.9	3.9	4.1
Drelaj	2.4	2.8	3.9	9.4	12.2	5.5	2.0	1.3	1.7	2.5	4.3	3.9	4.3
Gjakovë	23.5	26.7	19.2	15.9	14.4	6.6	2.7	1.7	3.3	4.7	11.2	18.0	12.3
Hani Elezit/G. Jankovic	8.0	9.7	11.3	14.2	16.6	12.7	7.4	3.6	3.8	5.3	6.8	8.6	9.0
Gjonaj	60.1	70.8	68.2	80.4	82.1	44.9	19.2	10.7	16.9	32.1	51.3	61.3	49.8
Gryke	3.7	4.3	5.9	13.0	16.8	7.9	3.3	2.1	2.4	4.0	6.3	5.0	6.2
Kepuz- Drini	28.9	36.3	33.9	43.1	48.5	25.3	10.6	5.7	9.4	15.3	26.4	30.6	26.2
Kepuz-Mirusha	2.8	3.8	3.4	3.0	2.5	1.3	0.8	0.5	0.6	1.1	1.8	2.8	2.0
Kline	2.9	3.7	3.4	3.0	2.5	1.4	0.8	0.6	0.7	1.1	1.8	2.6	2.0
Kormirja	7.6	11.3	12.8	8.8	8.0	5.2	2.3	1.5	1.7	2.6	4.2	7.1	6.1
Orqusha	4.3	5.2	6.0	8.6	12.7	7.1	2.8	1.5	1.7	2.6	4.4	4.7	5.1
Prizren	5.4	4.4	5.2	6.1	9.0	6.5	3.5	2.3	2.3	3.1	4.9	4.3	4.8
Vermice	73.2	89.1	79.2	92.4	100.4	55.9	26.4	14.8	22.6	36.2	54.2	70.2	59.5
Kormirja	7.6	11.3	12.8	8.8	8.0	5.2	2.3	1.5	1.7	2.6	4.2	7.1	6.1
Orqusha	4.3	5.2	6.0	8.6	12.7	7.1	2.8	1.5	1.7	2.6	4.4	4.7	5.1
Prizren	5.4	4.4	5.2	6.1	9.0	6.5	3.5	2.3	2.3	3.1	4.9	4.3	4.8
Vermice	73.2	89.1	79.2	92.4	100.4	55.9	26.4	14.8	22.6	36.2	54.2	70.2	59.5

Table A.3.5. Total, utilized and arable lands and agriculture housholdes by municipalities and regions in Kosovo*, 2014 *(Census: Kosovo* Statistical Agency)*

Rajoni/Komuna	Total agriculture land		Utilized agriculture land		Arable land- arat		Gardens	
	Number of agriculture economies	Surface (ha)	Number of agriculture economies	Surface(ha)	Number of agriculture economies	Surface(ha)	Number of agriculture economies	Surface (ha)
KOSOVË	**130,662**	**512,000.29**	**129,884**	**413,635.16**	**113,231**	**180,381.11**	**46,458**	**1,054.99**
PRISHTINË	***32,080***	***117,698.30***	***31,801***	***92,297.66***	***29,743***	***49,945.00***	***11,232***	***252.62***
Fushë Kosovë	1,782	5,245.22	1,760	4,714.06	1,670	3,278.14	475	10.16
Gllogoc	6,559	20,624.98	6,516	15,125.52	5,867	8,181.69	2,833	61.70
Graçanicë	1,756	6,141.66	1,726	5,658.85	1,703	4,989.73	447	10.78
Lipjan	6,215	21,549.90	6,143	18,547.41	5,874	10,304.87	1,795	38.79
Novobërdë	1,267	6,440.70	1,261	4,949.58	1,207	2,281.80	647	14.64
Obiliq	1,944	6,263.61	1,928	5,519.32	1,831	3,413.53	328	9.24
Podujevë	9,176	32,038.69	9,123	24,807.27	8,544	12,317.19	3,646	82.38
Prishtinë	3,381	19,393.54	3,344	12,975.65	3,047	5,178.05	1,061	24.93
MITROVICË	***15,267***	***61,666.68***	***15,190***	***48,148.73***	***13,831***	***25,893.69***	***4,822***	***107.96***
Leposaviq	:	:	:	:	:	:	:	:
Mitrovicë	2,803	13,278.38	2,786	10,942.41	2,058	2,297.54	792	17.50
Mitrovicë e Veriut	:	:	:	:	:	:	:	:
Skënderaj	6,232	27,559.12	6,205	19,700.73	5,983	12,703.41	2,261	50.59

Rajoni/Komuna	Total agriculture land		Utilized agriculture land		Arable land- arat		Gardens	
	Number of agriculture economies	Surface (ha)	Number of agriculture economies	Surface(ha)	Number of agriculture economies	Surface(ha)	Number of agriculture economies	Surface (ha)
Vushtrri	6,232	20,829.18	6,199	17,505.59	5,790	10,892.74	1,769	39.87
Zubin Potok	:	:	:	:	:	:	:	:
Zveçan	:	:	:	:	:	:	:	:
PEJË	***15,535***	***67,025.48***	***15,476***	***56,626.37***	***13,840***	***26,447.33***	***5 592***	***139.43***
Istog	5,058	23,443.52	5,047	20,653.91	4,410	9,091.08	2,027	50.51
Klinë	4,442	18,758.94	4,419	14,947.55	4,243	10,214.33	1,462	34.41
Pejë	6,035	24,823.02	6,010	21,024.91	5,187	7,141.92	2,103	54.51
PRIZREN	***23,534***	***97,597.08***	***23,425***	***80,647.22***	***18,483***	***22,210.12***	***8,593***	***196.49***
Dragash	2,710	28,708.50	2,691	27,662.24	1,277	386.80	863	17.03
Malishevë	6,579	21,286.95	6,553	14,908.73	5,793	8,939.20	2,327	52.30
Mamushë	486	1,270.02	479	1,229.19	474	933.23	98	2.78
Prizren	6,570	25,181.48	6,521	21,777.10	4,836	5,704.71	2,095	46.28
Suharekë	7,189	21,150.13	7,181	15,069.96	6,103	6,246.18	3,210	78.10
FERIZAJ	***14,807***	***48,109.16***	***14 696***	***38,772.92***	***11,793***	***14,836.78***	***6,080***	***125.43***
Ferizaj	7,373	22,434.53	7,298	18,708.56	5,817	9,077.18	2,512	53.85
Hani i Elezit	656	2,581.86	655	1,825.90	299	262.49	400	8.66
Kaçanik	2,908	10,156.56	2 903	7,883.43	2,361	1,516.57	1,456	27.68
Shtërpcë	1,355	4,806.14	1,352	4,227.35	1,081	294.40	743	15.72
Shtime	2,515	8,130.07	2,488	6,127.68	2,235	3,686.14	969	19.52
GJILAN	***14,294***	***59,782.40***	***14,229***	***49,960.30***	***13,473***	***20,933.17***	***6,265***	***145.78***
Gjilan	4,369	18,499.28	4,339	14,624.11	4,165	5,949.88	1,919	46.36
Kamenicë	3,069	18,110.19	3,059	14,928.75	2,958	4,323.51	1,042	23.74
Kllokot	511	1,566.50	510	1,213.45	508	804.84	158	4.59
Partesh	505	1,129.32	504	1,032.35	502	898.80	226	5.90
Ranillug	826	2,345.05	825	1,855.83	823	1,143.63	517	13.93
Viti	5,014	18,132.06	4,992	16,305.81	4,517	7,812.51	2,403	51.26
GJAKOVË	***15,145***	***60,121.19***	***15,067***	***47,181.96***	***12,068***	***20,115.02***	***3,874***	***87.28***
Deçan	3,935	11,447.57	3,917	10,043.88	2,874	2,901.94	1,370	29.86
Gjakovë	5,477	28,059.50	5,440	21,378.34	4,366	7,422.08	1,778	41.35
Junik	343	1,993.36	342	1,298.16	245	604.86	178	3.49
Rahovec	5,390	18,620.76	5,368	14,461.58	4,583	9,186.14	548	12.58

Table A.3.6. Irrigation water requirement, irrigation techniques and irrigation regime by group of crops in average arid conditions

Crops	Average irrigation water requirements by season in Kosovo* (mm)	Applied irrigation techniques	Irrigation efficiency	Average irrigation application rate (mm)	Number of applications during the season
Maize	285	Sprinkler	80-85%	60	5
Sunflower	240	Sprinkler	80-85%	65	4
Fodder crops – alfalfa	400	Sprinkler	80-85%	90	5
Vegetable (tomato, pepper)	360	Sprinkler/drip	80-95 %	10-12	20-40
Orchards – apple, plum, cherry	380	Drip irrigation	80-95 %	18	20

Table A.3.7. Producers' adaptive capacities in Kosovo*

Indicator	Lists	If yes, please note used area (e.g. in ha or in % from total irrigated area in the economy, number of farmers, number of farms, etc.)	Source (literature; documents, studies; projects/expert opinion, etc)	Comments
Micro-irrigation	Drip irrigation	3,300 ha or 15 % of total irrigated area / or around 0.8% of total utilized agricultural area	Green Report, 2016	According to the report and our terrain experience, almost all orchards, partly vegetable crops in the economy are irrigated by drip irrigation
	Micro sprinkler	Hard to estimate		Micro sprinklers are used in seedling production, production in greenhouses, and for frost protection
	Drip Fert irrigation	0.48% or 2,000 ha of total utilized agricultural area	Expert opinion	Drip fertigation is used mainly in modern fruit tree plantations/orchards and partly in greenhouses
Irrigation scheduling practices	Irrigation programmes	10% or round 40, 000 ha of total utilized agricultural area	Expert opinion	Used in areas where training programmes and courses were realized through different donor programmes in the economy and programmes provided by the business sector selling drip irrigation systems
	Sensors and data loggers	0.5% of total utilized agricultural area	Expert opinion	Used in areas where training programmes and courses were realized through different donor programmes in the economy
	Tensiometers	1% of total utilized agricultural area	Expert opinion	Used in areas where training programmes and courses were realized through different donor programmes in the economy
	Meteo stations	3% of total utilized agricultural area	Expert opinion	Meteo stations are used for irrigation only in commercialized farms. Individual agricultural holdings use info generally from media.
Soil moisture conservation methods	Organic mulch materials		Experts experiences in several investigations	Used mainly demo-plots where training programmes and courses were realized through the different donor programmes in the economy or horticulture producers cooperating with horticulture processors supported by the WB ARDP project or other donors
Training programmes	Lifelong learning programmes within universities			
	Vocational training programmes related to water	Around 750 students in the last 10 years have taken courses in irrigation of agricultural crops, drip fertigation and water quality in agriculture	Agriculture Faculty in Prishtinë and Pejë	All graduate programmes in plant crop production, post-graduate programme in Irrigation of Agricultural Crops
	Targeted training courses for farmers and young professionals	Around 450 farmers in the last 20 years have taken courses in best practices of irrigation of agricultural crops for proper use of water in Agriculture	Projects supported by different donors in the economy (EU, WB, SDC) together with MAFRD Extension Services and Department for Plant Production and Protection	EU Kosovo* Irrigation Rehabilitation Project KIRP II in addition to organized workshops, pilot farms and trainings, a detailed handbook has been prepared with best irrigation practices with the aim of efficient water use and minimizing water losses for all stakeholders including farmers. Every year, MAFRD organizes trainings and publishes brochures and manuals for farmers on different topics for crop production and best irrigation practices, developed by experts from specialized local companies.
Others	UV nets	Hard to estimate	Expert opinion	Used in commercial farms owned by them or through different donor programmes in the economy.

Study case: drip fertigation in commercial farm Me Agro








Annex 3.4. Additional materials – crop production linked to climate change

Table A.3.8. Most important crops in Kosovo*

Rank	Most important crops	Average area in the last 5 years (ha or number of trees)	Average yield in last 5 years (t/ha)
1	Maize	38,647.80	4.18
2	Pepper	3,092.20	18.02
3	Grape	3,349.20	6.84
4	Apple	2,773.60	10.42
5	Raspberry	1,546.20	4.72

Table A.3.9. Number of meteorological and phenological stations in Kosovo*

Meteorological stations	Automated Weather Stations (AWS)	Total weather stations	Phenological stations
4	12	16	0 (no institution responsible, only project activities)

Table A.3.10. Meteorological data available in Kosovo* required for implementing climate change analysis

Parameter	**Daily Max T**	**Daily Min T**	**Daily RH**	**Daily precipitation**	**Average daily wind speed**	**Daily sunshine duration**
Period covered	1950-present	1950-present	1950-present	1950-present	1950-present	1950-present
Number of stations	4	4	4	4	4	4
Coverage	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy

Since 2014, 12 meteorological stations have been operationalized, equipped with automatic measurement capabilities and real-time data transfer to the central system for collection and archiving. These automatic stations monitor the following parameters:

- Relative humidity Rh (%)
- Rainfall amount (mm)
- Air pressure (hPa)
- Continuous temperature (°C)
- Wind speed and direction (m/s)
- Radiation (W/m2)

Table A.3.11. Extreme weather events recorded in Kosovo*

Extreme event	**Date reported**	**Region affected**	**Affected area (in ha)**	**Affected crops and impact**
Hail	June 2013	Vineyard zone Suhareka	55	Damage to grapevine and bunches, high impact
Hail	May 2016	Vineyard zone Rahoveci	180	Damage to grapevine and bunches, high impact
Hail	May 2017	Vineyard zone Rahoveci	347	Damage to grapevine and bunches, high impact
Hail	June 2017	Vineyard zone Suhareka	180	Damage to grapevine and bunches, high impact
Hail	June 2017	Vineyard zone Rahoveci	220	Damage to grapevine and bunches, high impact
Hail	June 2023	Vineyard zone Rahoveci	197	Damage to grapevine and bunches, high impact
Flood	January 2021	Kosovo* Plain		High impact
Drought	2009-2015	All Kosovo*		High impact, 30.4 million EUR
Spring Frosts	2016	All Kosovo*		High impact, 5.1 million EUR
Extremely high temperatures	2017- 2021	All Kosovo*		High impact, 20.7 million EUR
Spring Frosts	2017	All Kosovo*		High impact, 17.9 million EUR
Hail	2020	All Kosovo*		High impact, 2.9 million EUR

Table A.3.12. New crop pests and diseases recorded in Kosovo*

Crop/disease Latin name	Crop/disease English name	First recorded	Crops/Cropping system affected	Level of spreading	Risk for production and productivity
Phytophtora capsici	Phytophtora capsici	It appeared as a disease in the 1970s	Pepper	Low	High
Flavescence dorée	Grapevine yellow	2021	Vineyards	Low	High
Esca	Black measles	2021	Vineyards	Low	High

Table A.3.13. The most vulnerable regions and crops to climate change in Kosovo*

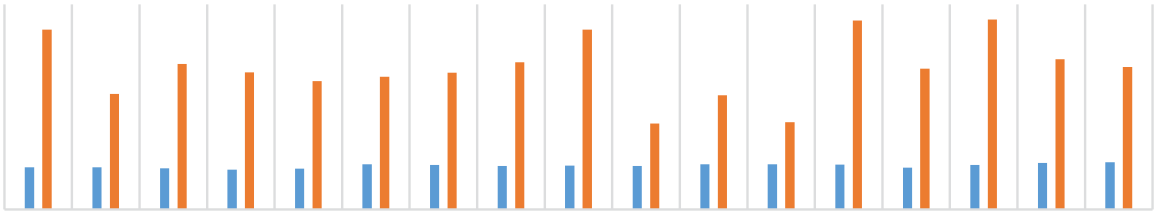
Most vulnerable regions	Crops
Dukagjin District	Hail damages on vegetable crops and vineyards
Kosovo* Plain, Podujevë	Raspberries and peppers
Kosovo* Plain, Vushtrri	Potatoes and strawberry

Table A.3.14. Climate change adaptation practices used or tested in Kosovo*

	Best adaptation practice in place	Farms affected	Tested
Drought	Water saving through the drip irrigation system	Small and big	High
Insolation	Greenhouse slaked lime to the interior roof use shading nets to protect the vines from intense sunlight	Small and big	High
Hail	Hail nets	Small and big	High

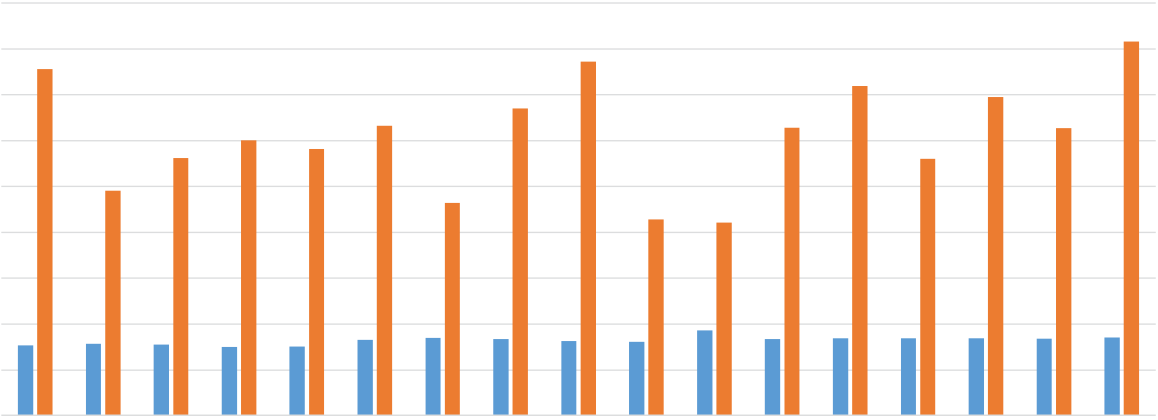
Annex 3.5. Additional materials – livestock farming linked to climate change

PRISHTINË



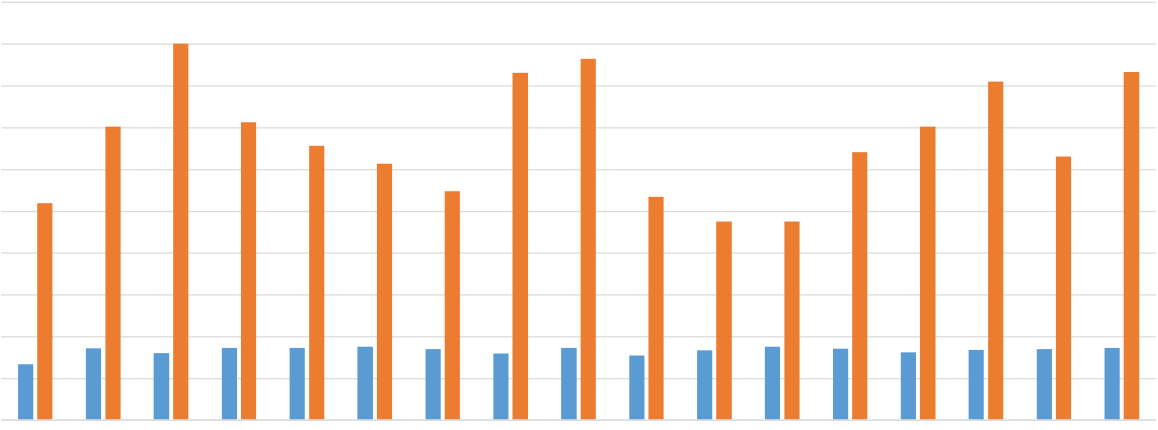
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tmax	16.4	16.5	16.1	15.5	15.9	17.6	17.3	17	17.1	16.9	17.6	17.6	17.5	16.3	17.3	18.2	18.4
tot.rainfall	70.2	45.1	56.7	53.5	50.1	51.8	53.4	57.4	70.2	33.5	44.6	34	73.7	54.9	74.1	58.6	55.6

FERIZAJ



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tmax	15.4	15.7	15.5	15	15.1	16.6	17	16.7	16.3	16.1	18.6	16.7	16.9	16.9	16.9	16.8	17.1
tot.rainfall	75.6	49.1	56.2	60.1	58.2	63.2	46.4	67	77.2	42.8	42.1	62.8	71.9	56	69.5	62.7	81.6

PEJË

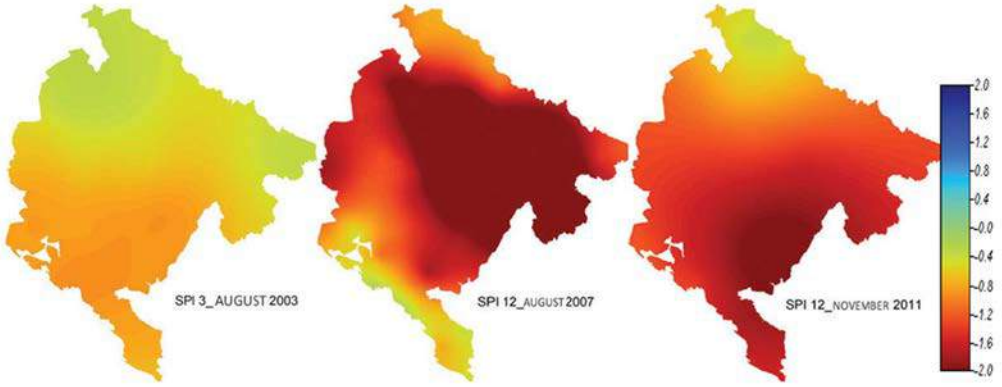


	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tmax	13.4	17.3	16.1	17.4	17.4	17.6	17.1	16	17.4	15.5	16.8	17.6	17.2	16.3	16.9	17.1	17.4
tot.rainfall	52	70.3	90.1	71.3	65.7	61.4	54.8	83.1	86.5	53.5	47.6	47.6	64.2	70.3	81	63.1	83.3

Figure A.3.4. Values of maximum temperatures and total average annual precipitation for the referent climate period 2002-2020, source HMIK

Annex 4. Montenegro climate change adaptation in agriculture – additional materials

