

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 I: REGIONAL SYNTHESIS REPORT



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

VOLUME I: REGIONAL SYNTHESIS REPORT

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

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Executive summary

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. It is composed of different profiles of experts and representatives of relevant authorities from the Western Balkans region, aiming to contribute to evidence-based policy in the area of climate change adaptation of the agricultural sector. 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 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 economies and regional level.

SWG wants to thank the Germany Federal Ministry of Food and Agriculture (BMEL) and German Corporation for International Cooperation (GIZ) for their overall support in this process.

The study provides an overview of the status of adaptation to climate change in agriculture in Western Balkan economies (WBE): Albania, Bosnia and Herzegovina, Kosovo *, Montenegro, North Macedonia, and Serbia. The focus is on the main developments in the socio-economic context, natural resources (soil and water), crop and livestock sector on economy and Regional levels. The study is presented in two parts: Regional Synthesis Report (Volume I) and Economies Reports (Volume II).

Climate change poses a major threat to agriculture and rural areas in the Western Balkans, impacting livelihoods, food security, and the overall economy. The sectoral and rural development in WBE continues to experience hindrances, reflecting farmers' adaptive capacity and vulnerability to climate change – slow productivity growth, high unemployment rates with persisting outmigration trends, aging population, limited access to productive assets, dominance of small-scale farming, fragmentation of agricultural land, weak value chains, lack of modernization and application of new technologies, not fully functional knowledge and innovation transfer systems, high vulnerability to external shocks caused by climate change or market distortions. This emphasizes the need for improved agricultural practices, investments in new technologies, and support for farmers to build resilience in the face of climate change.

The soil in WBE is under serious impact of climate-driven processes. Climate change and unsustainable agricultural practices are causing severe soil degradation. This reduces agricultural productivity and long-term soil health. Social awareness of soil, its importance, the need for its protection and the

1 *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.

process of adaptation to climate change needs to be strengthened. Soil health and fertility can be improved through promoting the use of cover crops, crop rotation, and reduced tillage. Soil degradation can be minimized by the adoption of natural fertilizers and organic farming methods to minimize soil degradation.

In general, water resources in WBE meet the needs for all purposes. However, economies from the region continuously and increasingly face huge damages caused by drought of varying intensity. Water management and sustainable irrigation practices are crucial for the stability and productivity of agriculture, with an urgent need for investment in hydro-meliorative systems and modern irrigation structures to improve water use efficiency, as well as to promote water-saving practices such as rainwater harvesting and improved irrigation scheduling. Drought-tolerant crops and varieties are a crucial adaptation strategy, reducing reliance on irrigation and the associated strain on water resources.

Across all WBE, several crops (grapes, wheat, apples and maize) were identified as sensitive to climate change and should be a focus of regional adaptation efforts. Other important crops with localized sensitivity need tailored solutions based on specific risks. Agriculture's sensitivity to climate change is a common theme across the Western Balkans, with specific regions and crops facing unique challenges. It is important to conduct serious research to understand these vulnerabilities and to design effective adaptation measures suitable to different climate, soils, and other crop growth factors prevailing in the region.

Climate change poses a significant threat to livestock farming in WBE through rising temperatures leading to heat stress in livestock, extreme weather events, changes in precipitation patterns affecting forage availability, and potential emergence of new diseases. The direct influence of climate change can be observed through disturbance in feeding, availability of water, and water quality. The impacts on livestock farming are manifested through reduced animal welfare and productivity, economic losses for farmers, and ultimately compromised food security.

Limited access to information, outdated knowledge, and lack of financial resources hinders WBE farmers' ability to adopt sustainable practices. This reduces the effectiveness of adaptation efforts. Farmers need timely and localized information on adaptation strategies. Research, policy and extension segments in WBE still lack sufficient knowledge about climate change impacts and adaptation strategies. There is need for all-around skilled personnel in climate-resilient agriculture.