Annex 4.1. Additional materials – water resources linked to climate change



Map A.4.1. Map of Drought Intensity 2003, 2007 and 2011 Expressed Through Anomalies of the SPI Index: SPI3 – Agricultural Drought 2003, SPI12 – Hydrological Drought 2007 and 2011

Source: Second National Communication on Climate Change

Table A.4.1. Irrigation systems

System/object	Municipality	Area (ha)	Irrigation method
A. Abandoned irrigation systems			
I Adriatic basin			
Sutorina	Herceg Novi	100	Drip irrigation
Mrčevo polje	Budva	250	Artificial rain
Experimental section	Ulcinj	150	Drip irrigation
Total I		500	
II Danube Basin			
Lužac-Dolac	Berane	30	Artificial rain
Brezojevica	Plav	150	Artificial rain
Doganje	Pljevlja	90	Artificial rain
Total II		270	
Total A		770	
B. Systems in operation			
I Adriatic Basin			
Ćemovsko polje (2310 ha)	Podgorica	1210	Drip irrigation
		1100	Artificial rain
Locally	-	13000	Combined (artificial rain and furrow)
Total I		15310	
II Danube Basin			
Local (traditional)	-	3000	Combined (drip irrigation, artificial rain and furrow)
Total II		3000	
Total B		18310	

Source: Water Management Strategy of Montenegro, Podgorica, 2017, page 64

Table A.4.2. Irrigation area

IRRIGATION	2016	2017	2018	2019	2020
Used water quantities, thousand m^3	6,564	6,965	6,815	6,821	7,353
From groundwaters	6,532	6,933	6,758	6,750	7,344
From surface waters	32	32	57	71	9
Water quantities consumed, million m^3	6,239	6,240	6,615	6,620	7,352
Total area irrigated, ha	**2,346**	**2,346**	**2,361**	**2,364**	**2,447**
Surface irrigation	5	5	9	11	9
Artificial rain	505	505	513	517	484
Drip irrigation	1,835	1,836	1,839	1,836	1,954
Arable fields and gardens	26	26	28	30	91
Orchards	98	98	92	90	113
Vineyards	2,222	2,222	2,241	2,244	2,243
Pumping plants	41	41	44	47	50
Pipelines, km	193	205	219	244	245
Main	70	72	68	75	74
Distributive	123	133	151	169	171

Source: Statistical Yearbook, 2022 – Climate and Environment – Monstat

Table A.4.3. Producers' adaptive capacities in Montenegro

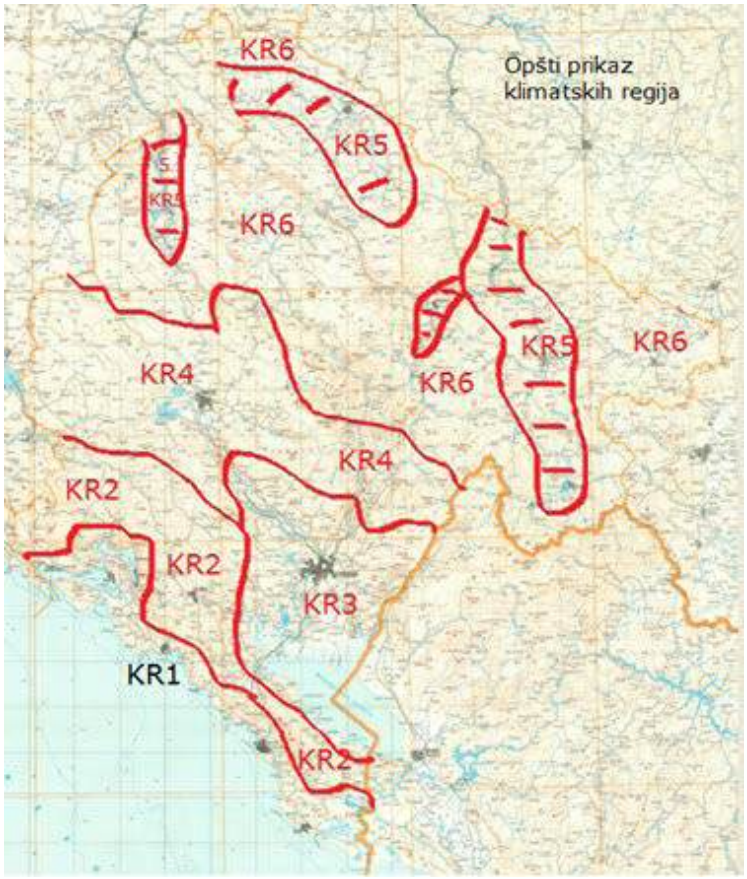
Indicator	Lists	Yes	No	If yes, please note used area (e.g. in ha or in % from total irrigated area in the economy, number of farmers, number of farms, etc.)	Expert opinion	Comments
Micro-irrigation	Drip irrigation	Yes		11 % of total agricultural utilized land.	Monstat	Primarily used in vineyards.
	Micro sprinkler	Yes		Hard to estimate		Micro sprinklers are used in seedling production and flower production in greenhouses, and for frost protection.
	Drip fertigation	Yes		Hard to estimate		
Irrigation scheduling practices	Irrigation programmes	Yes				Implemented in regions where training programmes and courses were conducted, supported by various donor initiatives within the economy and by programmes offered by the business sector involved in selling drip irrigation systems.
	Sensors and data loggers	Yes		Sporadic use	Expert opinion	Used on test plots
	Tensiometers		No		Expert opinion	
	Meteo stations	Yes		15% of total utilized agricultural area	Expert opinion	There are several ideas and projects that aim to use weather stations for irrigation (and plant protection)
Soil moisture conservation methods	Organic mulch materials	Yes		It is used on small areas	Expert opinion	The experience of experts is that it is more related to gardens
	Inorganic mulch material	Yes		Hard to estimate	Expert opinion	Mainly in vegetable and strawberry production in the economy
Training programmes	Lifelong learning programmes within universities	Yes		Occasional consultations with extension services and academia	University of Montenegro – Biotechnical Faculty	Occasional trainings
	Vocational training programmes related to water	Yes		Around 800 students in last 15 years have taken courses in amelioration	University of Montenegro – Biotechnical Faculty	Graduated programmes in plant crop production
	Targeted training courses for farmers and young professionals	Yes		Occasional consultations with agricultural producers and lectures in agreement with associations of agricultural producers	University of Montenegro – Biotechnical Faculty	Realization as part of fertility control activities and individual donor projects
Other	UV nets			Hard to estimate		It is used by farmers who are aware of the advantages but also have sufficient financial resources
	Cover crops			Hard to estimate		It is used by farmers who are aware of the advantages but also have sufficient financial resources

Annex 4.2. Additional materials – crop production linked to climate change

Annex 4.2.1

It is a rare phenomenon anywhere else in the world to encounter several climate types, subtypes and varieties in such a small area as Montenegro. Waters of the Atlantic and the Mediterranean and the Eurasian mainland have a major role in modifying the climate. There are three main types of climate in Montenegro:

- Mediterranean and the modified Mediterranean (coastal and Zeta-Bjelopavlići plain, with the surrounding mountainous terrain up to 600 m above sea level)
- Continental climate (continental part of Montenegro, up to 1000 m a.s.l. and valleys of rivers Ibar, Lim, Tara, Piva and Ćehotina) and
- Sub-mountain (above 1000 ma.s.l.) and mountain climate (above 1500 m a.s.l.)



Map A.4.2. Climatic regions (KR) in Montenegro

Based on a large number of climatic factors (location, position in relation to continental and large water surfaces, direct interaction with large water surfaces, topography and orientation of the terrain, great heterogeneity of the terrain, branched hydrographic boundary and mountain massifs), Montenegro is divided into 6 climatic regions.

Climatic region 1: coastline and the coastal part at an altitude of about 500-600 m. a.s.l. (coastline -– Ulcinj , Bar, Budva, Kotor, Tivat, Herceg Novi and the hinterland up to 500-600 m a.s.l.). This region has a maritime type of climate, moderately hot and dry summers and mild winters, the cold part of the year is rainy. Temperature amplitudes throughout the year are relatively small. In specific rare situations, along the coastal belt itself, high tropical temperatures of up to 40°C can occur, which do not last long. Strong winds are known as Jugo (southern directions associated with cyclonic activity) and Bura (north-northeasterly, associated with an anticyclone and its interaction with a cyclone in the central Mediterranean and the Ionian Sea). In the annual precipitation regime, periods of maximum and minimum are clearly distinguished, which is a characteristic of the maritime

type of precipitation. The main characteristics of this climatic region are average annual temperature 13-16°C; average temperature for the growing season (April-October) 20-22°C, average annual temperature amplitude 16-18°C, average annual rainfall 1500-2000 lit/m^2, average number of rainy days 120-140, and average annual number of sunny hours 2,000-2,500. The rainiest period is November-December, when about 50% of the total annual precipitation falls.

Climatic region 2: mountainous hinterland of the Adriatic and southwest of Montenegro – wider region of Orjen (Cetinje, Grahovo, Crkvice, Vrbanj). This region represents the border area between land and sea and is characterized by a modified maritime-continental climate, with minor admixtures of mountain climate. This is the rainiest climate region in Montenegro. The type of precipitation is purely maritime with accentuated rainy and dry periods. Also, large snowfalls can occur in this region, up to 200 cm in extreme situations. It is characterized by very pronounced temperature oscillations. The daily temperature amplitude is up to 20°C, and the annual temperature amplitude is up to 50°C. The main characteristics of this climate region are: average annual temperature around 10°C, and in mountainous areas around 4-6°C, average annual rainfall 3,000-5,000 lit/m^2, the rainiest period of the year is October--January, when about 50% of the total annual precipitation falls. The least amount of rain falls in the period June--August, only about 10% of the total annual amount. The rainiest month is November, when about 500-700 lit/m^2 falls.

Climatic region 3: central part of the Zetskobjelopavlić plain up to about 500-600 m a.s.l. (Podgorica, Danilovgrad, Zeta, Tuzi, Virpazar). This region has a continental type of climate, significantly modified by the maritime influence. Summers are long, very hot and dry with high tropical temperatures reaching and exceeding 40°C. Winters are generally mild with a dominant absence of snow. The cold part of the year is rainy. This climatic region is characterized by very strong stormy northerly winds. Northerly winds can be very strong, often with a stormy character, in extreme cases up to around 40 m/s. The autumn-spring transitional period is very short. The main characteristics of this climate region are: the average annual temperature is around 13-16°C, the hottest month is July with an average temperature of 24-28°C, the coldest month is January with an average temperature of 4-6°C, the average annual amount precipitation is 1,600-2,000 lit/m^2, the average annual number of summer days is 120-140, and 60-90 tropical days. The rainiest period is October- January, during which about 50% of the total annual precipitation falls. In the driest period of the year, June- August, only 15% of the annual amount falls.

Climatic region 4: western part of Montenegro and central part from 500 to 1,000 m a.s.l. (Nikšić, Šavnik, Plužine, Krstac, Vilusi, Velimlje). This climatic region has a rather homogeneous continental climate, significantly modified by the maritime type and with minor modifications by the mountain type. Summers are moderately warm and winters are cold. The region is characterized by significant precipitation, and heavy snowfall is certain during the winter. In some summer situations, high tropical temperatures between 35 and 40°C can be realized in the lowest basin and valley parts of this region. Late spring and early autumn frosts are common here, while severe frosts during clear winter nights are a regular occurrence. The main characteristics of this climatic region are the average annual temperature is about 8°C at higher to 11°C at lower altitudes, the average annual amount of rain is 1,800-2,400 lit/m^2, and the average annual insolation is 1,800-2,300 hours.

Climatic region 5: northern lowlands at 600-1,000 m a.s.l. (Berane, Bijelo Polje, Pljevlja, Andrijevica, Plav). This climatic region has a continental type of climate with moderately warm summers and cold winters. The annual precipitation regime is uniform, which means that there are no pronounced rainy and dry periods. The duration of seasons is balanced. This region has the lowest amount of precipitation in the territory of Montenegro. Temperature amplitudes are large and reach an average of 50-60°C on an annual basis, and 20-25°C on a daily basis. During winter, in the valley areas, during cold, clear nights, the so-called lakes of cold air are formed with extremely strong temperature inversions, where temperatures can drop to -30°C. The temperature during the summer in these areas can reach around 35-40°C. The appearance of frost and severe frost is something that happens regularly here in the cold part of the year. Also, there is a high risk of late spring and early autumn frosts that can cause great damage in the agricultural production sector. The main characteristics of this climatic region are average annual air temperature 7-10°C, average annual rainfall 700-1,000 lit/m^2, and average annual insolation of 1,700-1,900 hours.

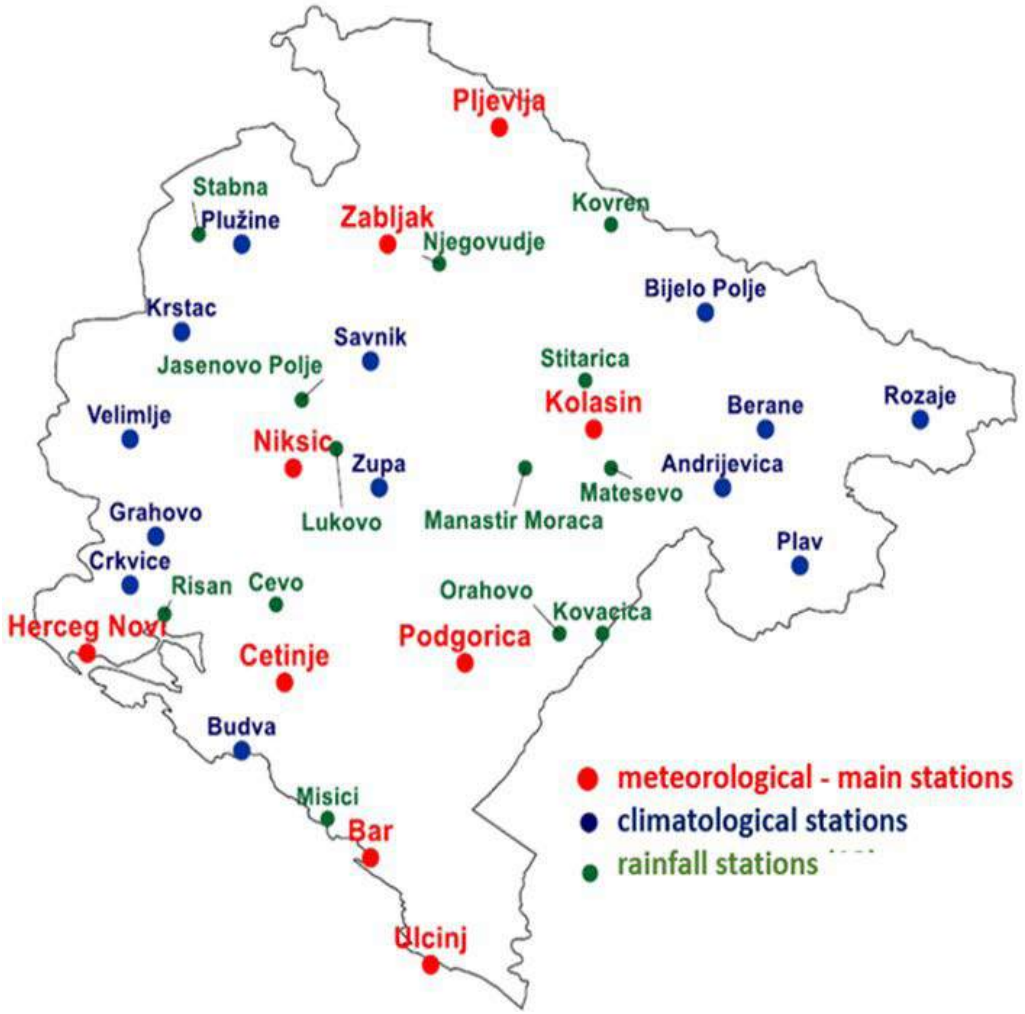
Climatic region 6: mountainous northern and central part of Montenegro from 1,000 m a.s.l. and more – Žabljak, Kolašin, Rožaje, Mojkovac). This climatic region includes mostly mountainous areas above 1,000-1,200 m a.s.l. It is characterized by a continental mountain climate, modified by the Mediterranean influence. The main characteristic of this climate is strong winters with snowfall and blizzards, pleasantly warm summers and strong southerly winds. The summer period is limited to June-August. During winter in the highlands, extremely low temperatures can reach below-30°C. Daily air temperature amplitudes are high. During most of the year, humidity is high. Smaller limited parts of this region (the highest mountain locations) have an average annual temperature below zero, which by definition means that in these localities an icy type of climate is represented, although in the summer the temperature can reach around 25°C. In the summer period, the maximum daily temperature is around 20-25°C, with the fact that at the heights of around 1,500 m a.s.l. in extreme meteorological situations it can reach and exceed 30°C. The precipitation regime is fairly uniform throughout the year, but there is still a clearly differentiated rainy period and a period with less precipitation. The summer period, especially June, can have a significant amount of rain. The maritime type of precipitation is strongly felt in this region, even though it is a continental climate region. The average maximum height of the snow cover is around 200-240 cm (for reference elevations at around 1,500 m a.s.l.). The main characteristics of this climate region are average annual air temperature from -2°C (at the highest elevations) to 8°C (at the lowest elevations around 1000 m a.s.l.), average annual rainfall of around 1,000-2,200 lit/m^2 and average annual duration sunrise around 1,400-1,600 hours.

Monitoring of meteorological indicators takes place at about 20 meteorological stations throughout Montenegro.

Table A.4.4. List of measuring stations

No	Station name	Latitude	Longitude	Elevation	Station type
1	Andrijevica	424400	194700	772	Climatological
2	Bar	420600	190500	5.7	Main
3	Berane	425100	195300	691	Climatological
4	Bijelo Polje	430200	194400	606	Climatological
5	Budva	421700	185000	2	Climatological
6	Crkvice	423400	183800	937	Climatological
7	Cetinje	422300	185500	640	Main
8	Grahovo	423900	184000	695	Climatological
9	Herceg Novi	422700	183300	10	Main
10	Kolašin	425000	193100	944	Main
11	Krstac	430000	184200	1017	Climatological
12	Nikšić	424600	185700	647	Main
13	Podgorica	422600	191700	49	Main
14	Plav, not operational	423600	195700	933	Climatological
15	Plužine	430900	185100	780	Climatological
16	Pljevlja	432100	192100	784	Main
17	Rožaje	425100	201000	1007	Climatological
18	Šavnik	425700	190600	825	Climatological
19	Ulcinj	415500	191300	29	Main
20	Žabljak	430900	190700	1,450	Main
21	Župa	424400	190700	789	Climatological
22	Čevo	423200	185500	760	Rainfall
23	Jasenovo Polje	425300	185600	940	Rainfall
24	Kovren	431100	193400	1,050	Rainfall
25	Kovačica	422900	193300	944	Rainfall
26	Lukovo	424800	190200	840	Rainfall

No	Station name	Latitude	Longitude	Elevation	Station type
27	Manastir Morača	424600	192400	270	Rainfall
28	Mateševo	424600	193400	990	Rainfall
29	Mišići	421000	190100	150	Rainfall
30	Njegovuđa	430700	191400	1,315	Rainfall
31	Orahovo	422900	192800	875	Rainfall
32	Stabna	431000	184600	780	Rainfall
33	Štitarica	425500	193100	1,050	Rainfall



Map A.4.3. Measuring stations (in 2022)

Annex 4.2.2

Analysis of climatic anomalies, expressed through differences in values of climatic parameters between climate normal (1961-1990) and the ten-year period from 2013 to 2022, shows that the climate in Montenegro is rapidly changing. There is an increasing frequency of extreme rainfall and floods, extreme air temperatures and drought. From the aspect of agricultural production, temperature is one of the most important climatic parameters, and these anomalies are most pronounced in the temperature regime that. Constant growth of air temperature is happening both in winter and in summer. The greatest increase in average annual air temperature compared to the climate normal was recorded in the area of climatic region 5 (area of continental climate; municipalities of Berane, Bijelo Polje, Pljevlja, Andrijevica and Plav). In the studied ten-year period, the temperature increased by 2.3°C (from 7.7°C to 10°C). In relation to the period 1961-1990, the average annual air temperature also increased significantly in climate region 6 (area of mountain climate; municipalities of Žabljak, Kolašin, Rožaje and Mojkovac) and was higher by 2°C (from 4.8°C to 6.8°C). The smallest increase in average annual temperature was recorded in climate regions 1 and 2 (maritime and modified maritime-continental climate)-1.2°C.

The number of tropical days and the duration of warm tropical waves increased significantly in the observed period. In the last 10 years, the average annual number of tropical days (when the maximum daily temperature reaches and exceeds 30°C) in climate region 3 increased from 66.1 in the period 1961-1990 to 90 days in the period 2013-2022, in region 1 from 25.4 at 68.9 and in region 2 from 18.1 at 42.9.

Compared to the climate normal, the average annual number of frosty days in region 6 (area of mountain climate) decreased from 166 to 131.9 (26% less), in region 3 (modified maritime climate) from 28.8 to 18. 9 days (52% less) and region 1 (maritime climate) from 7.4 to 6.6 (12% less).

Regarding the amount of precipitation, no significant changes were found between the observed periods, but there are significant changes in the precipitation regime – pronounced rainy and dry periods during the year. In relation to the climate normal (1961-1990), the total annual amount of precipitation slightly increased in all climate regions (from 0.64% in region 1 to 5.83% in region 3), except in climate region 4 where less precipitation was registered (-2.49%). Reduction in the number of days with strong precipitation and increase in the amount of precipitation during that period indicates an increase in precipitation intensity, as well as the occurrence of extreme unfavourable weather conditions, such as flooding.

Annex 4.2.3

The formation of yield is influenced by numerous factors, however, final yield mostly depends on the duration of the growing season. Longer vegetation period creates conditions for the formation of higher yield. That is why the optimal sowing period is one of the most important agrotechnical measures in plant production. The resistance of plants to adverse weather conditions (frost, drought, etc.), as well as the occurrence of diseases, pests and weeds, depends on the timely sowing date. Sowing time is the factor that modifies yield the most, but also practically determines the intensity of action of all other agrotechnical measures (fertilization, application of herbicides, etc.).

Due to excessive spring rainfall, the sowing of most of the main crops in Montenegro is often delayed. With the delay in sowing, the growth and development of plants shifts towards the warm summer months, so newly emerged plants immediately face high temperatures and drought. In such conditions, most growth stages are shortened, and thus the biomass accumulation period. At high temperatures, the physiological processes in the plant noticeably slow down, so the vegetative growth is significantly weaker. High temperatures, even with a sufficient amount of water, lead to a drop in yield and a decrease in its quality.

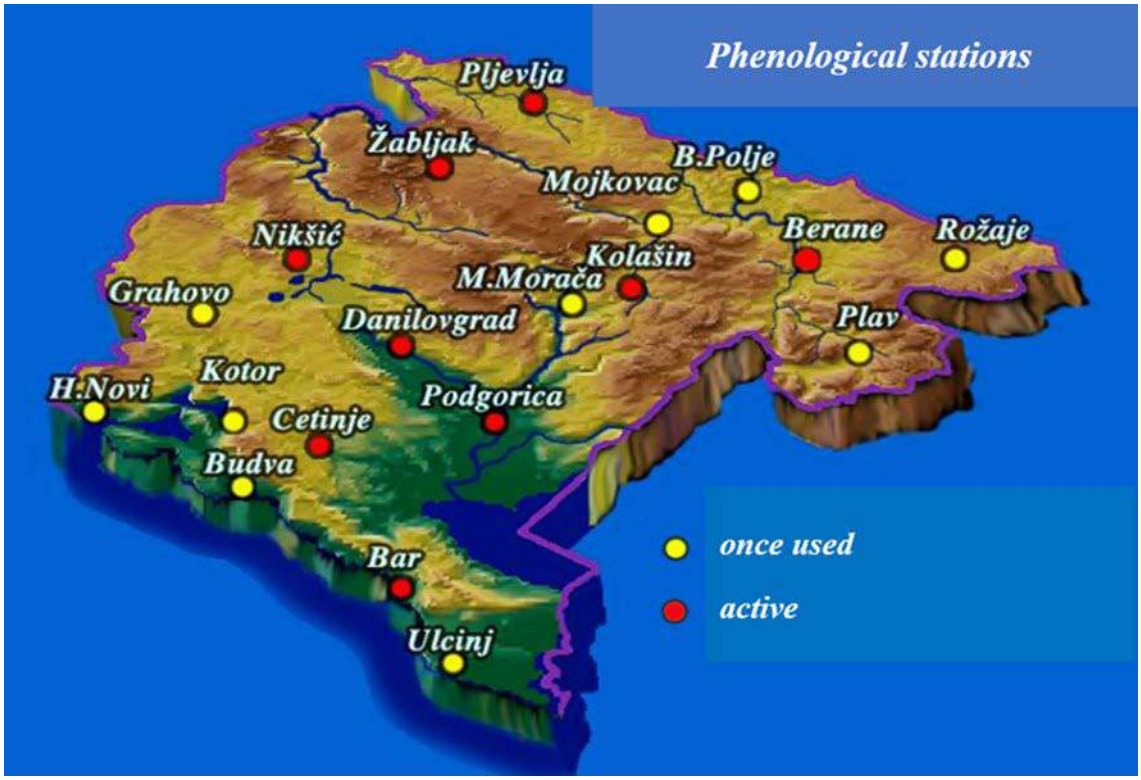
Potatoes are one of the most important agricultural crops in Montenegro, which are grown on nearly 20% of arable land. An excess of precipitation during the planting period, as well as high air temperatures and an increasingly frequent deficit of precipitation during the growing season, represent one of the greatest risks that threaten this production. Heavy and long-lasting rainfall, which is a frequent occurrence in April and May, causes

regular delays in planting potatoes. In the last decade, in 90% of the years, potato planting was delayed by 30 to 40 days, especially in the continental and mountainous areas of Montenegro. Drought and high temperatures after planting significantly delay the emergence of potatoes, so in some localities this phase lasts over a month. A major problem for potato production in certain years is heavy rainfall after planting, which causes the leaching of fertilizers and applied herbicides. In such conditions, with a rather reduced above-ground mass of the potato plant, there is often a massive appearance of weeds. High air and soil temperatures have a negative impact on the growth and development of potatoes. At high temperatures (above 25°C, and especially higher than 30°C), the vegetation period is shortened and the yield of tubers is reduced. High temperatures stimulate greater formation and branching of stolons, which has a direct negative impact on yield. At temperatures higher than 29°C, the formation and tuber bulking stops. Long-term exposure to high temperatures of 30 to 40°C during the period of tuber formation causes their degeneration.

Meadows and pastures represent an important resource for obtaining animal feed. In the structure of total agricultural utilized land, they participate with more than 94%. In recent years, under the influence of climate change, the growing season on meadows and pastures begins 10-15 days earlier. In years with a particularly rainy spring, the situation is completely different. High temperatures and drought shorten the duration of all phenophases of grass development, especially the leafing phase. This results in lower yields, but also lower quality of the produced fodder. The biggest problems in using this land occur when a hot and dry summer comes after a rainy spring.

The area under vineyards in Montenegro is 2,880 ha, and in the last 15 years it has been constantly increasing. More and more frequent extreme climatic conditions bring more and more problems to this branch of plant production. Rising air temperatures and faster temperature accumulation are the reason the growing season of grapevine starts earlier in recent years. Due to the increased number of very hot days and the increased duration of heat waves the growth stages of the grapevine occur earlier and are often shorter. All this together leads to faster ripening of grapes, and earlier harvest. In most wine-growing regions, the harvest occurs 10-15 days earlier than before. In years with a rainy spring, the vegetation of grapevine is usually delayed, and the dynamics of other phenophases are directly influenced by meteorological conditions. A big problem for viticulture production is the abundant rainfall during the month of May, which, in addition to having an adverse effect on fruitset, also promotes a more widespread occurrence of diseases. In such years, the yields are noticeably lower, as well as the quality of the harvested grapes. Due to the later start of the growing season, the harvest is usually delayed. Additional problems in such years are represented by autumn precipitation, which, in addition to the cracking of berries, also causes a greater appearance of mould. Such grapes are of poor quality and should not be used in the production of wine and brandy.

A similar situation occurs in fruit production as well. High temperatures, excess water in the winter-spring period, droughts in summer and autumn, late spring frosts and hail are increasingly appearing as a limitation for stable fruit production. As a result of global warming, the period until the fruit fully ripens is shortened, and in years with extremely hot and dry summers, due to forced ripening, this phenophase comes even earlier. Late spring frosts are also becoming a growing problem in this production. They destroy formed fruitlets, which leads to a significant reduction, and sometimes to a complete absence of yield.



Map A.4.4. Phenological stations

Table A.4.5. Beginning, end and duration of the growing season for cryophilic crops

Climatic region	Parameter	Period observed		Difference (days)
		2013-2022	1961-1990	
CR1	Beginning of the growing season	-	-	-
	End of the growing season	-	-	-
	Length of the growing season (days)	365	365	-
CR2	Beginning of the growing season	20March	27March	7
	End of the growing season	23November	9 November	14
	Length of the growing season (days)	248	227	21
CR3	Beginning of the growing season	-	30 January	30
	End of the growing season	-	-	-
	Length of the growing season (days)	365	335	30
CR4	Beginning of the growing season	13 March	22 March	9
	End of the growing season	29 November	17 November	12
	Length of the growing season (days)	261	240	21
CR5	Beginning of the growing season	16 March	26 March	10
	End of the growing season	21 November	4 November	17
	Length of the growing season (days)	250	223	27
CR6	Beginning of the growing season	10 April	22 April	12
	End of the growing season	2 November	19 October	14
	Length of the growing season (days)	206	180	26

Table A.4.6. Beginning, end and duration of the growing season for thermophilic crops

Climatic region	Parameter	Period observed		Difference (days)
		2013-2022	1961-1990	
CR1	Beginning of the growing season	27 February	15 March	16
	End of the growing season	9 December	3 December	6
	Length of the growing season (days)	285	263	22
CR2	Beginning of the growing season	25. April	30. April	5
	End of the growing season	11 October	6 October	5
	Length of the growing season (days)	169	159	10
CR3	Beginning of the growing season	16 February.	20 March	32
	End of the growing season	26 November	13 November	13
	Length of the growing season (days)	283	238	45
CR4	Beginning of the growing season	19 April	27 April	8
	End of the growing season	19. October	15. October	4
	Length of the growing season (days)	183	171	12
CR5	Beginning of the growing season	18 April	30 April	12
	End of the growing season	17 October	5. October	12
	Length of the growing season (days)	182	158	24
CR6	Beginning of the growing season	14 May	26 May	12
	End of the growing season	26 September	15 September	11
	Length of the growing season (days)	135	112	23

Annex 4.2.4

Table A.4.7. Most important crops in Montenegro

Rank	Most important crops	Average area in last 5 years (ha)	Average yield in last 5 years (tha^{-1})
1	Potatoes	1,637.8	16.8
2	Wheat	752.5	3
3	Corn	631.3	4.2
4	Watermelon	416.8	41.4
5	Cabbage	377.8	32.7
6	Clover	363.7	6.9
7	Alfalfa	359.7	6.9
8	Vineyards	2,807.8	8
9	Plums	286.1	3.7
10	Apples	214.2	6.9

Table A.4.3. Number of meteorological and phenological stations in Montenegro

Meteorological stations	Climatological stations	Rainfall Stations	Total weather stations	Phenological stations
9	12	12	33	9

Table A.4.8. Meteorological data available in Montenegro required for implementing climate change analysis

Parameter	Daily Max T	Daily Min T	Daily RH	Daily precipitation	Average daily wind speed	Daily sunshine duration
Period covered	1950-present	1950-present	1950-present	1950-present	1950-present	1950-present
Number of stations	33	33	21	33	21	12
Coverage	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy

Table A.4.9. Extreme weather events recorded in Montenegro

Extreme event	Date reported	Region affected	Affected area in ha	Crops affected and impact
Flood	December 2010	Nikšić	Significant area	Warehouse with 530 t of potatoes destroyed
Flood	March 2012	Tuzi	45	Most of early potato crops destroyed remaining crops suffered diseases
Low temperature and strong wind	January 2017	Bar, Ulcinj	Significant area	Significant area under citrus trees significantly damaged due to freezing
Stormy wind	February 2019	Tuzi	Significant area	Huge damage to greenhouses
Wet snow and freezing rain	January 2021	Bijelo Polje	Significant area	Great damage to greenhouses and raspberry plantations
Hail	June 2022	Broader area of Podgorica	Totally destroyed: 300 ha wine grape 130 ha table grape 90 ha peach	Other producers had damage – 40 to 70% of potential yield; in the municipality of Tuzi, damage caused to crops and agricultural facilities amounted to over 3.3 million EUR
Drought	2022	Whole economy	Whole cropping area	50% yield reduction for all rainfed crops
Flood	First half of 2023	Plav, Kolašin, Bijelo Polje and Podgorica	Significant area	Damage to agricultural crops estimated at around 1.7 million EUR.
Frequent high temperature and heath sters	2015, 2017, 2020, 2021	Whole economy	Significant area	Significant reduction in yield and its quality in most rainfed crops

Table A.4.10. New crop pests and diseases recorded in Montenegro

Crop/disease Latin name	Crop/disease English name	First recorded	Crops/Cropping system affected	Level of spreading	Risk for production and productivity
Polyphagotarsonemus latus	Broad mite	2006	Sweet pepper	Low	High
Liriomyza bryoniae	Agromyzid leaf miner	2006	Tomato and other species from the Solanaceae family	High	High
Aphis illinoisensis	Grapevine aphid	2007	Grapevine	Low	Low
Scaphoideus titanus	American grapevine leafhopper	2008	Grapevine	Low	Low
Frankliniella occidentalis	Western flower thrips	2008	Cucumbers	High	High
Luperomorpha xanthodera	Flea beetle	2009	Mandarin, orange, lemon, grapefruit	Low	Low
Tetranychus cinnabarinus	Carmin spider mite	2009	Tomato	Low	High
Tuta absoluta	South American tomato moth	2010	Tomato and other species from the Solanaceae family	High	High
Bemisia tabaci	Tobacco whitefly	2008	Cucumber, watermelon, sweet pepper	Low	Low
Rhinchophorus ferrugineus	Red palm weevil	2012	Palm	Low	High
Liriomyza trifolii	American serpentine leafminer	2012	Zucchini	Low	Low
Aleuroclava aucubae	Japanese laurel whitefly	2012	Citrus	Low	Low
Drosophila suzukii	Spotted wing drosophila	2013	Citrus	High	High
Aleurocanthus spiniferus	Orange spiny whitefly	2013	Citrus	High	High
Rhagoletis cingulata	Cherry fruit fly	2013	Cherry	Low	Low
Cydalima perspectalis	Box tree moth	2014	Box tree	High	Low

Table A.4.11. Most vulnerable regions and crops to climate change in Montenegro

Most vulnerable regions	Crops
Coastline and the coastal part at an altitude of about 500-600 m a.s.l.	Lemon
Central part of the Zetskobjelopavlić plain up to about 500-600 m a.s.l.	Orchards, cherries, apricot and peach, early potatoes
Western and central part of Montenegro from 500 to 1,000 m a.s.l.	All fruit species, cereals, potatoes
Northern lowlands at 600-1,000 m a.s.l.	All fruit species, cereals, vegetables, potatoes
Mountainous northern and central part of Montenegro from 1,000 m a.s.l. and mountainous areas above 1,000-1,200 m a.s.l.	Seed potatoes

Table A.4.12. Climate change adaptation practices used or tested in Montenegro

Parameter	Best adaptation practice in place	Farms affected	Tested
Drought	Irrigation	All	High
Low temperatures	Agrotextil	Small	To some extent
Insolation	Protective nets	All	High
Hail	Hail nets	All	To some extent

Annex 5. North Macedonia climate change adaptation in agriculture – additional materials

Annex 5.1. Additional materials – soils linked to climate change

Table A.5.1. Exposure of soils to climate change

Extreme	Units	Location	Area affected	Data availability	Data format	Period (e.g. give a dates of events, events/year, years, days, months)	Soil types affected (e.g. fluvisols, cambisols etc.)	Land productivity potential affected (e.g salinisation, OM depletion, pH, soils burried with sterile material, overloading, etc.)	Comments
Floods	ha	Areas along the big river courses of the Vardar, Bregalnica and Crna River	Areaas under a flood risk in Macedonia are estimated to 54.380 ha (alifieri at al 2021)., or 0.02% of the total area of the economy (25713 km^2)	yes	graphycal/ digital	1. Negotino 1995 (10 mil. EURO damage), 2. Radovish 2008 (3,5 mil. EURO damage) 3. January-Fevruary 2014, 26 municipalites affected (13.7 mil. EURO damage) 4. Skopje, 2016, (vicinity of Skopje), (70 mil. EURO damage)	Fluvisols (64,5% of flooded areas), Fluvisols Molic (10.41%), Gleysols (7.32%)	Burial of fertile soils with intert material (stones, sediment, raw organic material, debriss etc.), hydroporphyc conditions, soil contamiantion etc.	Official dat base for the flood events and area affectfed wholud be established. All data are stored within various sources
Heavy rainfalls (storms)	humber	Any area of the economy affected with rainfalls with high intensity. No data	No cata	no	numerical/ digital	Берово (99.8мм) 24.0702014: Bitola (116.0 mm) 19. 11 1979; D. Kapija (124.2) 19.11 1979, Gevgelija (201.0 mm) 05. 06 2004; K.Palanka (97.0 mm) 05. 07 1970, Lazaropole (154,4) 24. 10 1981; Ohrid (90,4 mm) 16. 11 1962; Prilep (120,2 mm) 19. 11 1979; Stip (86,9 mm) 24. 05 2017; Strumica (107,0) mm) 27. 07 2002. (Source 1)	Mostly Cambisols Chromic, Litosols,Regosols, Vertisols	Surface water floss, causing serious processes of soil erosion. Overloading of soils with accumilation of excessive rain water in valleys	Rainfall data exists but are not available to the public
Soil erosion	ha	Almost 97% of the economy is affecteed with various categories of soil erosion processes. Estimated area affected with the first (highest) category of soil erosion is bit more than 52000 ha.	Of the total area of Bosnia and Herzegovina, 89.01% is affected by erosion processes of various categories, while torrential flows affect an area of 12,970 km2 or 25.4%. (Additional GIS added analysis of data from Source 2)	yes	digital	Soil Erosion maps is elaborated with moddeling of the envir-pometal parameters for the wholle teritoory of the economy in 2021	Regososl, Leptosols, Leptososl Dystric or Eutric, Leptosol Calcaric, Vertisols, Cambisols Chromic	Erosion of the msot retile surface soil horizon and somethimes the wholle soil horizon. One of the heviest form of land degradation	Soil erosion fileds for measurement of the actual soil ersion procesess under different land use and management practices does not exists
Drought	km2	Most of the central part and south east of the coutnry as well as the region of Skopje and Kumanovo valleys	Drought-affected areas are categorised in five categories depending on the degree of intensity. Almost 767828 ha. falls within the two strongest categories of areas: vulnerable (740675 ha. or 96.5%) and strongly vulnerable (27153 ha. or 3,5%), to drought. (Additional GIS added analysis of data from Source 2)	yes	graphycal/ digital	Drought in the vulnerable areas occures every year. In the recent period the drought events (periods with high air temepra-ture and no-rain) are prolonging and becomes more frequent. Numer of consecutive dry days for the period 1951_2019: Berovo (61 days) 1961; Bitola (70 days) 1965; D. Kapija (103 days) 1969, Lazaropole (78 days) 2018; Stip (78 days) 1992; Strumica (96 days) 1992.	Chernozems, Complex of Cambisols Chromic and Vertisls, Fluvisols, Vertisols and Complex of Vertisols and Litososls Calcaric.	Soil moisture in the surface layer is low, soil microbiological activity is disturbed, ascedent movement of gorud water and possible salinisation and alcvcalisation, SOC depletion, soil pH is altered. Etc.	Drought as a climatologcial phenomenon should be more in the focus of the researches and data providers
Frosts	num-ber of frosty days	Measurements at meteorological stations of the Hydrometeoro-logical service as a part of the regular monitoring of air meteorological parameters	No available data for the late frost days and area affected	no	numerical/ digital	Average number of frost days for the period 1951-2019: Gevgelija (46), D. Kapija (64), Stip (71), Berovo (124) Bitola (86), K. Palanka (90), ,Lazaropole (123), Ohrid (63), Prilep (78), Strumica (75). Data for the late and eraly frosts which causes damage to agricultral crops are not available	Cambisols Chromic, Leptosols Calcaric, Regosols Coluvic, Vertisols, Cambisols	Soil physical properties	

Extreme	Units	Location	Area affected	Data availability	Data format	Period (e.g. give a dates of events, events/year, years, days, months)	Soil types affected (e.g. fluvisols, cambisols etc.)	Land productivity potential affected (e.g salinisation, OM depletion, pH, soils burried with sterile material, overloading, etc.)	Comments
Land slides	number	255 registered with known locations all over the economy; depneds to the geological properties, climate conditions and human activites	No data	yes	numerical/ digital	No data	Regosols, Vertisols and Cambisols Chromic formed over diluvial, proluvial or fluvioglacial sediments	Soil loss	
Forest fires	ha	South west, Eastern aprt and Vardarski Region	Smost affected regions were Southwest region with 1364 of burnt areas, and Vardarski region with almost 967 ha. Source 2	yes	graphycal/ digital	Every year, during the dry summer periods	Cambisols, Leptisols Dystric, Regososl, Leptososl, Regososl, Colluvic	Physical, chemical, and biological properties of soils	
Other extreme……									

Table A.5.2. Producers adaptive capacity

Indicator	Maangement practices	Area, ha	# of farmers	# of farms	Expert judgement	Confidence level	Comments
cultivation	reduced tillage+B4:H19	No data	No data	No data	Some areas	low	In some of the orchards <5000 ha and vineyards <8000 ha clasic cultivvation is replaced with perrenial grass cover
	no-tillage	No data	No data	No data	Not applied in practice	high	
	contour tillage	No data	No data	No data	Limited areas	high	
	strip cultivation	No data	No data	No data	Not applied	medium	
fertilizers maangement	soil laboratory testing chemes	No data	No data	No data	One scheme in practice supported by MAFWE for all newly established plantations	medium	In order to get incentives for new plantations (orchards and vineyards) farmers are obliged to perform soil laboratory testing
	organic fertilizers use	No data	No data	No data	Limited use	low	Due to the deficit of organic manyre, ituse is limited. Beside this the process of praration and aplication is usually improper
	exclusively use of mineral fertilizers	No data	No data	No data	Organic farming	high	
precise agriculture	systems for agro-ecological zoning	All area of the economy	All farms	No data	MAFWE have prepared agro-ecological zoning for the wholle teriotry of the economy	high	
	thematic soil quality maps	All area of the economy	All farms	No data	Soil texture maps, Soil pH map, Soil OC map, Soil Salinity map, Soil Erosion map, Drought map, etc.	hihg	The thematic maps were developed withih the project fo creatin of MASIS, as well withi the UNEP funded project (Source2)
	on-line services	No data	No data	No data	Desease alert and Irrigatoin sensors on lmited areas	medium	Orchars and vineyards in Prespa and Strumica regions on area <4000 ha
training programs	lifelong rearning programs within inuversities	No data	No data	No data	Not aplied	high	There are no systematically planned and organized trainings
	vocational training programs realted to soil	No data	No data	No data	Not applied	high	There are no systematically planned and organized vocational trainings
	targeted training courses for farmers	No data	No data	No data	Rarelly	medium	Within certain project activites and other campaings
land improvement practices	liming	No data	No data	No data	Rarrely	medium	
	on farm practices erosion control	No data	No data	No data	Rarrely	medium	
	saline soils management	No data	No data	No data	Not aplied	medium	