Reliable data on climate impacts, soil health, water resources, agricultural production, economic and socio-economic circumstances are all crucial for informed decision making. Governments and research institutions need to invest in robust and open-access data collection systems, and develop comprehensive monitoring, reporting and verification systems for continuous sectoral analysis. This will allow to track the effectiveness of adaptation measures and identify areas for improvement. Investments in research and development, with public and private sector collaboration, can accelerate the development and deployment of climate change adaptation solutions.

The EU approximation process is driving the Western-Balkan economies to align with the EU legislative and strategic frameworks. Many important legislative acts are still missing in WBE. In line with the EU ambition, WBE have committed to align with the European Green Deal's key elements by endorsing the Green Agenda for the Western Balkans (GAWB). The economies have undertaken to work towards ensuring green and digital transformation of the agricultural sector, including supporting adaptation to climate change in agriculture.

All WBE have well-developed agricultural policies and strategic documents following the EU framework. There is a notable push towards a more environmentally ambitious agenda, emphasizing environment, climate, and biodiversity-related goals, consistent overall with the EU Common Agricultural Policy. Implementation, however, remains a major challenge, with marginal payments related to climate change adaptation actually injected in the sector.

Fragmented institutional structures, overlapping mandates, and insufficient inter-sectoral collaboration limit effective implementation of adaptation measures. Coordination between relevant ministries (agriculture, environment, finance, education and science, social policy, etc.) and relevant stakeholders needs to be improved, with clear roles, responsibilities and effort sharing among different institutions involved in climate change adaptation in agriculture.

Western Balkan economies face financial constraints to invest in adaptation measures, infrastructure improvements, and research and development. Farmers in particular lack the financial resources to invest in new technologies and sustainable practices. Tailored effective financial mechanisms and measures need to be developed to support farmers in adopting climate-smart practices and technologies.

These elaborated findings and recommendations provide grounds for a more actionable roadmap for building a climate-resilient agricultural sector in WBE. By implementing these steps, economies can empower farmers to adapt to climate change, create a more equitable future for all stakeholders in the face of climate change and ensure long-term food security in the region.

In that context, the identified priorities and actions for more effective implementation of the recommendations are as follows:

- Establish a regional task force dedicated to coordinate regional adaptation efforts and implement recommendations and priority actions, identify funding opportunities, facilitate collaboration and develop joint research projects, including representatives from all Western Balkan economies.
- Develop national and regional strategic roadmaps for climate change adaptation in agriculture, focusing both on specific national contexts, as well as shared regional goals, resource pooling, and joint initiatives in Western Balkan economies.
- Implement pilot applied research projects to test and demonstrate potential adaptation practices and technologies, and showcase their effectiveness, facilitating broader adoption.
- Create and conduct capacity-building programmes for farmers, policymakers, extension services and other relevant stakeholders to enhance knowledge and skills for adaptation. Building capacity at all levels is essential for the successful implementation of adaptation strategies.
- Establish a digital platform for knowledge exchange and support the dissemination of innovative solutions and best practices across the region.
- Encourage quadruple helix collaborations between governments, private sector, research institutions, and civil society organizations to mobilize resources and expertise.
- Build research capacities by establishing a Regional Innovation Hub for Agriculture and Climate Change to boost currently underdeveloped research and innovation activities and create an enabling environment for effective scientific-based adaptation of the agricultural sector to climate change in the region.

This comprehensive approach, combining sector-specific and cross-sectoral strategies with overarching goals for resilience and cooperation, ultimately addresses the multifaceted impacts of climate change on agriculture in the Western Balkan region. Implementing these recommendations and priority actions will require a concerted agenda with collaborative efforts from regional governments, international organizations, the private sector, and local communities.

1.

Adaptation to climate change in agriculture – status, gaps and recommendations in Western Balkan economies

1. Adaptation to climate change in agriculture – status, gaps and recommendations in Western Balkan economies

1.1. 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 of 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 (WB) are one of the regions in Europe most heavily affected by the impact of climate change. Climate change already poses significant challenges to agriculture in the region, affecting crop yields, production resources, water availability, human and 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. The whole region is under the significant increase of temperature, most pronounced in Montenegro and Bosnia and Herzegovina, and somewhat less in North Macedonia; an alarming increase of temperature is expected over the whole territory, with a temperature increase of 1.2ºC in the near future, warming further by 1.7-4.0°C and even exceeding 5.0°C by the end of the century, depending on the global efforts in greenhouse gasses (GHG) emission reduction (RCC, 2018). Rural areas are significantly impacted by climate change. The region 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 GHG emissions, 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 on 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 climate change effects (Füssel and Klein, 2017). Stronger adaptive capacity moderates the potential impact of exposure and sensitivity, and hence reduces vulnerability (Figure 1.1).

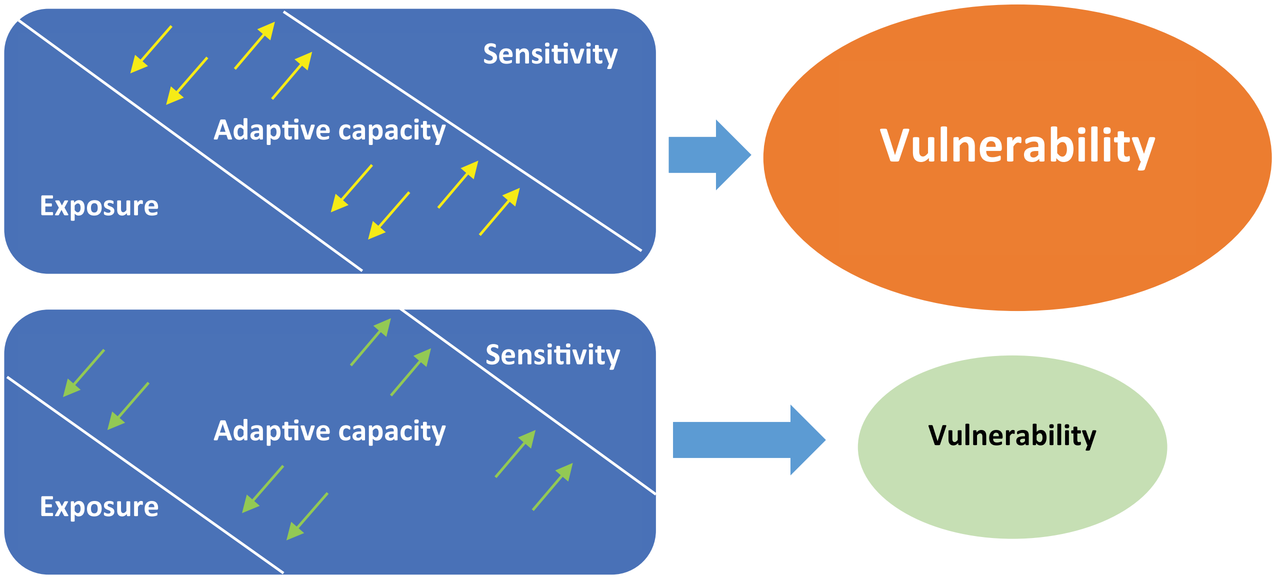


Figure 1.1. Adaptation decreases vulnerability

Source: adapted from Engle (2011)

The Agenda 2030 with its 17 Sustainable Development Goals (SDGs) along with the European Green Deal and its nine policy areas, are the key strategic frameworks for the transformation of Europe into a climate-neutral continent in the future decades. Climate action is also at the core of the reformed EU 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 and digital 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 permanent part of the SWG structure. They are comprised of relevant national, regional and international experts, as well as representatives of relevant authorities to 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 relevant issues for better and more successful climate change adaptation in agriculture in the region.

1.2. 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 leve**l. Furthermore, it focuses on the following objectives:

- Providing a summary of the 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 policies, reflecting resource limitations and competing priorities.
- Identifying data availability, accessibility and quality, and data gaps related to the analysis of climate change in agriculture.
- Identifying trends, practices and responses to climate change effects in the economies.
- Providing conclusions and recommendations on the status of adaptation to climate change in agriculture in Western Balkan economies.

1.3. Methods, data and structure of the study

The comprehensive Study on Climate Change Adaptation in Agriculture – Status and Prospects in the Western Balkan Economies is presented in two parts: Volume I – Regional Synthesis Report and Volume II – Economies Reports (Figure 1.2).