Table A.5.3. Gaps and challenges to meet EU Soil Strategy and Adaptation Strategy in Macedonia

Document	Document type	Foreseen actions	Relevance for the EU adapteation strategy	Relevance for the Soil Deal	Relevance for the EU Soil Strategy	Identified gaps	Identified challenges
National Strategy for Agriculture and Rural Development (NSARD)	Strategy	Tupes of interventions in agricutural policy: 5.4.2. System for agricultural advisory services, 5.6.2. Maangement with land resources, Adaptaion of agriculture to climate change, 6.1.Enforcement of the knwledge trasfer and straightening the connections between research and practice, 6.2. Strengthening of advisory services within the the knowledge and innovation system, 6.3. Enhancing interactive innovation in agriculture, 6.4. Supporting the digital transition in agriculture, 6.5. System for mandatory training and education in agriculture,	High	High	High	The actions foreseen in the Strategy should be adressed In the lLegal documents and Programs of work	The existing instituional, idnividual and technical capacities should be enforced in order to meet the foreseen actions and policies
National Strategy for Sustainable Development	Strategy	The Strategy outlines that the sustainable developmenbt should as a starting point to have in focus e the rich and relativelyundisturbed natural and cultural resources of the Republic of Macedonia. On of the general goals and the leading principles of the strategy are: To introduce E-governance (electronic) nationally and local level, FOcus on the high educatied working force. On of the identifyed gaps fIn the Strategy is: Weak capacity for the cross-sectoral and integrated approach needed to achieve sustainable development. Conlusions realted to agricultre are: Need for a general law for agricultural and rural development based on the concept of sustainable development, together with a strategic plan for agriculture and rural development which would follow. 1. The necessity to strengthen the administrative capacities in the agricultural sector, especially as it relates to the management of the common market organizations and rural development activities. 2. Basic instruments for managing the Community should be adopted agricultural policy, especially the instruments related to the management of pre-accession assistance in rural development (IPARD), as well as 3. Integrated administrative and control system (IACS) and Farm Register (FR). Proper organization of integrated administrative and control is required system (IACS) as well as the Land Parcel Identification System (LPIS).	High	Medium	Medium	Some parts of the foreseen goals are partially implemented e.g. Cross-sectoral and ontegrated aproach realted to agroculture and soil is still not in function	Lack of awareness for the need of colaboration and integrates aproach in the process of sustainable development
Long-Term Strategy on Climate Action and Action Plan	Strategy	The Strategy outlines the importance of mitigation and adaptation to cliamte change and the need of mainstreaming the set of measutres and plicies into the legal framework. The Strategy foresees two specific adaptive obejectives: 1. To build soild system for thre regular and periodic collection of data for the production and dissemination fo scientific and technical knowlege, 2. TO establish comprehensive policy planning, coordination and policy implementation instruments for climate action. THe Strategy foresees and a set of action for achieving of the specific goals for adaptaion.	High	High	High		Cpacities for implementing of the foreseen goals and actions.
Law on agricultural land	Law	The Law contains provisions realted to the rights of use, land tenure, and concession, briefly enumerate the best practices for maintaining soil fertility, few provisions related to protection from soil erosion and forest fires.	Medium	High	High	The Law doe not adresses all issues realted to protecion and sustainable use of agricultural and forest land	Implemnting of some provision of the Law
Law on Climate Action	Law	This law regulates the establishment of a framework for climate action for the reduction of greenhouse gas emissions in the atmosphere and their removal through natural and other absorbents, as well as adaptation to climate change.	High	Medium	High	The las is still in the process of adoption	Implemnting of the Law in practice
Law on organic production	Law	The Law contains provisions that explicitly define protection of soil fertility, soil cultivation, fertilizers use, and improvement of soil properties in organic production	High	High	High		Mechanizms for the fully-Implemntation of the Law in practice

Source 1: https://www.mzsv.gov.mk/%D0%9F%D0%BE%D1%87%D0%B5%D1%82%D0%BD%D0%B0/%D0%9F%D1%80%D0%BE%D0%B3%D1%80%D0%B0%D0%BC%D0%B8.aspx
Source 2: https://www.moepp.gov.mk/wp-content/uploads/2014/12/Nacionalna-Strategija-za-Odrzliv-Razvoj-vo-RM-NSSD-Del-1.pdf
Source 3: https://www.moepp.gov.mk/wp-content/uploads/2014/12/Nacionalna-Strategija-za-Odrzliv-Razvoj-vo-RM-NSSD-Del-1.pdf
Siurce 4: https://unfccc.int/sites/default/files/resource/MKD_ES_LTS_Nov2021.pdf

Table A.5.4. Best practices in place

Indicator	Best practice in place	Area affected, ha	Soil organic matter maintenance	Soil reaction	Combating soil erosion	Soil salinisation	Water conservation	Other
cultivation								
Redduced tilage	interrow grassing in orchards and vineyards	Expert judgement: approx. 13.000 ha	Increasing	Stable	Controled	Controled	Positive effects	
Organic agriculture	Yes	3195 ha at various plant croping systems (2022) Source 1 and 2	Increasing	Improved	Positive effects	Controled	Positive effects	
.....								
fertilizers maangement								
Use of organic fertilizers	Yes	All area under organic farming. Mulching of grass reziduses in orchards and vineyards. In total >25000 ha	Increasing	Improved	Positive effects	Controled	Positive effects	
Fertirigation	Yes	In green houses and some orchards. Approx. >1000 ha	Stable	Improved	Positive effects	Controled	Positive effects	
irrigation								
1Micro-irrigation- Drip irrigation	In vegetable produciton, vineyards and orchards	No data	Stable	Improved	Positive effects	Controled	Positive effects	
Micro-irrigation- Sprinkler irrigation	In orchards and vegetable production	No data	Stable	Improved	Positive effects	Controled	Positive effects	
precise agriculture								
Deseases early warnign system	yes	Approf >5000 ha	Positive effects	Positive effects	Positive effects	Positive effects	Positive effects	
Irrigation sensors	yes	Approx. >2000 ha	Positive effects	Positive effects	Positive effects	Positive effects	Positive effects	
Weather stations	yes	Approx. >20000 ha	Positive effects	Positive effects	Positive effects	Positive effects	Positive effects	
training programs								
Extension services trainings	No	No data	Positive effects	Positive effects	Positive effects	Positive effects	Positive effects	
Other professional trainings for farmers carried out by governmental and non-governmental organizations	No	No data	Positive effects	Positive effects	Positive effects	Positive effects	Positive effects	

Source 1: https://makstat.stat.gov.mk/PXWeb/pxweb/mk/MakStat/MakStat__Zemjodelstvo__OrganskoProizvodstvo/125_Zem_Mk_oRast_ml.px/?rxid=46ee0f64-2992-4b45-a2d9-cb4e5f7ec5efBosnu i Hercegovinu. Ministarstvo vanjske trgovine i ekonomskih odnosa Bosne i Hercegovine, (Maj, 2022.)

Source 2: https://www.stat.gov.mk/PrikaziPoslednaPublikacija.aspx?id=5

Annex 5.2. Additional materials – water resources linked to climate change

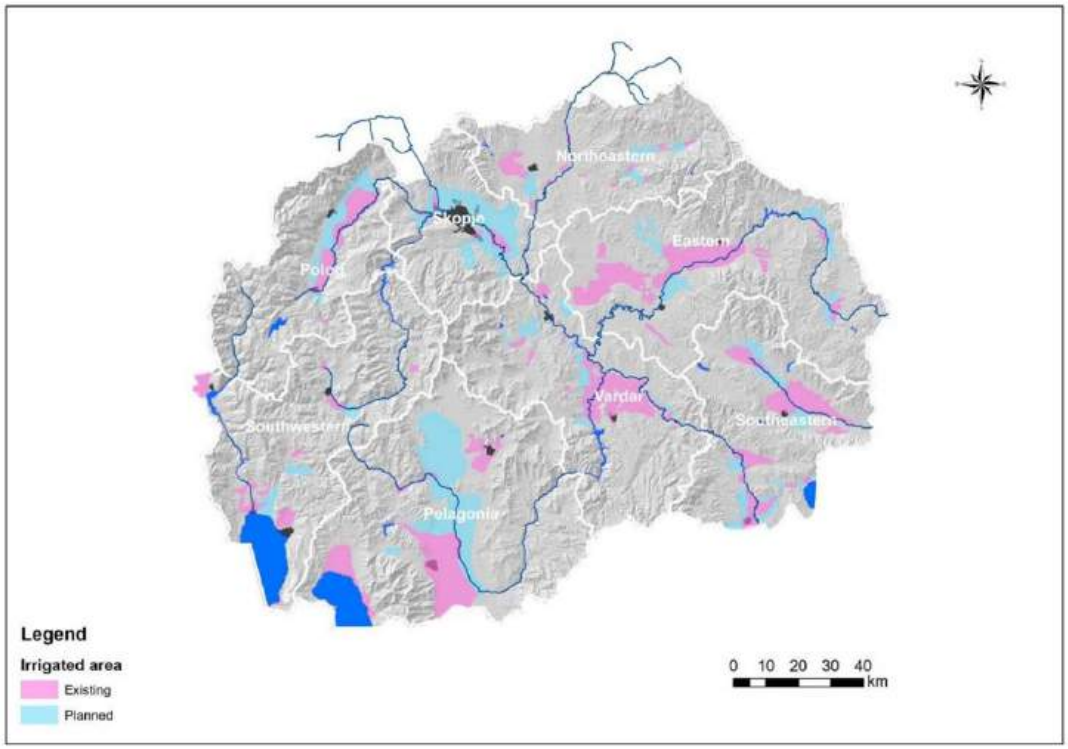


Figure A.5.1. Existing and planned irrigation area in North Macedonia – digital version

Source: Minchev, 2014

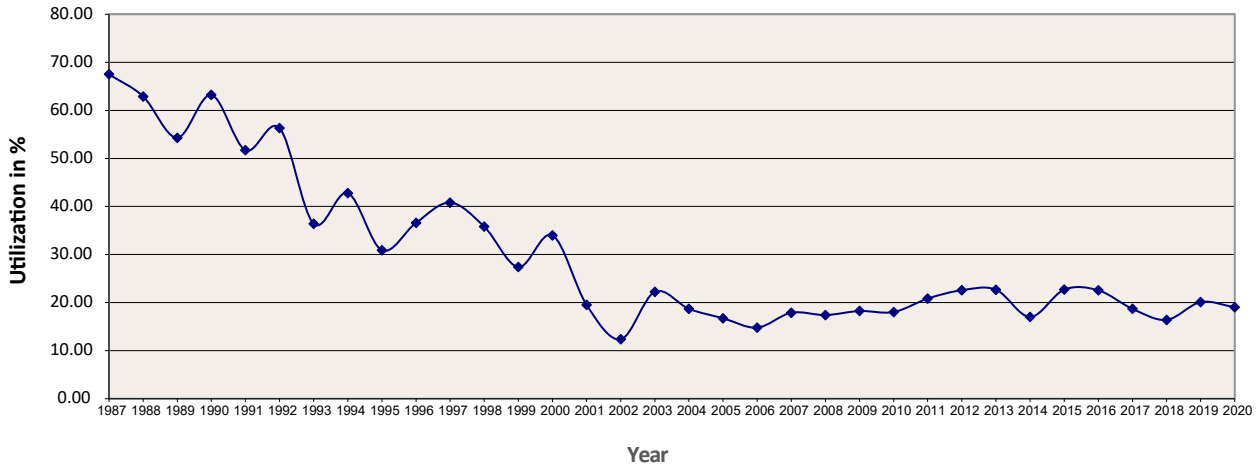


Figure A.5.2. Efficiency use of irrigation systems in North Macedonia in the period 1987-2020

Source: AD Water Management

(Data processed by the Department of Water Management and Erosion – Faculty of Agricultural Science and Food, Skopje)

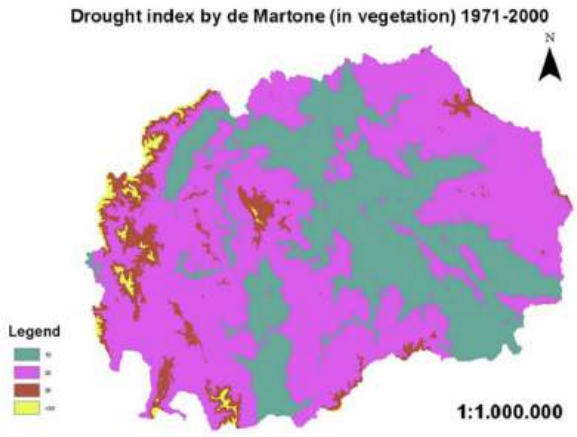


Figure A.5.3. De Martonne drought index for the period 1971-2000

Source: Second National Communication to UNFCCC, 2008

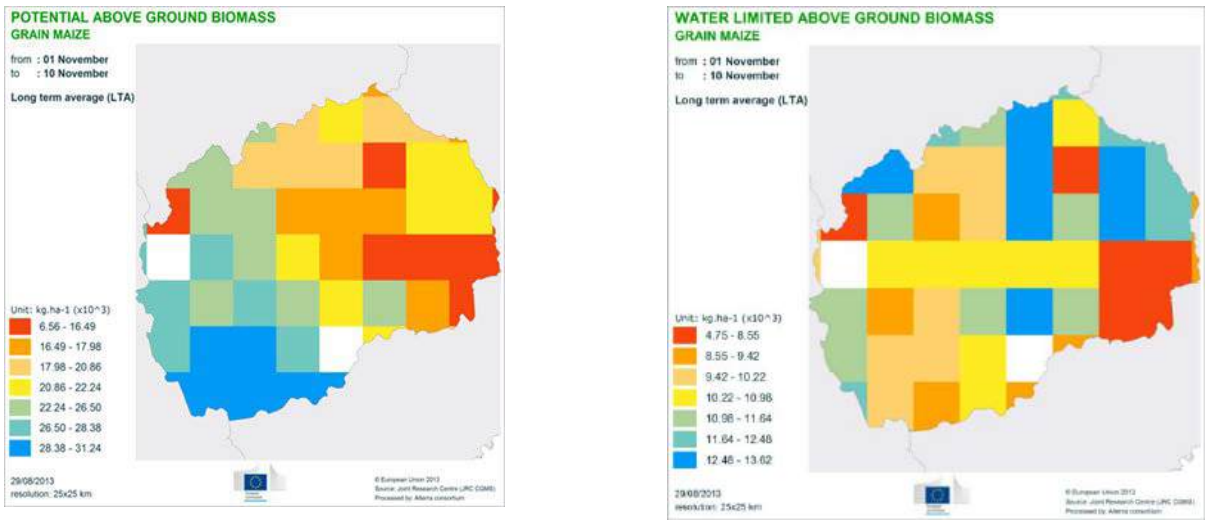


Figure A.5.4. Potential above ground biomass (grain maize) and water limited ground biomass (grain maize) for the period 1975-2012

Source: JRC MARS Weather database, Chukaliev (2014)

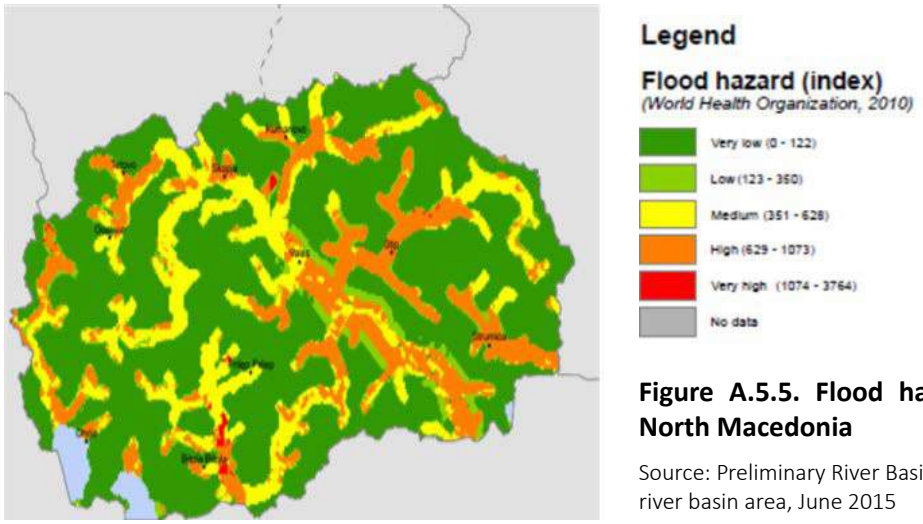


Figure A.5.5. Flood hazard (index) in Republic of North Macedonia

Source: Preliminary River Basin Management plan for the Strumica river basin area, June 2015

Table A.5.5. Producers' adaptive capacities in North Macedonia

Indicator	Lists	Yes	No	If yes, please note used area (e.g. in ha or in % from total irrigated area in the economy, number of farmers, number of farms, etc.)	Source (literature; documents, study; projects/expert opinion, etc)	Comments
Micro-irrigation	Drip irrigation	Yes		8,000 ha or 10 % of total irrigated area / 50,000-60,000 ha or around 16 to 19% of total utilized agricultural area	State Statistical Office, 2016 / Expert opinion	According to our field experience, almost all orchards, vineyards, vegetable crops in the economy are irrigated by drip irrigation
	Micro sprinkler	Yes		Hard to estimate		Micro sprinklers are used in seedling production, cucumber and flower production in greenhouses, and for frost protection
	Drip fertigation	Yes		60% or 25,000- 30,000 ha of total utilized agricultural area	Expert opinion	
Irrigation scheduling practices	Irrigation programmes	Yes		60% or 25,000-30,000 ha of total utilized agricultural area	60% or 25,000-30,000 ha of total utilized agricultural area	Used in areas where training programmes and courses were realized through different donor programmes in the economy and programmes provided by the business sector selling drip irrigation systems
	Sensors and data loggers	Yes		10% of total utilized agricultural area	Expert opinion	Used in areas where training programmes and courses were realized through different donor programmes in the economy
	Tensiometers	Yes		10% of total utilized agricultural area	Expert opinion	Used in areas where training programmes and courses were realized through different donor programmes in the economy
	Meteo stations	Yes		10% of total utilized agricultural area	Expert opinion	Meteo stations are used for irrigation only in business entities. Individual agricultural holdings use results from meteo stations generally by local associations, mainly for plant protection at regional level, while few farmers use results for irrigation scheduling (Prespa local association is an example in apple production).
Soil moisture conservation methods	Organic mulch materials	Yes			Expert experience in several investigations	Used in areas where training programmes and courses were realized through different donor programmes in the economy
	Inorganic mulch material	Yes		5% from total utilized agricultural area		Mainly in vegetable production in the economy
Training programmes	Lifelong learning programmes within universities	Yes		Occasional programme for extension services and graduated students	Faculty of Agricultural Sciences and Food, Skopje (FASF)	Occasional trainings
	Vocational training programmes related to water	Yes		Around 1,000 students in the last 15 years have taken courses in irrigation of agricultural crops, drip fertigation and water quality in agriculture	FASF Skopje	All graduate programmes in plant crop production, postgraduate programme in irrigation of agricultural crops and PhD study courses on management of natural resources in agriculture
	Targeted training courses for farmers and young professionals	Yes		Around 500-600 farmers in the last 15 years have taken courses in irrigation of agricultural crops and drip fertigation for proper use of water in agriculture.	Projects supported by different donors in the economy (USAID, UNDP, GEF, IPA programmes, UNESCO, GTZ) together with the Department of Water and Land Reclamation at FASF, Skopje.	More than 20 brochures and manuals have been published on this topic by experts from the Department of Water and Land Reclamation at the Faculty of Agricultural Sciences and Food, Skopje for continuous improving of farmers' capacities. More than 300-400 farmers were introduced to new technologies in irrigation.
Other	UV nets	Yes		Hard to estimate	Expert opinion	Used in areas where training programmes and courses were realized through different donor programmes in the economy
	Cover crops	**Yes**		Hard to estimate	Expert opinion	Used in areas where training programmes and courses were realized through different donor programmes in the economy

Table A.5.6. Best practices in North Macedonia related to water and CC in agriculture (economy expert experience or literature results/documents/studies/projects)