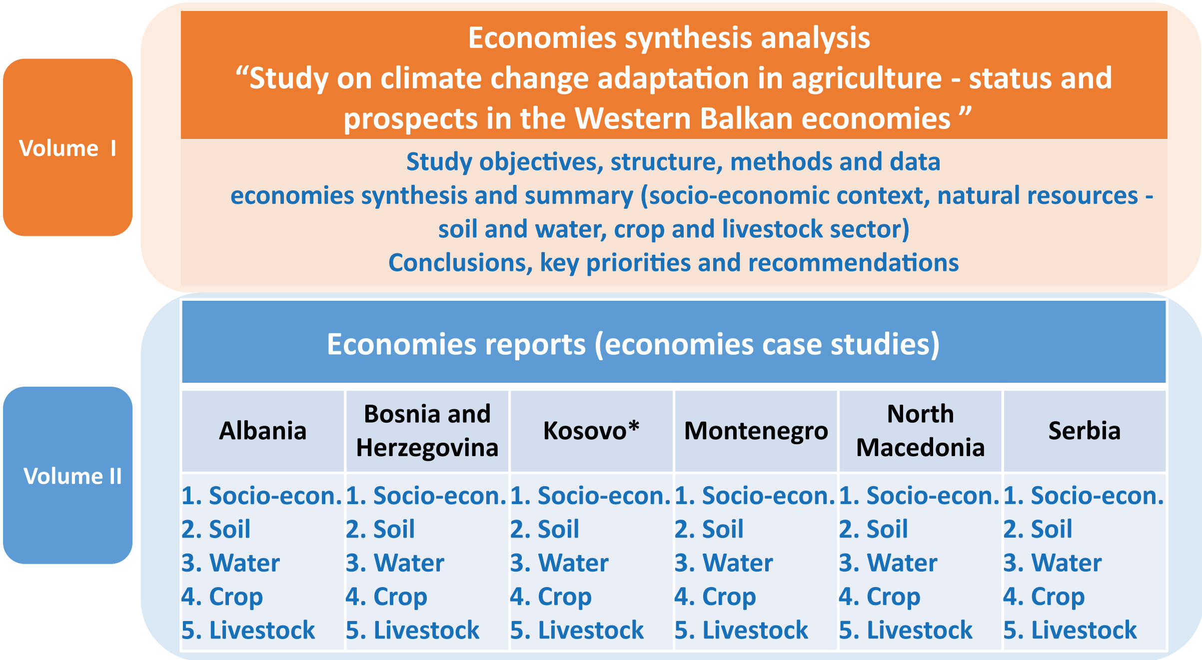


Figure 1.2. Conceptual framework and structure of the study

The **Regional synthesis analysis (Volume I)** is structured into eight chapters. The introductory chapter gives an overview of the background and purpose of this comprehensive study, its objectives, methods and data used. The subsequent chapters synthetize the findings and the logic of the elaborate economies reports (Volume II), addressing the adaptation to climate change in agriculture and its status, gaps and recommendations across the respective six Western Balkan economies (WBE): Albania (AL), Bosnia and Herzegovina (BA), Kosovo* (XS), Montenegro (ME), North Macedonia (MK) and Serbia (RS). In that respect, different angles of the climate change adaptation in agriculture are presented in the Western Balkan economies context.

Chapter 2 provides a snapshot of the status of the **economic, socio-economic and agricultural sector situation** related to climate change adaptation in Western Balkan economies , covering the macro-economic background; key agricultural sector level overview; land use features and trends; farm structure key indicators and context in terms of adaptive capacities.

Chapter 3 highlights the key features of the **legislative framework, institutional setup and policy support** towards agricultural sector adaptation to climate change in Western Balkan economies .

Chapter 4 includes the status of **soils linked to climate change in agriculture** across the study economies , with brief estimation of the exposure and sensitivity of soils to climate change and its influence on the overall soil health; outline of the existing gaps and challenges to meet the newly adopted EU strategic and legal documents on soil and adaptation; summary of the sustainable measures and best practices already applied for the protection of agricultural land; and overview of the already adopted mechanisms and opportunities for effective adoption of adaptation measures for soil health protection.

Chapter 5 is dedicated to the status of **water resources linked to climate change in agriculture**, with analysis of water resources, their importance for agricultural production and irrigation status in the study economies ; drought risk assessment and crop water requirements; overview of the existing

2 *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.

farmers' adaptive practices for proper water use under climate change; summary of economies strategies and adaptation plans for water use in agriculture, including reports, research and development (R&D), projects and communications within the United Nations Framework Convention on Climate Change (UNFCCC) framework.

Chapter 6 focuses on **crop production analysis** linked to climate change adaptation in agriculture, through most common agrometeorological indices; phenological monitoring; existing crop models used for estimating crop response to climate change extreme weather events; information on the most important crops sensitive to climate change, vulnerable regions and their combination; 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; and current infrastructure and systems for preventing the negative effects of weather extremes on crop production.

Chapter 7 covers the **livestock farming analysis** linked to climate change adaptation in agriculture in Western Balkan economies , with focus on heat stress risk assessment for ruminants, pigs and poultry and an overview of the existing farmers' adaptive practices for mitigating the impacts of climate change.

Chapter 8 synthesizes the main **concluding remarks with key recommendations and priorities** of this comprehensive effort.

Volume II contains the economies reports addressing the adaptation to climate change in agriculture and its status, gaps and recommendations in each of the respective six Western Balkan economies. Within each economy chapter, there are five main sections that address different angles of the 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.

The analysis stems from a desk 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 economies 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. Selected references are provided at the end of Volume I, while the full extensive lists of references are enclosed in the economies reports (Volume II).

Given the complex knowledge and profile needed to cover the different aspects of adaptation of agriculture to climate change, respective chapters were developed by a multidisciplinary group of experts, led and edited by regional coordinators.

2.

Status of economic, socio-economic and agricultural sector situation in WBE related to climate change adaptation

2. Status of economic, socio-economic and agricultural sector situation in WBE related to climate change adaptation

Climate change can have significant implications for the Western Balkan economies , adding a new layer of complexity to the region's economic and socio-economic landscape. The Western Balkans are particularly vulnerable to extreme weather events such as floods, droughts, and heatwaves. These events can disrupt agricultural production, damage infrastructure, displace populations, and disrupt supply chains, leading to economic losses and a significant negative impact on GDP growth.

Climate change effects may have both a direct and an indirect impact on the Western Balkan agricultural sector and development of rural areas. 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 incomes, and, ultimately, food security on a local, regional, and international level (EEA, 2019). From a socio-economic standpoint, these economies exhibit high vulnerability because of the relatively high, though declining, unemployment rates, especially among women and the youngest, and a still significant portion of the population employed in the agricultural sector, which is extremely vulnerable to climate variability and climate change. This reinforces the need to increase resilience to climate change impacts on key socio-economic sectors and ecosystems, with a defined system to monitor socio-economic vulnerability to climate change.

2.1. WBE macroeconomic background

The Western Balkan region consists of six small open economies: Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia and Serbia. The region presents a complex economic picture. Following the repercussions of the COVID-19 crisis and the subsequent shocks caused by the war in Ukraine, macroeconomic stability has recently resumed, though with a slow recovery pace. An increasingly pressing factor is climate change, with a particular focus on its impact on agriculture, the backbone of most economies in the region.

Western Balkan economies are small; all six economies together generated a total of EUR 129 billion combined output of GDP at current prices in 2022 (Table 2.1), an equivalent to 0.8% of the EU's GDP standing at EUR 15,807 billion in the same year (WB StatDBs, EUROSTAT, 2024). Almost half is produced by Serbia, as the largest economy among WBE, followed by Bosnia and Herzegovina, Albania and North Macedonia.