Indicator	Best practice in place	Yield affected	Water use efficiency	Fertilizer use efficiency	Improving soil water properties	Source
Drip irrigation	Yes	Yield increased up to 30% in pepper, 37% in tomato, 20-30% in fruit in comparison with furrow irrigation	Up to 89% in tomato, 76% in pepper in comparison with furrow irrigation	More than 5 times in tomato and more than 2 times in pepper in comparison with furrow irrigation		-Iljovski et al., Application of modern irrigation techniques in orchards production (2004-2005), Ministry of Education and Science of the R. Macedonia -Cukaliev, O., Tanaskovik, V., Kanwar, R. S., Heng Kheng Lee., Mukaetov, D., (2008). Irrigation and fertigation effects on nitrogen use efficiency & tomato yield. International Agricultural Engineering Journal 17 (1-4): pp. 19-26 -Tanaskovik, V., Cukaliev, O., D, Romic., Ondrasek, G., (2011). The Influence of Drip Fertigation on Water Use Efficiency in Tomato Crop Production. Agriculture Conspectus Scientificus. Vol.76 (2011), No. 1, pp. 57-63 -Kiprijanovski, M., Tanaskovik, V., Dimov, Z., Beleski, K., Bandjo, S., Gjamovski, V., Cukaliev, O., Mukaetov, D., (2015). The adaptation measures of agriculture on climate change. Final report of three year investigation. USAID and Rural Development Network of the Republic of Macedonia -Tanaskovik, V., Cukaliev, O., Kanwar S.R., Heng, L.K., Markoski, M., Spalevic V., (2016). Nitrogen Fertilizer Use Efficiency of Pepper as Affected by Irrigation and Fertilization Regime. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, Vol 44, Issue 2, pp.525-532. DOI:10.15835/nbha44210415 -Tanaskovik, V., Cukaliev, O., Romić, D., Ondrasek, G., Savić, R., Markoski, M., Nechkovski, S., (2019). Water use efficiency and pepper yield under different irrigation and fertilization regime. CONTRIBUTIONS, Section of Natural, Mathematical and Biotechnical Sciences, MASA, Vol. 40, No. 1, pp. 53–62, Dedicated to academician Gjorgji Filipovski on the occasion of his 100th birthday. ISSN 1857–9027; e-ISSN 1857–9949 -Cukaliev, O., Mukaetov, D., Tanaskovik, V., Kiprijanovski, M., Nechkovski, S., (2015). Irrigation scheduling of apple based on soil water properties in Prespa region of the Republic of Macedonia. International Conference of Soil. Proceedings. Agricultural University in Tirana, pp. 250-251, Tirana, 4-6 May 2015
Drip Fertigation	Yes	Yield increased up to 25% in tomato in comparison with drip irrigation and spreading of fertilizer traditionally	Up to 25% in tomato, 60% in sour cherry in comparison with drip irrigation and spreading of fertilizer traditionally	More than 2 times in pepper in comparison with drip irrigation and spreading of fertilizer traditionally		
Irrigation scheduling practices (soil sensors with data loggers, tensiometers, drip irrigation programmes)	Yes	Yield increased	Yes, according to our research and field results and farmers' experiences	Yes, according to our research and field results and farmers' experiences		
Mulch – plastic	Yes	Yield increase	Up to 17% in tomato production, and 25% in fruit production, in comparison with treatment without mulch material			-Kiprijanovski, M., Tanaskovik, V., Dimov, Z., Beleski, K., Bandjo, S., Gjamovski, V., Cukaliev, O., Mukaetov, D., (2015). The adaptation measures of agriculture on climate change. Final report of three year investigation. USAID and Rural Development Network of the Republic of Macedonia -Cukaliev, O., Tanaskovik, V., Kiprijanovski, M., Lazarevska, Stanislava., Mukaetov, (2012-2015). UNDP Project: Restoration of Lake Prespa Ecosystem", Support to the Introduction of Sustainable Farming Practices in the Prespa Lake Watershed -Cukaliev, O., Tanaskovik, V., Kiprijanovski, M., Lazarevska, Stanislava., Mukaetov, (2015-2020). UNDP Project: Technical Assistance for Introduction of Sustainable Farming Practices in the Strumica River Basin

Indicator	Best practice in place	Yield affected	Water use efficiency	Fertilizer use efficiency	Improving soil water properties	Source
Mulch organic	Yes	Yield increase	Up to 12% in fruit production in comparison with treatments without organic mulch material		Improving soil water properties	-Kiprijanovski, M., Tanaskovik, V., Dimov, Z., Beleski, K., Bandjo, S., Gjamovski, V., Cukaliev, O., Mukaetov, D., (2015). The adaptation measures of agriculture on climate change. Final report of three year investigation. USAID and Rural development network of the Republic of Macedonia. -Cukaliev, O., Tanaskovik, V., Kiprijanovski, M., Lazarevska, Stanislava., Mukaetov, (2012-2015). UNDP Project: Restoration of Lake Prespa Ecosystem", Support to the Introduction of Sustainable Farming Practices in the Prespa Lake Watershed -Cukaliev, O., Tanaskovik, V., Kiprijanovski, M., Lazarevska, Stanislava., Mukaetov, (2015-2020). UNDP Project: Technical Assistance for Introduction of Sustainable Farming Practices in the Strumica River Basin
UV net	Yes	Yield increase	Up to 7% in fruit production and 9 % in vegetable production in comparison with treatments without UV net			-Kiprijanovski, M., Tanaskovik, V., Dimov, Z., Beleski, K., Bandjo, S., Gjamovski, V., Cukaliev, O., Mukaetov, D., (2015). The adaptation measures of agriculture on climate change. Final report of three year investigation. USAID and Rural Development Network of the Republic of Macedonia.
Deficit irrigation	Yes	To some extent	Up to 16% in pepper production	No results		-Kiprijanovski, M., Tanaskovik, V., Dimov, Z., Beleski, K., Bandjo, S., Gjamovski, V., Cukaliev, O., Mukaetov, D., (2015). The adaptation measures of agriculture on climate change. Final report of three year investigation. USAID and Rural Development Network of the Republic of Macedonia.
Application of Trichoderma harzianum	Yes	Yield increase	Up to 5% in vegetable production and 9% in comparison with treatments without Trichoderma			-Kiprijanovski, M., Tanaskovik, V., Dimov, Z., Beleski, K., Bandjo, S., Gjamovski, V., Cukaliev, O., Mukaetov, D., (2015). The adaptation measures of agriculture on climate change. Final report of three year investigation. USAID and Rural Development Network of the Republic of Macedonia.

Table A.5.7. Reports, R&D, projects in the last 20 years related to proper water use and CC in North Macedonia

Project Title	Supporter (Agency/Institution)	Year of implementation
– The Use of Nuclear Techniques in Soil Fertility and Water Management Studies in Order to Obtain Higher Crop Yield	IAEA/FAO, Vienna Austria	2002-2003
– Establish of Training Centre for Irrigation and Agricultural Water Management	UNESCO	2006
– Education, Research and Training for Global Environmental Change and Sustainable Management of Natural Resources in the Western Balkans	SIU, Norwegian Cooperation Program	2006-2010
– Drought Management Centre for South-East Europe	EU under the Instrument for Pre-Accession Assistance (IPA)	2011
– Adaptation to Climate Change in Agriculture	USAID	2012-2015
– Interactive Farmers Support System for Efficient Water Use Management –RULAND	EU under the Instrument for Pre-Accession Assistance (IPA)	2012-2013
– Restoration of Prespa Lake Ecosystem: Support to the Introduction of Sustainable Farming Practices in the Prespa Lake Watershed	UNDP	2013- 2015
– Technical Assistance for Introduction of Sustainable Farming Practices in the Strumica River Basin	UNDP	2015-2020
– Supporting the preparation of the 1st, 2nd and 3rd Biennial Update Report and the 1st, 2nd, 3rd and 4th National Communication on Climate Change in AFOLU sector	UNDP, GEF and MoEPP	2003-2023
– Revenue diversification pathways in Europe and Africa through bio-based sustainable agricultural innovations (DIVAGRI)	Horizont 2020	2020-present
– Improving Efficiency in Water and Soil Management – (RER5028)	IAEA, Regional Technical Cooperation Project,	2022-present

Annex 5.3. Additional materials – crop production linked to climate change

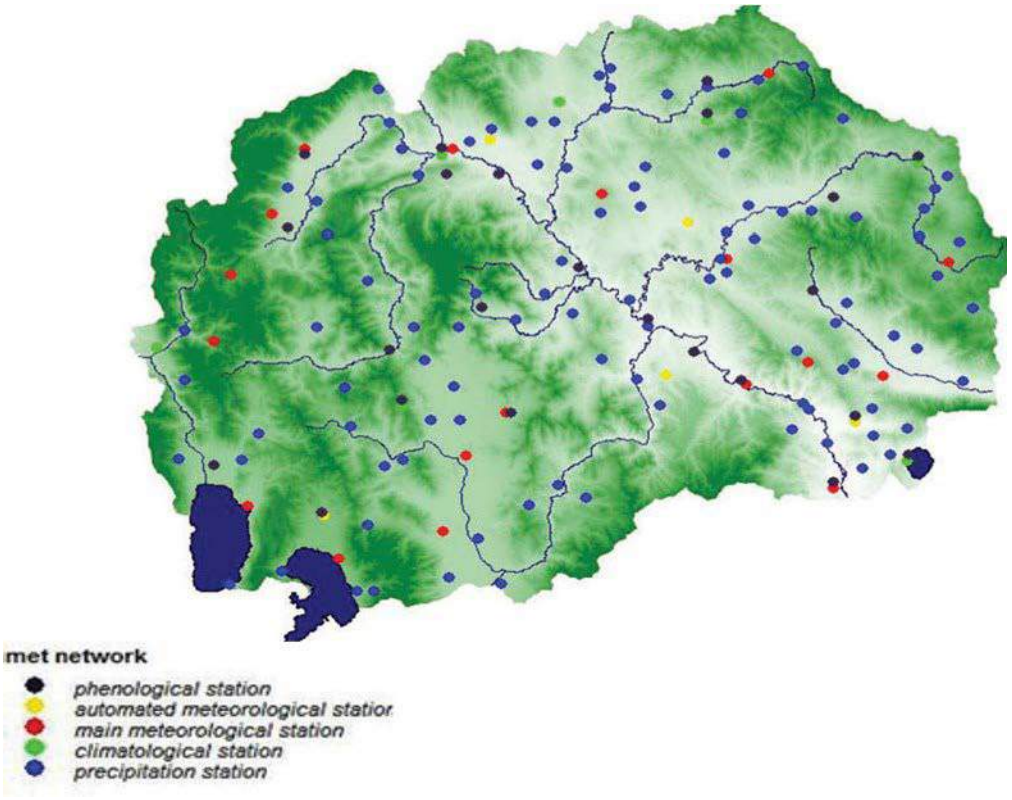


Figure A.5.5. Meteorological Network in the Republic of North Macedonia

(Source: Stevkova, S., Alcinova Monevska, S. (2019). Agrometeorological services provided by the Hydrometeorological Service of the Republic of North Macedonia, Biological Rhythm Research, Vol. 50, No. 2)

Table A.5.8. Position of meteorological stations in North Macedonia (spatial coverage)

N°	Meteorological station	Latitude	Longitude	Elevation (m)
1	Amzabegovo	41°49′00″	22°20′00″	250
2	Berovo	41°43′00″	22°25′00″	827
3	Bitola	41°03′00″	21°12′00″	586
4	Valandovo	41°19′00″	22°23′00″	100
5	Veles	41°43′00″	21°14′00″	175
6	Gevgelija	41°09′00″	22°23′00″	59
7	Gostivar	41°48′00″	20°05′00″	525
8	Debar	41°31′00″	20°03′00″	675
9	Delchevo	41°58′00″	22°24′00″	630
10	Demir Kapija	41°25′00″	22°21′00″	125
11	Kavadarci	41°26′00″	22°20′00″	260
12	Katlanovska Banja	41°54′00″	21°14′00″	240
13	Kichevo	41°31′00″	20°05′00″	620
14	Kochani	41°55′00″	22°22′00″	345
15	Kratovo	42°05′00″	22°20′00″	640
16	Kriva Palanka	42°12′00″	22°22′00″	691
17	Krushevo	41°22′00″	21°11′00″	1,230
18	Kumanovo	42°08′00″	21°14′00″	338
19	Lazaropole	41°32′00″	20°04′00″	1,332
20	Makedonski Brod	41°31′00″	21°11′00″	545
21	Mavrovi Anovi	41°42′00″	20°04′00″	1240
22	Nov Dojran	41°13′00″	22°24′00″	180
23	Radovish	41°38′00″	22°22′00″	380
24	Resen	41°05′00″	21°10′00″	881
25	Ohrid	41°07′00″	20°04′00″	760
26	Popova Shapka	42°01′00″	20°05′00″	1,750
27	Prilep	41°21′00″	21°13′00″	661
28	Skopje Zajchev Rid	42°01′00″	21°12′00″	301
29	Skopje Petrovec	41°57′00″	21°13′00″	240
30	Solunska Glava	41°42′00″	21°12′00″	2,540
31	Strumica	41°26′00″	22°23′00″	224
32	Shtip	41°44′00″	22°21′00″	322

Table A.5.9. Position of the Automated Weather Stations (AWS) operated by UHMR, as reported in the year 2020 sourced from their website (information not available at present)

No.	Location	Elevation	Latitude	Longitude
	Berovo	834	22.848628	41.718926
	Bitola	589.01	21.3536	41.0417
	Valandovo	109	22.556264	41.315045
	Veles	228	21.775278	41.714444
	Vinica	509	22.5122	41.8769
	Vodocha/Strumica	260	22.600687	41.45024
	Vodocha Dam	405	22.565833	41.420833
	Gradsko	197	21.945028	41.572157
	Gjurishte/Sveti Nikole	861.1	21.8361	41.8986
	Ilovica	782	22.848713	41.488082
	Jazhince	784	21.175625	42.161355
	Jasen	1423	21.242388	41.825473
	Jasenovo	367	21.72165	41.517665
	Kavadarci	244	22.019722	41.442222
	Kargo Airport/Shtip	272	22.085556	41.8225
	Kosturino/Strumica	435	22.608461	41.357227
	Kochani	338	22.41199	41.909495
	Kriva Palanka	690	22.3311	42.2033
	Krushevo	1268	21.244444	41.374167
	Lazaropole	1337	20.6958	41.5372
	Mavrovi Anovi	1281	20.7572	41.7025
	Makedonski Brod	670	21.211667	41.509167
	Novo Selo/Gostivar	1171	20.86727	41.941873
	Novo Selo/Strumica	280	22.887751	41.417769
	Ohrid	758	20.7972	41.1147
	Pozharane/Konche	1030	22.4381	41.4711
	Pozharane/Gostivar	874.34	20.8706	41.8508
	Ponikva/Kochani	1580	22.35618	42.032421
	Popova Shapka/Tetovo	1784	20.879009	42.01587
	Radovish	352	22.473192	41.621092
	Resen	881	21.022041	41.088669
	Skopje/Gazi baba	256	21.464444	42.007413
	Skopje/Zajchev Rid	302	21.3997	42.0164
	Skopje/Karposh	257	21.387044	42.006642
	Slivovo	922	20.845592	41.400438
	Strumica	223.45	22.6653	41.4419
	Suvi Laki/Berovo	992.7	22.808768	41.56051
	Tetovo	453	20.965024	41.9861
	Topolchani	842	21.43263	41.24037
	Turja	375	22.656907	41.554376
	Creshevo	273	21.51206	42.037411
	Shtip	326.57	22.1803	41.753611
	Shtirovica	1450	20.618611	41.806389

Table A.5.10. Most important crops in North Macedonia

Rank	Most important crops	Average area in last 5 years ha	Average yield in last 5 years t/ha
1	Wheat	70,534	3.42
2	Barley	45,454	3.14
3	Maize	32,660	4.62
4	Rice	3,236	6.11
5	Tobacco	16,082	1.60
6	Potatoes	12,502	14.97
7	Tomatoes	5,551	27.96
8	Peppers	9,479	21.82
9	Alfalfa	19,424	5.45
10	Grape	23,561	11932
	Fruit	**Average number of trees in last 5 years**	**Average total production in last 5 years in t**
1	Apple	4,710,160	118,437
2	Plum	1,737,995	34,310
3	Peach	575,378	11,282.4

Table A.5.7. Number of meteorological and phenological stations in North Macedonia

Network operated by professional observers (full/part time)			Automated Weather Stations	Agrometeorological stations	Phenological stations
Main meteorological stations	Climatological stations	Rainfall stations			
19	**7**	**103**	**56**	**6 National Hydromet 7 Resen Farmers Association More than 50 METEOBOT**	**24**

Table A.5.11. Meteorological data available in North Macedonia required for implementing climate change analysis

Parameter	Daily Max T	Daily Min T	Daily RH	Daily precipitation	Average daily wind speed	Daily sunshine duration
Period covered	1947-present	1947-present	1947-present	1947-present	1947-present	1947-present
Number of stations	26	26	26	129	26	19
Coverage	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy	Whole economy

Table A.5.12. New crop pests and diseases recorded in North Macedonia

Crop/disease Latin name	Crop/disease English name	First recorded	Crops/Cropping system affected	Level of spreading	Risk for production and productivity
Tuta Absoluta	Tomato leafminer	2011	Tomato	High	High

Table A.5.13. Most vulnerable regions and crops to climate change in North Macedonia and expected yield reduction in different zones, World Bank Report

Most vulnerable crops/regions	Region (statistical NUTS and LAU), climate, or other as used in the economy		
	Mediterranean	**Continental**	**Mountain**
Grape	-47 to-12	-53 to 8	n/a
Apple	-6- to-7	-63 to 6	-4 to 13
Vegetable	-21 to 10	-28 to 8	n/a
Winter wheat	-3 to-1	13 to 15	70 to 105
Maize	-75 to-56	-77 to 8	n/a
Alfalfa	-14 to 45	-10 to 42	43 to 56
Pasture	-4 to 19	-4 to 33	20 to 58
Assessment of vulnerability: +++ high; ++ medium; + low; – not vulnerable			
Most vulnerable crops/regions	**Region (statistical NUTS and LAU), climate, or other as used in the economy**		
	Mediterranean	**Continental**	**Mountain**
Grape	+++	+++	n/a
Apple	++	+++	+
Vegetable	++	++	n/a
Winter wheat	++	-	-
Maize	+++	+++	n/a
Alfalfa	+	-	-
Pasture	++	+	-

Table A.5.14. Most vulnerable regions and crops to climate change in North Macedonia, Second National Report to UNFCCC

Most vulnerable regions	**Crops**
Central Vardar Valley	Grape
Southeast Part	Orchards, tomato and pepper
Southern Vardar Valley	Tomato and pepper, grape
Skopje–Kumanovo Region	Cereals
Ovche Pole Region	Alfalfa, winter wheat

Table A.5.15. Climate change adaptation practices used or tested in North Macedonia

	Best adaptation practice in place	**Farms affected**	**Tested**
Drought	Irrigation	All	High
Efficient on-farm water use	Drip irrigation	Small	High
Efficient on-farm water use	Mulching for reducing non-productive water losses	Small	Medium
Insolation	Protective nets	All	High
Insolation	Covering of the grape clusters with leaves	Small	Low
Insolation	Using nets to cover greenhouses and plastic tunnels and/ or using lime to white-paint roofs	Small	Medium
Hail	Hail nets	All	To some extent

Table A.5.16. Major component values, livelihood vulnerability indices and ranking, per municipality

Component	Aggregated latent components			Composite vulnerability indices			Ranking (different indices)		
Municipality	AC	SE	EX	LVIm	AVI	LVI IPCC	LVIm	AVI	LVI IPCC
Skopje	0.378	0.621	0.634	0.490	0.544	0.007	71	70	68
Arachinovo	0.691	0.665	0.611	0.675	0.656	0.201	21	16	7
Berovo	0.620	0.765	0.328	0.654	0.571	-0.040	37	62	69
Bitola	0.589	0.638	0.474	0.598	0.567	0.040	65	65	65
Bogdantsi	0.665	0.457	0.619	0.582	0.580	0.130	68	60	38
Bogovinje	0.700	0.590	0.532	0.644	0.607	0.137	42	42	37
Bosilovo	0.711	0.560	0.643	0.648	0.638	0.198	41	24	9
Brvenitsa	0.679	0.600	0.510	0.635	0.596	0.113	49	56	48
Valandovo	0.691	0.495	0.632	0.612	0.606	0.160	61	44	24
Vasilevo	0.717	0.446	0.636	0.608	0.600	0.158	64	53	25
Vevchani	0.654	0.752	0.487	0.680	0.631	0.106	17	28	52
Veles	0.641	0.763	0.599	0.685	0.668	0.183	12	9	15
Vinitsa	0.669	0.620	0.569	0.643	0.619	0.148	44	37	33
Vrapchishte	0.693	0.576	0.526	0.635	0.598	0.126	50	54	40
Gevgelija	0.668	0.461	0.604	0.585	0.578	0.125	67	61	42
Gostivar	0.662	0.605	0.546	0.631	0.604	0.126	55	47	41
Gradsko	0.693	0.624	0.617	0.661	0.645	0.194	32	20	13
Debar	0.640	0.730	0.564	0.669	0.645	0.149	24	21	31
Debartsa	0.643	0.752	0.418	0.668	0.605	0.046	25	46	64
Delchevo	0.654	0.825	0.467	0.706	0.649	0.100	6	18	54
Demir Kapija	0.718	0.609	0.603	0.668	0.643	0.195	26	22	11
Demir Hisar	0.648	0.727	0.486	0.666	0.620	0.098	27	36	55
Dojran	0.683	0.532	0.609	0.619	0.608	0.155	59	41	27
Dolneni	0.694	0.727	0.423	0.685	0.615	0.085	13	40	59
Zhelino	0.676	0.610	0.534	0.640	0.607	0.128	45	43	39
Zelenikovo	0.700	0.648	0.689	0.679	0.679	0.252	19	4	3
Zrnovtsi	0.648	0.622	0.543	0.630	0.604	0.118	57	48	46
Ilinden	0.638	0.665	0.571	0.643	0.625	0.139	43	31	35
Jegunovtse	0.669	0.613	0.525	0.636	0.602	0.119	48	50	44
Kavadartsi	0.626	0.577	0.653	0.610	0.619	0.161	62	39	23
Karbintsi	0.725	0.728	0.517	0.711	0.657	0.176	5	15	19
Kichevo	0.614	0.692	0.324	0.624	0.544	-0.042	58	71	71
Konche	0.662	0.685	0.559	0.663	0.635	0.151	31	25	29
Kochani	0.632	0.593	0.526	0.609	0.584	0.094	63	59	56
Kratovo	0.711	0.844	0.634	0.757	0.730	0.291	2	2	2
Kriva Palanka	0.705	0.751	0.555	0.713	0.670	0.195	4	7	10
Krivogashtani	0.681	0.625	0.398	0.636	0.568	0.049	47	63	63
Krushevo	0.676	0.669	0.457	0.656	0.601	0.089	36	52	58
Kumanovo	0.656	0.800	0.574	0.705	0.677	0.184	7	5	14
Lipkovo	0.684	0.661	0.535	0.664	0.627	0.145	29	30	34
Lozovo	0.695	0.749	0.532	0.704	0.659	0.170	8	13	20
Mavrovo and Rostusha	0.637	0.547	0.458	0.590	0.548	0.052	66	69	62

Component	Aggregated latent components			Composite vulnerability indices			Ranking (different indices)		
Makedonska Kamenitsa	0.690	0.695	0.600	0.685	0.661	0.201	14	10	6
Makedonski Brod	0.695	0.730	0.443	0.691	0.623	0.101	11	32	53
Mogila	0.671	0.668	0.450	0.652	0.597	0.081	39	55	60
Negotino	0.665	0.585	0.643	0.633	0.631	0.181	53	27	17
Novatsi	0.678	0.713	0.537	0.681	0.643	0.153	16	23	28
Novo Selo	0.694	0.426	0.567	0.580	0.562	0.111	69	67	50
Ohrid	0.631	0.746	0.490	0.665	0.622	0.091	28	34	57
Petrovets	0.682	0.690	0.575	0.677	0.649	0.178	20	17	18
Pehchevo	0.639	0.758	0.306	0.660	0.568	-0.042	33	64	70
Plasnitsa	0.691	0.755	0.525	0.703	0.657	0.163	9	14	22
Prilep	0.608	0.708	0.449	0.634	0.588	0.040	51	57	66
Probishtip	0.676	0.760	0.579	0.701	0.672	0.194	10	6	12
Radovish	0.689	0.618	0.555	0.652	0.621	0.151	40	35	30
Rankovtse	0.751	0.819	0.638	0.769	0.736	0.318	1	1	1
Resen	0.621	0.688	0.392	0.631	0.567	0.009	56	66	67
Rosoman	0.688	0.560	0.610	0.632	0.619	0.167	54	38	21
Sopishte	0.671	0.661	0.605	0.664	0.646	0.183	30	19	16
Sveti Nikole	0.626	0.732	0.540	0.660	0.633	0.121	34	26	43
Staro Nagorichane	0.656	0.834	0.620	0.722	0.703	0.230	3	3	4
Struga	0.631	0.725	0.451	0.653	0.602	0.059	38	51	61
Strumitsa	0.638	0.385	0.659	0.542	0.561	0.115	70	68	47
Studenichani	0.686	0.661	0.662	0.674	0.670	0.230	22	8	5
Teartse	0.693	0.566	0.552	0.633	0.604	0.139	52	49	36
Tetovo	0.649	0.642	0.524	0.636	0.605	0.111	46	45	49
Centar Zhupa	0.636	0.719	0.513	0.659	0.622	0.106	35	33	51
Chashka	0.700	0.668	0.522	0.674	0.630	0.149	23	29	32
Cheshinovo-Obleshevo	0.684	0.542	0.535	0.618	0.587	0.118	60	58	45
Chucher-Sandevo	0.680	0.692	0.609	0.680	0.660	0.200	18	11	8
Shtip	0.628	0.778	0.571	0.682	0.659	0.156	15	12	26
Mean	*0.665*	*0.658*	*0.542*	*0.653*	*0.621*	*0.133*			
Min	*0.378*	*0.385*	*0.306*	*0.490*	*0.544*	*-0.042*			
Max	*0.751*	*0.844*	*0.689*	*0.769*	*0.736*	*0.318*			
StDev	*0.046*	*0.100*	*0.083*	*0.044*	*0.040*	*0.069*			

Source: Martinovska Stojcheska, A., Dimitrov, L. (2021)

Table A.5.17. List of measures related to climate change adaptation from the national system for support of agriculture

RURAL DEVELOPMENT FINANCIAL SUPPORT PROGRAMME 2023

Measures for financial support for rural development

- Training and information of agricultural producers
- Investments to modernize agricultural holdings
- Investments to increase the economic value of forests
- Investments in infrastructure for the development of agriculture, forestry and water management and protection against natural disasters – other investments intended for water infrastructure (124.1)
- Cooperation for the development of new products, processes and technologies in the agricultural and food sectors (integrated projects)
- Aid for agricultural activity in areas with limited agricultural activity opportunities (POM)
- Help to carry out agricultural activities to protect and improve the environment

Technical support in agriculture and rural development

- Production and publication of educational, informational, scientific, promotional and professional materials, publications and magazines
- Implementation of research, analysis, proposal – projects, studies and strategic documents in the field of agriculture and rural development
- Investments to establish scientific and demonstration examples
- Establishing and implementing innovative practices
- Air cloud sowing services for natural disaster prevention and adverse climate events on agricultural crops
- Investments for improvement of meteorological stations , as well as costs for procuring hardware and software for hydrometeorological equipment and radar system
- Costs for procuring and installing a precision agriculture platform (central information platform and temperature sensors for sheet and flower folders, oxygen level sensors, ultraviolet radiation, electric conductivity, volumetric water content and soil temperature, sheet humidity sensors, arcass diameter, stem and fruit and temperature sensors, humidity and air pressure) for ten farms located throughout the territory of the Republic of North Macedonia
- Costs for organizing workshops and promotional campaigns in the field of agriculture and rural development

AGRICULTURAL FINANCIAL SUPPORT PROGRAMME 2023

- Support for premiums and insurance
- Aid for agricultural activity in areas with limited production opportunities (POM)
- Support for drip irrigation and anti-hail nets provided by IPARD

Annex 6. Serbia climate change adaptation in agriculture – additional materials

Annex 6.1. Additional materials – soils linked to climate change

Table A.6.1. Exposure of soils to climate change in Serbia

	Units	Location	Area affected	Data availability	Data format	Period	Soil types affected	Land productivity potential affected
Floods	Ha	23 municipalities affected in 2021	2021 – 15,000 ha (1)	Yes	Graphical/ hardcopy	January	Fluvisol, Eugleys	Structural changes, soil fertility,, and decrease in soil microbial communities
Heavy rainfall,s (storms)	Number	43 in 2021, 409 in 2022	Source 4	Yes	Graphical/ digital	https:// www.eswd. eu/ESWD	Lithosols, Sirozems – Regosols and Arenosols	Structural changes, soil fertility
Drought	Ha	Monitoring at 28 locations	Source 2	Yes	Graphical/ digital		Vertisol, Cambisol, Fluvisol	pH level, nitrogen (N), phosphorus (P), and potassium (K) fertility levels
Frosts	Number of frosty days	Monitoring at 30 stations	Source 2	Yes	Graphical/ digital	number of frosty days/ month/year	Fluvisol, Leptosol	Soil physical properties
Landslides	Number, km^2		30% of the territory (3)	Yes	Numerical/ digital	No data	Leptosol, Cambisol	Soil loss, sediment deposition, mixing of soil material
Forest fires	Ha	Data available in the Ministry of Interior	2021-– 834 ha (1)	Yes	Numerical/ digital	Every year	No data	Nutrient cycling and physical, chemical and biological properties of soils

Source 1: Statistical Yearbook of the Republic of Serbia, 2022, Statistical Office of the Republic of Serbia, Belgrade, 2022
Source 2: Republic Hydrometeorological Institute of Serbia https://www.hidmet.gov.rs/eng/meteorologija/uslovi_vlaznosti.php
Source 2: Republic Hydrometeorological Institute of Serbia https://www.hidmet.gov.rs/ciril/meteorologija/klimatologija_srednjaci.php
Source 3: SEPA, 2022. State of the Environment Report in the Republic of Serbia for 2021, Ministry of Environmental Protection, Environmental Protection Agency http://www.sepa.gov.rs/download/IZVESTAJ_2021.pdf
Source 4: ESWD, European Severe Storms Laboratory, European Weather OBserver (https://www.eswd.eu/ESWD/)

Table A.6.2. Producers' adaptive capacities relevant for sustainable use of soils in Serbia

Indicator	Management practices	Area (ha)	# of farmers	Expert judgement	Confidence level	Comments
Cultivation	Reduced tillage	10.06% (1)			Medium	
	No-tillage	No-tillage: 20,909 ha (1)	0.83%		Medium	
	Contour tillage			<5%	Medium	
	Strip cultivation			<5%		
Fertilizer management	Soil laboratory Testing schemes			30% farms according to the law, 70% farms in 10 years	Medium	
	Organic fertilizer use	373,871 ha (2)	49% (2)		High	
	Exclusive use of mineral fertilizers			30-40% of farms	Medium	
Precise agriculture	Systems for agro-ecological zoning			<10%	Low	With windbreak (shelterbelt)
	Thematic soil quality maps			<10%	Medium	
	On-line services		11,000	10-15%	Medium	Geoportal of the Agricultural Land Administration https://gisportal.gdi.net/portal/apps/sites/#/upravapz Digital field book, crop observation through satellite images, precise weather forecast, calculation of production costs and expected profit, land sampling optimization, etc. 11,000 farmers, 30,000 parcels Prognostic reporting service for plant protection (https://www.pisvojvodina.com/Preporuke_BD/)
Training programmes	Lifelong learning programmes within universities			<5%	Medium	
	Vocational training programmes related to soil			<5%	Medium	Good example: FAO Project Increasing National Capacities to Assess the Risk of Diffuse Agricultural Soil Pollution 2022-2023
	Targeted training courses for farmers		Training: 3.1% farms in 2012 (2) Consultation with extension services – 82,511 farms or 24.67% in 2022 in Central Serbia (3)		Medium	Good example: Ministry of Agriculture, Forestry and Water Management (MAFWS) in cooperation with FAO is implementing the project Building Resilience of the Agricultural Sector to Natural Disasters. The goal of the project is to improve the capacity to reduce the risk of natural disasters and climate-resistant agriculture in the Republic of Serbia, both at the national and local levels.
Land improvement practices	Liming			<1% in the Vojvodina Region (no need), 10-20% in Central Serbia with state subsidies	Medium	
	On-farm practices, erosion control			10-20%	Low	The anti-erosion measure is defined in Article 18 of the Law on Agricultural Land https://www.paragraf.rs/propisi/zakon_o_poljoprivrednom_zemljistu.html
	Saline soil management			150,000 ha – total area of saline soils Under protection: <10%	Medium	There is a proposal to further protect those areas with no-tillage system

Source 1: Survey on the structure of agricultural holdings 2018 – Land, 2019. Statistical Office of the Republic of Serbia, ISBN 978-86-6161-183-4 https://publikacije.stat.gov.rs/G2019/Pdf/G20196003.pdf

Source 2: Census of Agriculture 2012. Agriculture in the Republic of Serbia, 2013. Statistical Office of the Republic of Serbia, ISBN 978-86-6161-077-6, ISBN 978-86-6161-076-9. https://pod2.stat.gov.rs/objavljenepublikacije/popis2012/pp-knjiga1.pdf

Sources 3: Ministry of Agriculture, Forestry and Water Management (software: Poljosfera)

Table A.6.3. Gaps and challenges to meet EU Soil Strategy and Adaptation Strategy in Serbia

Document	Foreseen actions	Relevance for the EU adaptation strategy	Relevance for the Soil Deal	Relevance for the EU Soil Strategy	Identified gaps	Identified challenges
1. Strategy on Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 (Official Gazette of the Republic of Serbia, No. 85/2014)	Strategic soil management goals include sustainable resource management and environmental protection and improvement of the quality of life in rural areas. The implementation of the concept of sustainable development in agriculture and realization of the goals set within the strategy, i.e. soil management policy, are directed towards efficient soil management and increased availability of land resources, including 1. higher use of agricultural land; 2. increase of land ownership and consolidation of plots; 3. establishment of a functional market; 4. improvement of soil infrastructure; 5. increase of ameliorated areas and improvement of soil fertility; 6. acceleration of property restitution – restitution (including cooperative property) and (re)privatization; 7. reduction of soil loss and degradation; 8. controlled conversion of agricultural land; 9. more efficient use of land of lower quality, i.e. uncultivated agricultural land; 10. systematic monitoring of soil quality; 11. establishment of an efficient soil management system (cadastre, GIS, LPIS)	Yes	Yes	Yes	The goals are not fully met.	Establishment of an efficient soil management system
2. Water Management Strategy of the Territory of the Republic of Serbia until 2034 (Official Gazette of the Republic of Serbia, No. 3/2017), with Action Plan 2021-2023 (Official Gazette of the Republic of Serbia,, No. 79/2021)	The Strategy is a planning document that determines long-term directions for water management in the territory of the Republic of Serbia. From the aspect of soil and land protection against degradation and desertification, the goals and measures are important, especially regarding diffuse sources of pollution and protection against flooding by external waters	High	Medium	Medium	Development of decision-making tools in accordance with the goals of the Strategy	Adequate use of wetlands and potentially flood zones Protection against erosion and floods Protection against inland water flooding (drainage)
3. Low Carbon Development Strategy for the period 2023-2030 with projections until 2050 (Official Gazette of the Republic of Serbia , No. 46/2023)	Strategy recognizes climate change risks affecting sustainable development of the Republic of Serbia. Namely, the Strategy defines two specific objectives related to adaptation to climate change – Objective 4: Preserving the potential of mitigation measures, stipulated until 2030 and 2050, by increasing resilience to climate change in priority sectors; and Objective 5: Promoting a transfer to climate-neutral economy and society resistant to climate change	High	Medium	Medium		Preserving the potential of mitigation measures, established until 2030 and 2050, by increasing resilience to climate change in agricultural production

Document	Foreseen actions	Relevance for the EU adaptation strategy	Relevance for the Soil Deal	Relevance for the EU Soil Strategy	Identified gaps	Identified challenges
4. IPARD III Programme Agri-environment-climate measures	The Agri-environment-climate measure in IPARD III Programme for the Republic of Serbia (2021-2027) consists of four operations that aim to enhance cultivation methods adapted to the environment and the features of landscapes, and to enhance the Republic of Serbia biodiversity and ecosystem services, promote water conservation and water quality improvement, and contribute to climate change adaptation and mitigation principally by sustainable input use and improving soil management. Supporting more sustainable practices and management of agricultural land in rural areas will contribute to maintain a favourable landscape and environment for enhanced public goods. It includes the 4 following operations: Operation 1 – Crop rotation on arable land; Operation 2 – Grassing in inter-row area in permanent crop land; Operation 3 – Establishment and maintenance of pollinator strips; Operation 4 – Sustainable management of meadows and pastures. These operations are also directly relevant to the achievement of the vision and strategic goals of the National Agriculture and Rural Development Strategy which underlines the importance of a more responsible and sustainable use of resources and agricultural practices. Furthermore, the operations are highly relevant and complementary to the 5 Pillars of the Green Agenda for the Western Balkans.	Medium	Low	Medium	This Nature Protection Programme of the Republic of Serbia for the period 2021-2023, based on the provisions of the Law on the Planning System of the Republic of Serbia and in accordance with the Strategic Plan of the UN Convention on Biological Diversity for the period 2011-2020, sets relevant planned issues aimed to protect biodiversity and to implement decisions made during regular sessions of the Conference of Parties to this Convention and other ratified international treaties on nature protection, biodiversity conservation and climate change	Promotion of the benefits of applying agri-environmental-climate measures and increasing the level of interest
5. Nature Protection Programme of the Republic of Serbia for the period 2021-2023. (Official Gazette of the Republic of Serbia , No. 53/2021)	This Nature Protection Programme of the Republic of Serbia for the period from 2021 until 2023, based on the provisions of the Law on Planning System of the Republic of Serbia and in accordance with the Strategic Plan of the UN Convention on Biological Diversity for the period 2011-2020, sets relevant planned issues aimed to protect the biodiversity and to implement decisions made at regular sessions of the Conference of the Parties to this Convention and other ratified international treaties on nature protection, biodiversity conservation and climate change	High	High	High	Weak interaction between networks of climate change and biodiversity researchers, policy makers and stakeholders; lack of systematic monitoring of the impact of climate change on biodiversity	Monitoring the impact of climate change on nature at the national level
6. Law on Climate Change (Official Gazette of the Republic of Serbia, No. 26/2021)	Climate Change Act – establishes a basis for planning, update and implementation of policies, measures and activities in the area of adaptation to climate change	High	High	High	Vertical and horizontal institutional coordination Use of economic instruments for the implementation of the Law	Enforcement control The preparation of the Climate Change Adaptation Programme with Action Plan is underway and in accordance with the principles of the European Union Climate Change Adaptation Strategy (adopted in 2021)

Document	Foreseen actions	Relevance for the EU adaptation strategy	Relevance for the Soil Deal	Relevance for the EU Soil Strategy	Identified gaps	Identified challenges
7. Law on Disaster Risk Reduction and Emergency Situation Management (Official Gazette of Republic of Serbia, No. 87/2018)	The Law regulates reduction of risk from disasters and management of emergency situations; in this context disaster risk reduction entails climate change monitoring and adaptation of the society to the expected consequences	High	High	High	Observed and projected climate changes (scenario) are not included in the risk assessment	Enforcement control
8. The Law on Agricultural Land (Official Gazette of the Republic of Serbia, No. 62/2006, 65/2008 – other law, 41/2009, 112/2015, 80/2017 and 95/2018 – other law)	The Law regulates the planning, protection, organization and use of agricultural land.	Medium	High	High	Use of economic instruments for the implementation of the Law	Enforcement control
9. The Law on Soil Protection (Official Gazette of the Republic of Serbia , No. 112/2015)	The Law regulates soil protection, systematic monitoring of the state and quality of soil, remediation measures, recultivation, inspection supervision and other issues of importance for the protection and conservation of soil as a natural resource of national interest	Medium	High	High	Use of economic instruments for the implementation of the Law	Enforcement control
10. The Law on Agriculture and Rural Development (Official Gazette of the Republic of Serbia , No. 41/2009, 10/2013, 101/2016 – other law, 101/2016, 67/2021 –other law, and 114/2021)	The Law sets out the basic definitions, rights and responsibilities of agricultural producers, enforcing duty for protection of the environment, animal health, animal welfare and soil.	Medium	Medium	Medium	Use of economic instruments for the implementation of the Law	Enforcement control
11. The Law on Subsidies for Agriculture and Rural Development (Official Gazette of the Republic of Serbia, No. 10/2013, 142/2014, 103/2015, 101/2016, and 35/2023)	The Law prescribes the following list of subsidies: 1) subsidies for preservation of plant genetic resources; 2) subsidies for preservation of animal genetic resources; 3) subsidies for agri-environmental measures, good agricultural practices and environmental protection; 4) subsidies for organic production; 5) subsidies for sustainable use of land; 6) subsidies for sustainable use of forest	Medium	Low	Medium	Gaps are not identified	Enforcement control
12. Sofia Declaration on the Green Agenda for the Western Balkans and the Action Plan for the implementation of the Sofia Declaration						

Source 1: https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/strategija/2014/85/1
Source 2: https://www.paragraf.rs/propisi/strategija-upravljanja-vodama-u-srbiji-do-2034.html
http://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/drugiakt/2021/79/1/reg»
Source 3: https://www.ekologija.gov.rs/sites/default/files/2023-06/strategija_niskougljenicnog_razvoja.pdf
Source 4: http://www.minpolj.gov.rs/download/IPARD-III-Programme-for-the-Republic-of-Serbia-for-the-period-2021-2027-CLEAN-21-Jan-2022.pdf
Source 5: https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/drugiakt/2021/53/1
Source 6: https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/skupstina/zakon/2021/26/1/reg
Source 7: https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/skupstina/zakon/2018/87/1/reg
Source 8: https://www.paragraf.rs/propisi/zakon_o_poljoprivrednom_zemljistu.html
Source 9: https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/skupstina/zakon/2015/112/19/reg
Source 10: https://www.paragraf.rs/propisi/zakon_o_poljoprivredi_i_ruralnom_razvoju.html
Source 11: https://www.paragraf.rs/propisi/zakon_o_podsticajima_u_poljoprivredi_i_ruralnom_razvoju.html
Source 12: https://www.rcc.int/docs/596/action-plan-for-the-implementation-of-the-sofia-declaration-on-the-green-agenda-for-the-western-balkans-2021-2030

Table A.6.4. Sustainable measures and best practices already applied for the protection of agricultural land in Serbia

Indicator	Best practice in place	Area affected, ha	Soil organic matter maintenance	Soil reaction	Combating soil erosion	Soil salinisation	Water conservation	Other
Cultivation								
No-tillage	Partially	No-tillage: 20,909 ha or 0.83% (1)	Positive	Stable	Positive	Stable	Positive	Soil biodiversity improvement
Organic agriculture	Yes	Agriculture area under organic farming in 2021 is 0.67% (2)	Positive	Stable	Positive	Neutral	Positive	
Conservation of arable land in the winter period	Yes	Winter crops: 687,930 ha or 26.79%. Growing crops for protection: 16,124 ha or 0.63%. Protection with plant residues (straw or stubble): 122,054 ha or 4.75% (1)	Positive	Stable	Positive	Stable	Positive	
Fertilizer management								
Application of organic fertilizers	Partially	Solid manure is used by 49% of households Area of 373,871 hectares, which is 11% of the total areas of utilized agricultural land (3)	Positive	Stable	Positive	Neutral	Positive	
Integrated production	Partially	No data	Positive	Positive	Positive	Positive	Positive	
Irrigation								
Micro-irrigation – Sprinkler irrigation	Yes	12.2% of total irrigated area/8,800 farms/12,200 ha	Positive	Stable	Positive	Neutral	Positive	
Micro-irrigation – Surface irrigation	Yes	60.6% of total irrigated area/43,600 farms/60,500 ha	Positive	Stable	Positive	Neutral	Positive	
Irrigation scheduling practices – Irrigation programmes	Yes	50%	Positive	Stable	Positive	Neutral	Positive	
Precise agriculture								
Use of AgroSense platform – artificial intelligence, satellite images, meteorological data, digital field records	yes	10,000 farmers (4)	Positive	Positive	Positive	Positive	Positive	
Training programmes								
Extension services training	Yes	82,511 farms or 24.67% in 2022 in Central Serbia – consultation with extension services	Positive	Positive	Positive	Positive	Positive	
Vocational training programmes related to climate change adaptation	Yes	No data	Positive	Positive	Positive	Positive	Positive	Good example: FAO Projects Strengthening Disaster Resilience in Serbia's Agriculture Sector; Increasing National Capacities to Assess the Risk of Diffuse Agricultural Soil Pollution