Table 2.1. Key macroeconomic indicators (average 2017-2022)

Indicator	AL		BA		XS*		ME		MK		RS	
	2012	2022	2012	2022	2012	2021	2012	2022	2012	2022	2012	2022
GDP (at current prices, mil. EUR)	9,590	17,963	13,117	23,266	5,059	7,817	3,181	5,924	7,585	12,898	33,679	60,371
Value added (at current prices, mil. EUR)	8,296	14,288	10,685	19,532	4,167	6,244	2,668	4,769	6,561	11,592	28,426	49,671
GDP per capita (EUR)	3,306	6,430	3,419	6,763	2,799	4,316	5,126	9,598	3,680	5,136	4,677	8,882
External trade balance (mil. EUR)	-2,266	-3,899	-3,781	-5,452	-2,232	-3,935	-1,406	-2,834	-1,947	-3,826	-5,945	-11,404
Unemployment rate (%)	14	11	28	15	31	21	20	15	31	14	26	9
Food, beverages and tobacco in household expenditures (%)	39	45	:	33	45	46	36	:	37	52	38	36

Source: WBE STAT Databases, authors' calculations. Note: (:) data not available.

The per capita GDP is rising over time, ranging from 4,316 EUR in Kosovo* to 9,598 EUR in Montenegro in 2022. However, the persistent changes in temperature above its historical norm in the region are predicted to adversely affect the real output growth in the future. A recent IMF study on long-term impact of climate change on economic activity across economies (Khan et al., 2021), estimated that in the extreme scenario, in absence of mitigation policies, the real GDP per capita in WBE would be reduced by almost 10% by 2100 (the world average being 7%). Montenegro is by far seen as the most affected economy in the region (9.6% to 17.5% by 2100, depending on the scenario), while the least negative effect is expected for Serbia (0.8% to 8.7% by 2100, Figure 2.1).

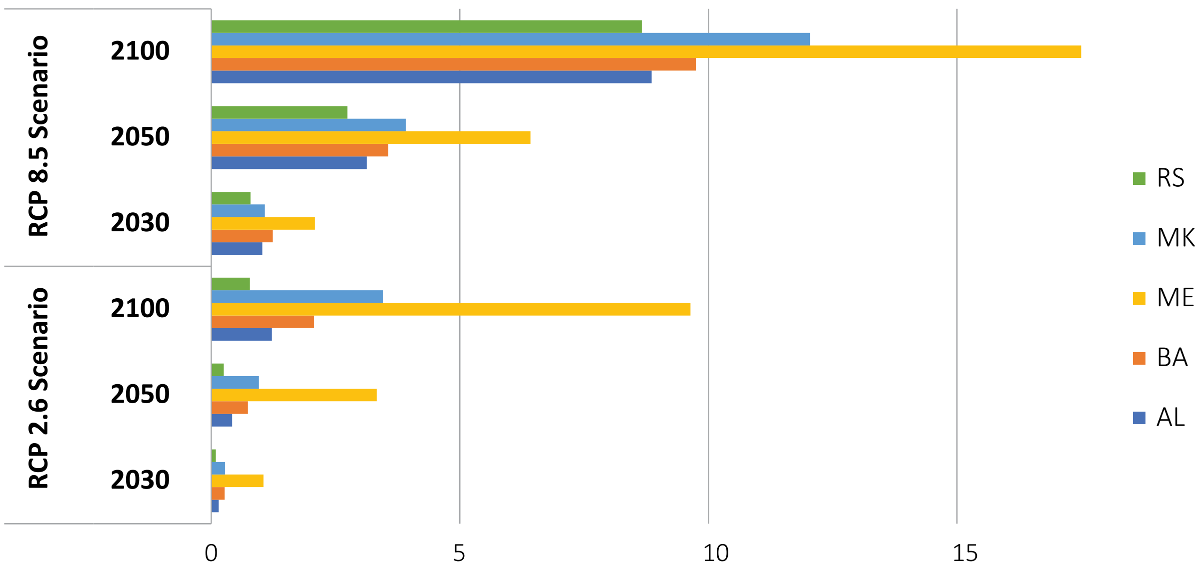


Figure 2.1. Predicted loss in GDP per capita

Source: adapted from Khan et al. (2021)

Significant challenges persist with the global economic slowdown and internal circumstances. Economic growth, though positive, is projected to fall short of pre-pandemic levels, hinting at a fragile recovery (WBG, 2023). Additionally, the region's heavy reliance on trade with the EU exposes it to external vulnerabilities, as an economic slowdown in Europe could have a ripple effect on the Western Balkans. The foreign trade balance of all economies is negative and deepening over time (it has doubled in value over the last decade in the case of Serbia, North Macedonia and Montenegro, Table 1).