Source 1: Survey on the structure of agricultural holdings 2018 – Land, 2019. Statistical Office of the Republic of Serbia, ISBN 978-86-6161-183-4 https://publikacije.stat.gov.rs/G2019/Pdf/G20196003.pdf
Source 2: SEPA, 2022. State of the Environment Report in the Republic of Serbia for 2021. Ministry of Environmental Protection, Environment Protection Agency http://www.sepa.gov.rs/download/IZVESTAJ_2021.pdf
Source 3: Census of Agriculture 2012. Agriculture in the Republic of Serbia, 2013. Statistical Office of the Republic of Serbia, ISBN 978-86-6161-077-6, ISBN 978-86-6161-076-9. https://pod2.stat.gov.rs/objavljenepublikacije/popis2012/pp-knjiga1.pdf
Source 4: https://biosens.rs/en/themes/agrosense



Picture A.6.1. Floods 2014_ D. Vidojevic



Picture A.6.2. Floods 2014_ D. Vidojevic



Picture A.6.3. Floods 2014_ D. Vidojevic



Picture A.6.4. Floods 2014_ D. Vidojevic



Picture A.6.5. Erosion processes Kopaonik_2023_ D. Vidojevic



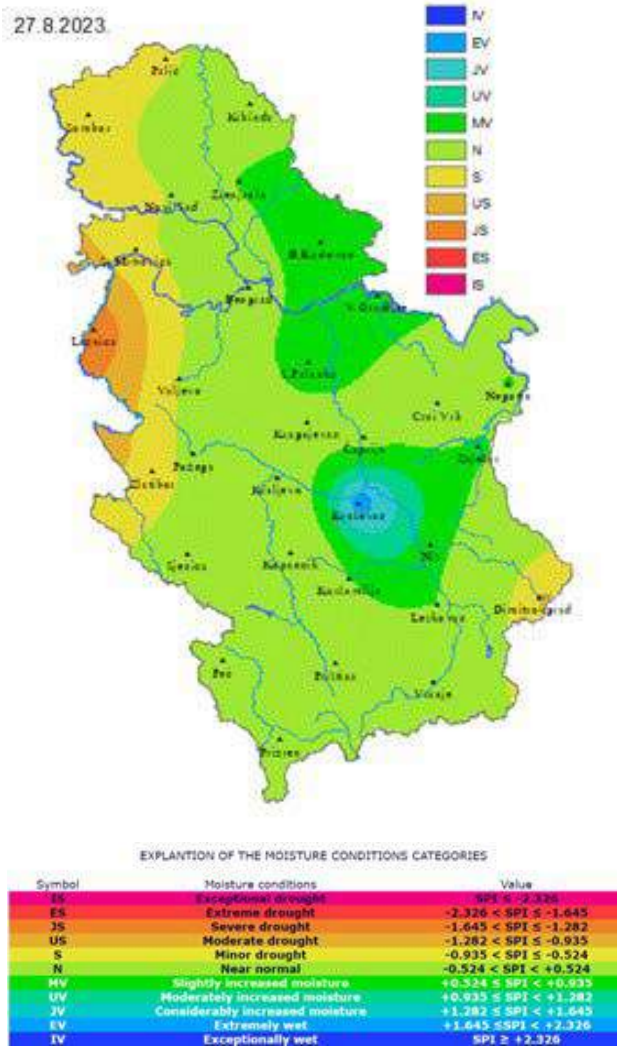
Picture A.6.6. Erosion processes Kopaonik_2023_ D. Vidojevic



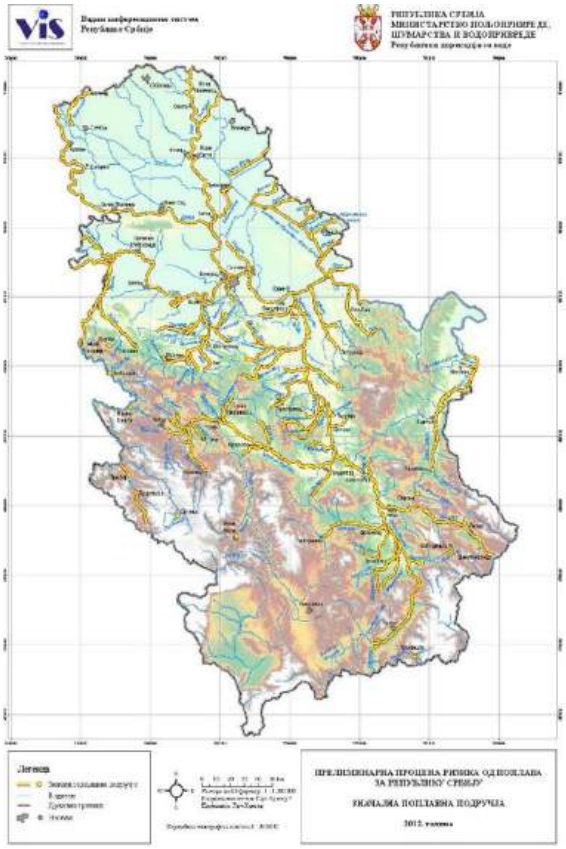
Picture A.6.7. Erosion processes Kopaonik_2023_ D. Vidojevic



Picture A.6.8. Anti hail protection net Eastern Serbia_ D. Vidojevic



Map A.6.1. Moisture conditions – drought monitoring in the Republic of Serbia, RHMZ
https://www.hidmet.gov.rs/eng/meteorologija/uslovi_vlaznosti.php



Map A.6.2. Areas with potential significant flood risk in Serbia
https://www.rdvode.gov.rs/lat/uredjenje-vodotoka-pp-rizika-poplava.php

Annex 6.2. Additional materials – water resources linked to climate change

Table A.6.5. Producers' adaptive capacities in Serbia

Indicator	Lists	Yes	No	If yes, please note used area (e.g. in ha or in % from total irrigated area in the economy, number of farmers, number of farms, etc.)	Source (literature; documents, studies; projects/ expert opinion, etc)	Comments
Micro-irrigation	Drip irrigation	Yes		27.2% of total irrigated area / 19,430 farms / 27,000 ha	Census of Agriculture, 2012	Subsurface irrigation system is applied for field crops
	Micro sprinkler	Note		Hard to estimate		Micro sprinklers are used for frost protection
	Drip fertigation	Yes		80%	Census of Agriculture, 2012	
	Sprinkler irrigation	Yes		12.2 % of total irrigated area/8.800 farms/12,200 ha	Census of Agriculture, 2012	
	Surface irrigation	Yes		60.6% of total irrigated area / 43,600 farms / 60,500 ha	Census of Agriculture, 2012	Used in highly intensive and automated irrigation system mainly for orchards
Irrigation scheduling practices	Irrigation programmes	Yes		50%	Expert opinion	Used in highly automated irrigation systems for orchards
	Sensors and data loggers	Yes		30%	Expert opinion	Used in highly automated irrigation systems for orchards
	Tensiometers	Yes		30%	Expert opinion	Used in vegetable production, and some orchards
	Meteo stations		No	Official data from Republic Hydrometeorological Institute is used for irrigation scheduling		Meteo stations are used for plant protection only
Soil moisture conservation methods	Organic mulch materials	Yes			Experts' experience	
	Inorganic mulch material	Yes			Experts' experience	
Training programmes	Lifelong learning programmes within universities	Yes		Benefits from the introduction of irrigation and drainage in the territory of the Republic of Serbia, FAO and the Institute for Science Application in Agriculture (IPN), October 2022	Materijali sa edukacija Arhive | Stranica 3 od 9 | Poljoprivredna Savetodavna i Stručna Služba Srbije (psss.rs)	Universities, FAO, Agronet, Institute for Science Application in Agriculture (IPN) organize professional education
	vocational training programmes related to water	Yes				University of Belgrade, Faculty of Agriculture, graduate, postgraduate and PhD study courses soil and water management; University of Novi Sad, Faculty of Agriculture graduate, postgraduate and PhD study courses on water management
	Targeted training courses for farmers and young professionals	Yes				Thematic education of farmers and young professionals; Company for the Design of irrigation system educate farmers after instalment
Other	UV nets	Yes		Hard to estimate		
	Cover crops	**Yes**		Hard to estimate		
	Anti-frost irrigation system	**Yes**		Hard to estimate		

Table A.6.6. Best practices in Serbia related to water and climate change in agriculture

Indicator	Best practice in place	Yield affected	Water use efficiency	Fertiliser use efficiency	Improving soil water properties	Other	Source
Drip irrigation	Yes	Yield increase	High	To some extent	To some extent		Expert experience
Subsurface irrigation system	Yes	Yield increase	High	To some extent	To some extent		Expert experience
Fertigation	Yes	Yield increase	High	High	Not applicable		Expert experience in blueberry production (MS thesis)
Anti-hail nets	Yes	Yield quality assurance	High	Not applicable	Not applicable		Prokopljević D., R. Stričević, B. Miletaški, 2012, Uticaj protivgradne mreže na evapotranspiraciju voćnjaka jabuka u Čelarevu. Savetovanje Melioracije 12. Novi Sad 26. 01.2012. Organizator. Univ. u Novom Sadu, Poljoprivredni fakultet. Tematski zbornik radova, str. 1-7.
Mulch – plastic	Yes	Yield increase	High	Not applicable	To some extent		Ćosić, M., Stričević R., Djurović, N., Moravčević, Dj., Pavlović, M., Todorović M. (2017): Predicting biomass and yield of sweet pepper grown with and without plastic film mulching under different water supply and weather conditions. Agricultural Water Management Vol. 188, p. 91–100.
Mulch organic	Yes	Yield increase	High	Not applicable	To some extent		Pavlović, M., Ćosić, M., Stričević, R., Đurović, N., Bogdan, I. (2018): Irrigation and mulching effects on the raspberry leaf temperatures measured by thermal imaging camera. ISHS Symposium "Methods and Applications in Horticultural Science", 5-7. October, Potsdam, Germany. Acta Horticulturae 1197: 179-186 M33 10.17660/ActaHortic.2018.1197.24 https://doi.org/10.17660/ActaHortic.2018.1197.24
Leaves spraying by suspension of Kaolin	Yes	Yield increase	High	Not applicable	Not applicable		Cosic M., N. Djurovic, M. Todorovic, R. Maletic, B. Zecevic, R. Stricevic (2015) Effect of irrigation regime and application of kaolin on yield, quality and water use efficiency of sweet pepper. Agricultural Water Management 159, 139–147
Protection of cold	Yes	Yield increase	To some extent	Not applicable	Not applicable		Expert experience
Deficit irrigation	Yes	To some extent	High	High	To some extent		Lipovac, A., Bezdan, A., Moravčević, D., Djurović, N., Ćosić, M., Benka, P., & Stričević, R. (2022). Correlation between Ground Measurements and UAV Sensed Vegetation Indices for Yield Prediction of Common Bean Grown under Different Irrigation Treatments and Sowing Periods. Water, 14(22), 3786.
Surface water accumulation	Yes	To some extent	High	To some extent	Not applicable		Expert experience
Use of drainage canal for irrigation / water reuse	Yes	To some extent	To some extent	To some extent	Low		Expert experience
Organic fertilization (manure, compost)	Yes	Yield increase	High	High	High		Expert experience

Table A.6.7. Documents

Document	Document type	Foreseen actions	Relevance for the EU adaptation strategy	Relevance for the EU water directive / water strategy	Identified gaps	Identified challenges
Water Master Plan, (2001) Ministry of Agriculture, Forestry and Water Management, Republic of Serbia; Institute Jarosalv Černi www.srbijavode.rs/images/dokumenti/vodoprivredna_osnova_republike_srbije.pdf	Strategy and action plans	Development of irrigation system, maintenance of drainage canals	**High**	**High**	Planned activities are not carried out according to the projected dynamics	
EU IPARD III Programme 2021-2027, https://ipard.rs/ipard-iii-program-u-srbiji/	Website				Not started yet	Contributing to mitigating climate change and encouraging sustainable management of natural resources; Supporting investments in material assets and technical improvements in agriculture
Subvention for the irrigation equipment, https://subvencije.rs/vesti/apv-bespovratna-sredstva-za-navodnjavanje-u-2017-godini/	Website	Development of irrigation systems			Not all subventions are used	Farmers need experts' help for documentation preparation
Second Biennial Update Report and Third National Communication under UNFCCC	National report	Application of new mitigation technology, water savings	**High**			
Group of Authors (2015). First National Adaptation Plan in Climate Change Condition for Republic of Serbia. Ed: Ministry of Agriculture and Environmental Protection, Belgrade. https://www.klimatske-promene.rs/wp-content/uploads/2017/09/NAP-UNDP-2015-srpski.pdf	National report	Development of irrigation system, maintenance of drainage canals	**High**			
(2011-2019): TR 37005 – Estimation of climate change impact on water resources in Serbia	National scientific projects	Application of new mitigation technology, water savings		**High**	Lack of knowledge in the field	Employment of irrigation experts
(2011-2019) Research on climate change and its impact on the environment – impact monitoring, adaptation and mitigation	National scientific projects	Application of new mitigation technology, water savings		High	Lack of knowledge in the fields	Employment of irrigation experts
https://adaptacije.klimatske-promene.rs/wp-content/uploads/2021/04/Institucionalni-kapaciteti-za-CCA-1.pdf	National report/draft			High		

Document	Document type	Foreseen actions	Relevance for the EU adaptation strategy	Relevance for the EU water directive / water strategy	Identified gaps	Identified challenges
https://adaptacije.klimatske-promene.rs/wp-content/uploads/2021/04/Postojeca-politika-regulatorni-i-institucionalni-okvir-1.pdf	National report/draft			High		
Overview and assessment of the existing policy, regulatory and institutional framework for adapting to climate change with recommendations for the development and improvement of a special policy and regulatory framework – Report 3 https://adaptacije.klimatske-promene.rs/dokumenta/	National report/draft		High	High		
Report	National report/draft		High	High		

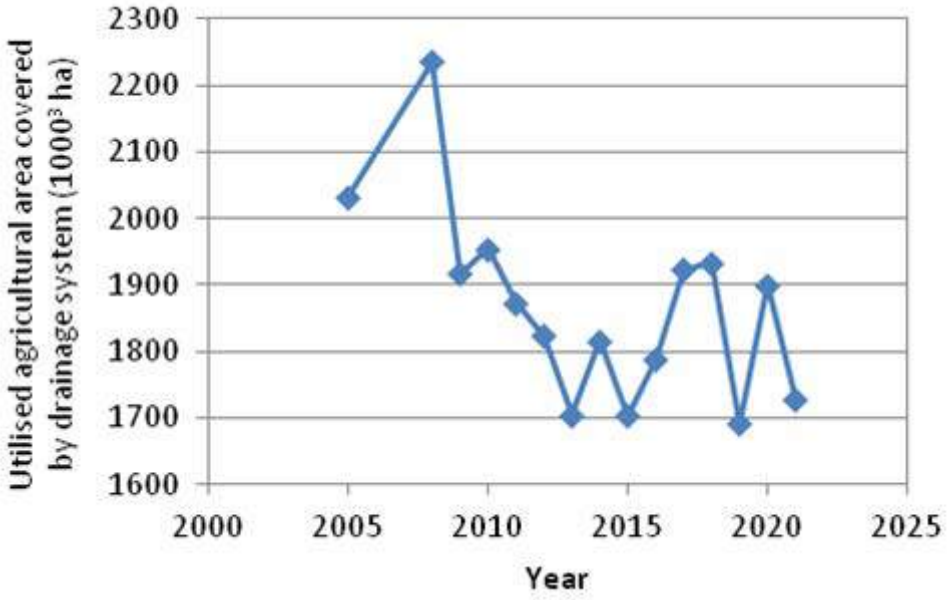


Figure A.6.1. Utilized agricultural area covered by drainage systems in the Republic of Serbia

Annex 6.3. Additional materials – crop production linked to climate change

Table A.6.8. Short overview of climate change hazards grouped in climate hazard categories according to impact, for near past periods (2001-2020 and 2011-2020) and for the future 2041-2060 period, compared to the 1961-1990 period

Group of climate hazards	2001-2020 (2011-2020)	2041-2060
Excess of heat	Average temp. +1.4°C (+1.8°C) Average JJA +2,0°C (+2,4°C); average max. JJA +2,2°C (+2,6°C) Heat waves +2,4 (+3) Hot days (above 35°C) +4 to +7 in low altitudes (in some areas +10)	Average temp. +3.1°C Heat waves +4 to +5 Hot days (above 35°C) above +20 in low altitudes
Excess of water	Shift of average monthly maximum from late spring and early summer to earlier months (change of annual distribution of precipitation) Fraction of precipitation in extreme events increased over 100% (change of precipitation distribution by intensity toward more extreme events) High risk of extreme precipitation over 7% of Serbia	Extreme precipitation continues to increase Risk of extreme precipitation increasing in intensity and over larger territory – 56% of territory under high risk
	In domestic rivers, increase of river discharge in the period of higher water levels in rivers Increase of the risk of soil degradation because of extreme precipitation	
Deficit of water	Decrease of average JJA precipitation 10%-20% (change of annual distribution of precipitation) 4 years with drought per decade (5 years) – there was 1 in the baseline period Extreme drought: 1 in 2011-2020 Average level of aridity/humidity: humid climate	Decrease of average JJA precipitation over 20% Each year is a year with drought Extreme drought: 3-4 per decade Increasing level of aridity, on average: dry sub-humid
	Decrease of river discharge in the period of low waters in domestic rivers Increase of the duration of the period of low waters Increasing risk of land and soil degradation Reduction of the speed of recharge of groundwaters	
Storms	Increase in intensity and frequency, including wind gusts and hail Increase of the average size of hail grain	

Table A.6.9. Short overview of identified climate change impacts on agriculture (crop production) in Serbia

Group of climate hazards	Impacts	Consequences
Excess of heat	Disturbance of normal phenological development, acceleration of some phenophases during extreme heat and early ripening Early growing season start triggered by warmer winter and spring periods and increased risk from appearance of frost in growing season Increased heat stress and damages on fruits during extreme heat Reduction of soil quality because of the change in environmental conditions favourable for its regeneration	Increased variability in the quality and quantity of yield, compared to long-term average Reduction of yield quality and quantity Increased water demands Reduction in soil quality Damages to agricultural infrastructure
Excess of water	Too wet soil conditions cause negative impacts and create unfavourable conditions for germination and root development At the time of flowering and pollination, precipitation can reduce fertilization and thus yield Reduction of soil quality due to erosion Favourable for the development of plant diseases Floods can completely destroy crop yields and damage agricultural infrastructure	
Deficit of water	Plants are under increased frequency of water deficit stress Due to frequent seasonal lack of water or lack during the growing season, impacts are visible in the reduction of long-term average production rates Decreasing soil quality due to insufficient moisture and wind erosion	
Storms	Physical damage to plants and fruits Damage to agricultural infrastructure	

Table A.6.10. Recommendation on adaptation measures/actions in crops production under climate changing conditions on the national level

1. Group of measures which require direct investments			
What to do?	**How?**	**Enablers**	
Protection of orchards and vineyards from hail and extreme temperatures	Anti-hail nets and nets for shading	Increase national investment in subsidies and education of producers	
Protection of orchards and vineyards from frost	Anti-frost systems	Increase national investment in subsidies and education of producers	
Insurance	Policy adjustments to climate change related loss reductions	Education of producers and insurance companies	
2. Main measures – group of measures which require a systematic approach			
What to do?	**What to do?**	**What to do?**	
Enable implementation of short-term adaptation (adjustments of production) - adaptation of production to upcoming weather conditions (mitigation of the impacts of weather extremes)	Use of information on the current state and future weather conditions (from long-term to short-term forecast) and adjustments of interventions to reduce negative impacts	Education on the use of prognostic products and interventions that should be implemented (education of advisory services and producers, introduction in school programmes)	
Enable long-term adaptation – adaptation of agricultural production to climate changing conditions	Zoning of climate favourable conditions for growing, including relevant risk assessment, under climate changing conditions, with recommendation for more resilient production and variety selection	Regular update of zoning projects of fruit and viticulture production and development study for zoning of annual crops production	
3. Measures which enable implementation of the main group of measures			
What to do?	**What to do?**	**What to do?**	
Improvement of agrometeorological services	Effective dissemination of information on the observed and forecasted heat and wet/dry conditions, with products adjusted for users in agriculture	Improvement of monitoring system, development of high-resolution forecast products adjusted for agriculture (from long-term to short-term forecast), improvement of information dissemination	
Improvement of scientific knowledge on climate change and impacts and effective measures for mitigation of negative impacts	Monitoring of climate change impacts (including pests and diseases), regular update of vulnerability and risk assessment using new available data and regular update of recommendations for mitigation of risks	Implementation of the latest knowledge in zoning projects and studies, in educational materials, etc.	
4. Measures which secure conservation of natural resources and development of sustainable agriculture in climate changing conditions			
What to do?	**How?**	**Enablers**	
Optimization of irrigation, in accordance with needs and resources	Increasing capacity for irrigation and irrigation efficiency	Introduction of knowledge on climate change and impacts on water resources, soil and water requirements in plans for the development of irrigation systems and implementation of irrigation Education on optimal and on-time irrigation	To include the nexus concept agriculture-water-soil in strategic documents, zoning projects, studies and education
Sustainable land management	Protection and potential improvement of soil productivity by implementation of optimal tillage and irrigation, fertilization and use of pesticides, under climate changing conditions	Introduction of knowledge in education of advisory services and other stakeholders, and introduction of recommendations in zoning projects and studies for different sub-sectors.	

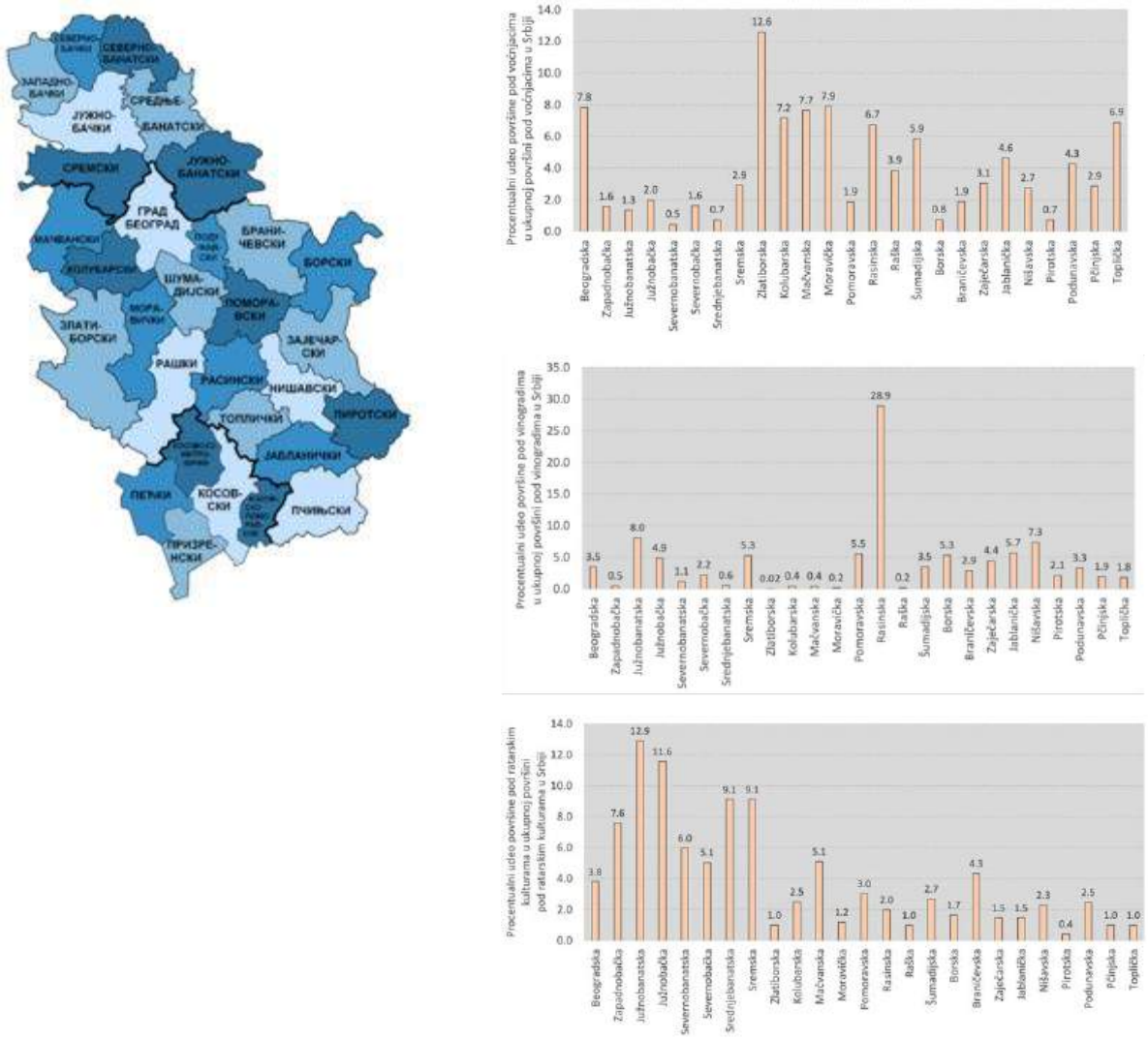


Figure A.6.2. Administrative regions in Serbia

Note: V&R assessment was done on the level of regions (without Kosovo*). Distribution of areas under fruit production (% of total area under fruit production) in the upper panel, distribution of areas under vineyards (% of total area under vineyards) in the middle panel, distribution of areas under annual crops (% of total area under annual crop production) in the lower panel.

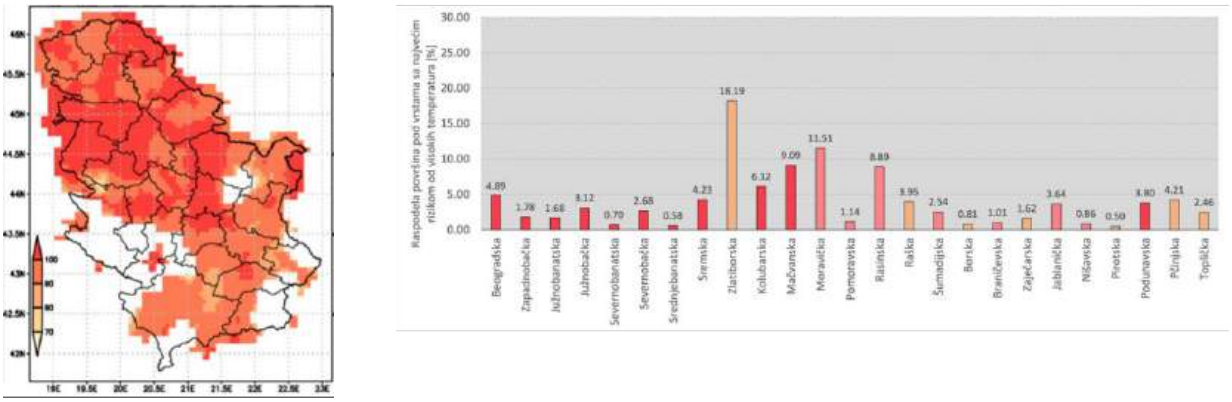


Figure A.6.3. Left panel – Duration of the growing season period overlapping with the period with high probability for the occurrence of extreme temperatures (change of phenological development under changing climate conditions included in the calculation). Right panel – Distribution of areas with cultivation of the most sensitive varieties, with colours showing risk levels (red is high risk, pink is medium and orange is low).

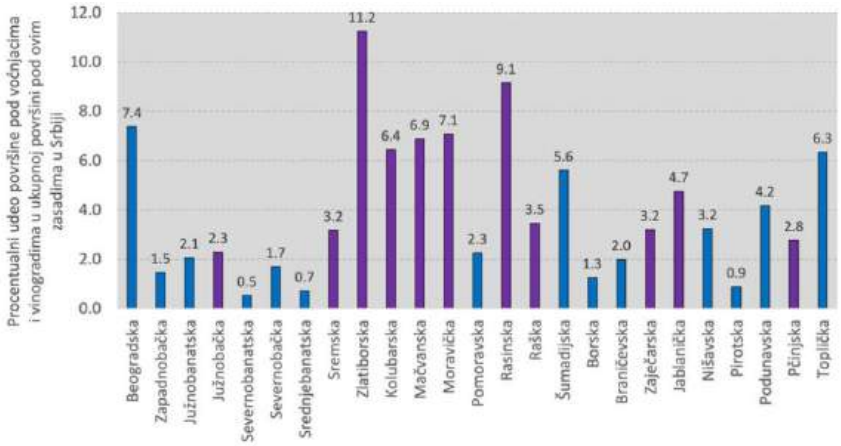


Figure A.6.4. Distribution of areas with cultivation of perennial crops and hail risk level (purple is high risk, blue is medium risk)

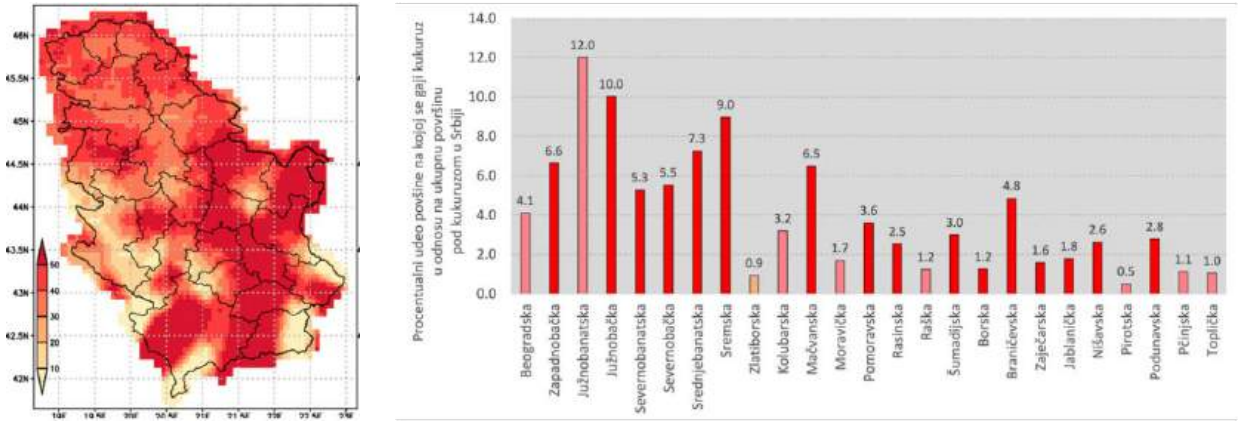


Figure A.6.5. Left panel – Frequency of years within climate period (%), for the period 2041-2060, with occurrence of dry and high temperature conditions during the phenological stage of maize developments when the maize is highly sensitive. Right panel – Distribution of areas with maize production with colours showing risk levels (red is high, pink is medium, orange is low)

List of acronyms

AEZ	Agro-Ecological Zones
AFOLU	Agriculture, Forestry and Other Land Use
AFSA	Albanian Financial Supervisory Authority
AFSARD	Agency for Financial Support to Agriculture and Rural Development (North Macedonia)
AgGVA	Agricultural Gross Value Added
AKIS	Agriculture Knowledge and Innovation System
AL	Albania (Country code- ISO 3166-1 alpha-2)
ALB	Albania (Country code- ISO 3166-1 alpha-3)
AMS	Automated Meteorological Stations
ANC	Areas with Natural Constraints
AP	Action Programme
APMC	Agricultural Policy Measures Classification tool
AquaCrop	AquaCrop FAO crop-water productivity model
AQUASTAT	FAO's Global Information System on Water and Agriculture
ARDPF	Agriculture and Rural Development Programme Fund (Albania)
ASBH	Agency for Statistics of Bosnia and Herzegovina
ATP	Autonomous Trade Preference
ATTC	Agricultural Technology Transfer Centres
AVI	Average Livelihood Vulnerability Index
AWS	Automated Weather Stations
AWU	Annual Work Units
BA	Bosnia and Herzegovina (Country code- ISO 3166-1 alpha-2)
BCM	Billion Cubic Meters
BD	Brčko District
BDDAFW	Brčko District Department of Agriculture, Forestry and Water Management
BiH	Bosnia and Herzegovina (Country code- ISO 3166-1 alpha-3)
BiOMA	Biophysical Model Applications
BUR	Biennial Update Report
CAN	Climate Action Network
CAP	Common Agricultural Policy
CC	Climate Change
CCA	Climate Change Adaptation
CCCs	Climate Change Committees
CCHF	Crimean-Congo haemorrhagic fever
CCKP	Climate Change Knowledge Portal

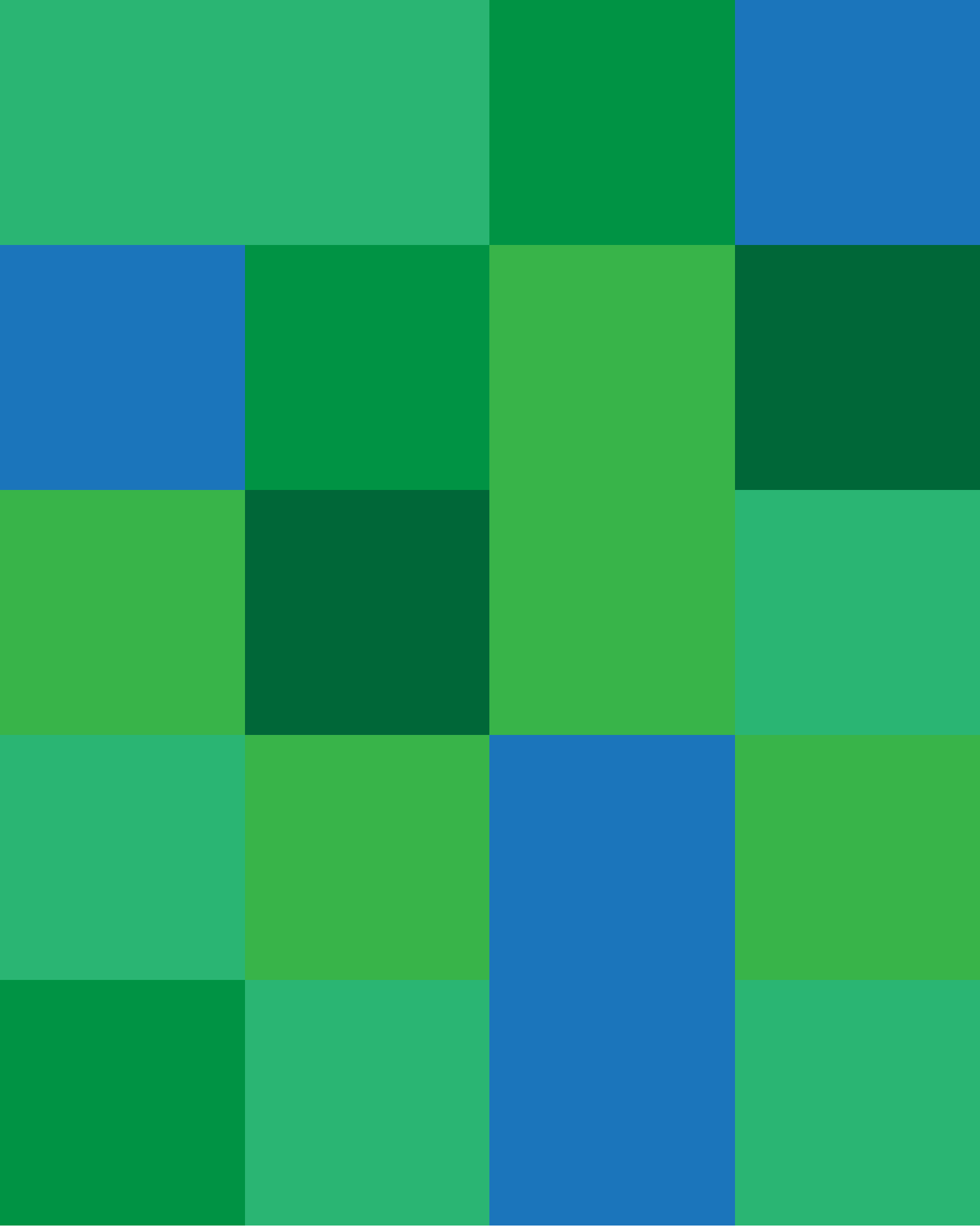
CCU	Climate Change Unit
CDM	Clean Development Mechanism
CLRTAP	Convention on Long-Range Transboundary Air-Pollution
CMC	Crisis Management Centre
COP28	Conference of the Parties 28 (United Nations Climate Change Conference)
CPC	Civil Protection Committee
CROPFLEX	Tool for irrigation timing and nutrient scheduling
CropSyst	Multi-year multi-crop simulation model (FAO)
CropWat	Computer program for calculation of crop water requirements and irrigation requirements based on soil, climate and crop data (FAO)
CSA	Climate-Smart Agriculture
CSOs	Civil Society Organizations
DLDD	Desertification, Soil Degradation and Drought
DMP	Drought Management Plan
DNA	Designated National Authority
DRRM	Disaster Risk Reduction and Management
DSSAT	Decision Support System for Agrotechnology Transfer
DTM	Digital Terrain Model
EbAs	Ecosystem-based Approaches
EEA	European Environment Agency
EFFB&H	Environmental Fund of the Federation of Bosnia and Herzegovina
EFFIS	European Forest Fire Information System
EIONET	European Information and Observation Network
EOBS	Daily gridded observational dataset for precipitation, temperature and sea level pressure in Europe
EPA	Environmental Protection Agency
EPEEFRS	Environmental Protection and Energy Efficiency Fund of the Republic of Srpska
EPR	Environmental Performance Review
ERP	Economic Reform Programme
ET_0	Evapotranspiration
EU	European Union
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organisation of the United Nations
FAOSTAT	Food and Agriculture Organization Statistical Database
FBiH	Federation of Bosnia and Herzegovina
FFIS	Forest Fires Information System
FHMI	Federal Hydrometeorological Institute of Bosnia and Herzegovina
FLW	Food Loss and Waste
FSDN	Farm Sustainable Data Network

FSS	Farm Structure Survey
FUE	Fertilizer Use Efficiency
FVC	Fractional Vegetation Cover
GAEC	Good Agricultural and Environmental Conditions
GAP	Good Agricultural Practice
GAWB	Green Agenda for the Western Balkans
GCF	Green Climate Fund
GDD	Growing Degree Days
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse gasses
GIS	Geographic Information System
GLD	Grazing livestock density
GRB	Gender-responsive budgeting
GVA	Gross Value Added
HA	Hectare
HMIK	Hydrometeorological Institute of Kosovo*
HMS	Hydro-Meliorative Systems
IACS	Integrated Administration and Control System
IGEO	Institute of Geosciences (Albania)
IHMS	Institute for Hydrometeorology and Seismology (Montenegro)
IMF	International Monetary Fund
IMHS	Institute of Meteorology, Hydrology, and Seismology (Albania)
iMWGCC	Inter-Ministerial Working Group on Climate Change
INSTAT	Institute of Statistics (Albania)
IPA	Instrument for Pre-Accession Assistance
IPARD	Instrument for Pre-Accession in Agriculture and Rural Development
IPCC	Intergovernmental Panel on Climate Change of the United Nations
ISFM	Integrated Soil Fertility Management
JRC	Joint Research Centre
KEPA	Environmental Protection Agency (Kosovo*)
KIMP	Irrigation Master Plan (Kosovo*)
KIRP	Irrigation Rehabilitation Project (Kosovo*)
KM	Bosnia and Herzegovina convertible mark
LAI	Leaf Area Index
LAU	Local Administration Unit
LDN	Land Degradation Neutrality
LEADER	Links between activities for the development of rural economy

LEK	Albanian lira
LPIS	Land Parcel Identification System
LSG	Local self-government
LSU	Livestock Units
LVI	Livelihood Vulnerability Index
MAFRD	Ministry of Agriculture, Forestry and Rural Development (Kosovo*)
MAWFFiBH	Federal Ministry of Agriculture, Water Management and Forestry
MAFWE	Ministry of Agriculture, Forestry and Water Economy (North Macedonia)
MAFWM	Ministry of Agriculture, Forestry and Water Management (Montenegro, Serbia)
MAFWRS	Ministry of Agriculture, Forestry and Water Management (Republika Srpska)
MAPs	medicinal and aromatic plants
MARD	Ministry of Agriculture and Rural Development (Albania)
MASIS	Macedonia Soil Information System
MCM	Million Cubic Meters
MED	Ministry of Economy Development (Kosovo*)
MEI	Ministry of Energy and Infrastructure (Albania)
MESPI	Ministry of Environment, Spatial Planning and Infrastructure (Kosovo*)
MFIs	Microfinance Institutions
MIDAS	Montenegro Institutional Development and Agricultural Strengthening project
MIS	Management Information System
MK	Macedonia (Country code- ISO 3166-1 alpha-2)
MKD	Macedonian denar
MNE	Montenegro (Country code- ISO 3166-1 alpha-3)
MOEPP	Ministry of Environment and Physical Planning
MoFE	Ministry of Environment and Physical Planning (North Macedonia)
MOFTER	Ministry of Foreign Trade and Economic Relations (Bosnia and Herzegovina)
MoHSP	Ministry of Health and Social Protection (Albania)
MONSTAT	Statistical Office of Montenegro
MoTE (MTE)	Ministry of Tourism and Environment (Albania)
NACP	National Agency for Civil Protection (Albania)
NAMAs	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plan
NAPM	National Action Plan on Mitigation
NARDS	National Strategy on Agriculture and Rural Development
NbS	Nature-based Solutions
NC	National Communication
NCFMNH	National Centre for Forecast and Monitoring of Natural Hazards
NDC	Nationally Determined Contributions
NDVI	Normalized Difference Vegetation Index

NEA	National Extension Agency
NFP	National Focal Point
NGOs	Non-governmental organisations
NIPH	National Institute of Public Health
NMHS	National Meteorological and Hydrological Service
NSCC	National Strategy on Climate Change
NSDEI	Strategy for Development and European Integration (Albania)
NSSD	National Strategy on Sustainable Development
NSZP	National Strategy for Nature Protection
NUTS	Nomenclature of territorial units for statistics
NWC	National Water Council
OIV	International Organisation of Vine and Wine
PDSI	Palmer Drought Severity Index
PIM	Participatory Irrigation Management
PSSS	Agricultural Advisory and Expert Service of Serbia
RBC	River Basin Councils
RCC	Regional Cooperation Council
RCP	Representative Concentration Pathway
RHMZ	Republic Hydrometeorological Institute (Serbia)
RHMZRS	Republic Hydrometeorological Institute (Republika Srpska)
RS	Republic of Serbia (Country code- ISO 3166-1 alpha-2)
RS (BiH)	Republika Srpska (Bosnia and Herzegovina)
SARDF	Strategy for Agriculture, Rural Development and Forestry (Albania)
SASPAC	National Plan for European Integration 2022 (Albania)
SDGs	Sustainable Development Goals
SEE	South-East Europe
SEPA	Environment Protection Agency (Serbia)
SIS	Soil Information System
SOC	Soil organic carbon
SOM	Soil organic matter
SORS	Statistical Office of the Republic of Serbia
SPEI	Standardized Precipitation Evapotranspiration Index
SPI	Standardized Precipitation Index
SS	Daily sunshine duration in hours
SSO	State Statistical Office of the Republic of North Macedonia
StatDBs	Statistical Databases (SWG AgPolicy monitoring)
SWG	Standing Working Group
SWICCA	Service for Water Indicators in Climate Change Adaptation
SWSI	Surface Water Supply Index

THI	Thermal Humidity Index
UAA	Utilized Agricultural Area
UHMR	National Hydrometeorological Service of the Republic of North Macedonia
UN	United Nations
UNCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
UV	Ultra-Violet
WB	Western Balkans
WB6	Western Balkan six (economies)
WBE	Western Balkan economies
WBG	World Bank Group
WFD	Water Framework Directive
WMO	World Meteorological Organization
WUA	Water Users Associations
WSRA	Water Services Regulatory Authority
WUA	Water User Associations



Version 1; October 2024