Unemployment continues to fall, as all Western Balkan economies have seen a decrease in unemployment rates over the last decade. Nevertheless, with unemployment still considerably exceeding the European average, this highlights the need for job creation and investment in human capital. Women's unemployment remains higher than men's, except for a fairly small difference in the other direction in North Macedonia and Montenegro in 2021 (Eurostat, 2023). The highest unemployment gender gap is noted in Bosnia and Herzegovina with 7.6% in 2021, followed by Kosovo* with 6.0%(Figure 2.2). Employment rates for women are just below 60% in Serbia and Albania, and below 50% in the remaining four economies – in the EU, this rate is at 68% (Eurostat, 2023).

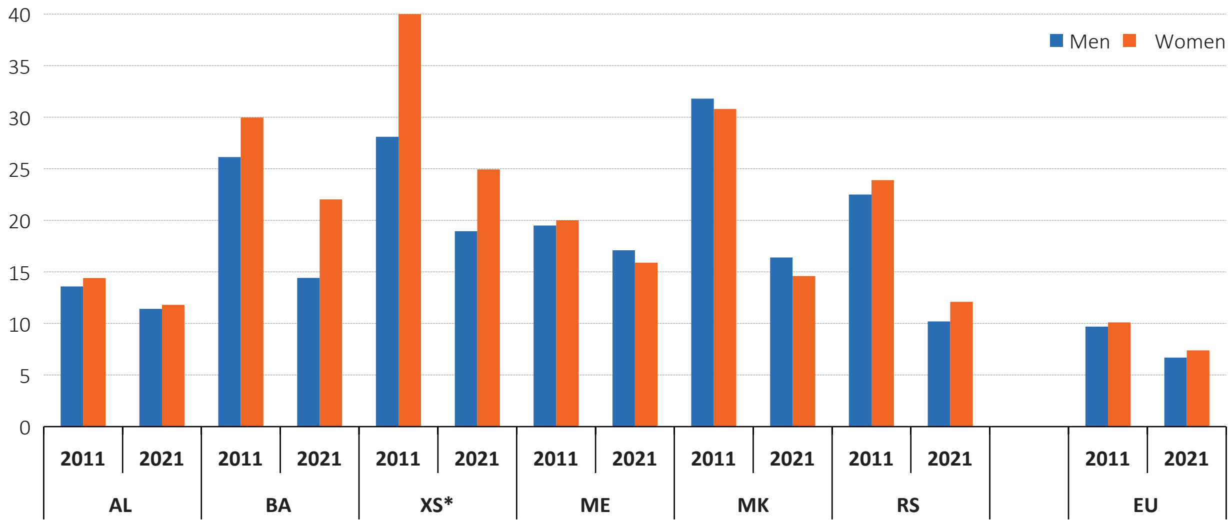


Figure 2.2. Unemployment rates in WBE and EU

Source: EUROSTAT (2023)

Although the labour market has become more accessible, the living standards of the population are still far below EU standards. Inflation pressures in the WB6 region are easing, after peaking in 2022, but price pressures persist. The proportion of the household budget spent on food, beverages and tobacco, has risen in most economies , except Serbia, reaching record high levels most notably in North Macedonia (52% in 2022). Poverty is slowly alleviated, but still affects a significant portion of the population in WBE (risk of poverty after social transfers in the Western Balkans range around 21-22%, compared to the EU average of 16.8% in 2021). Nonetheless, the income inequality expressed through the Gini coefficient has stayed relatively low with a declining trend, averaging roughly 31-33%, indicating that although poverty rates are still high, there is some equity in the distribution of income (Figure 2.3).

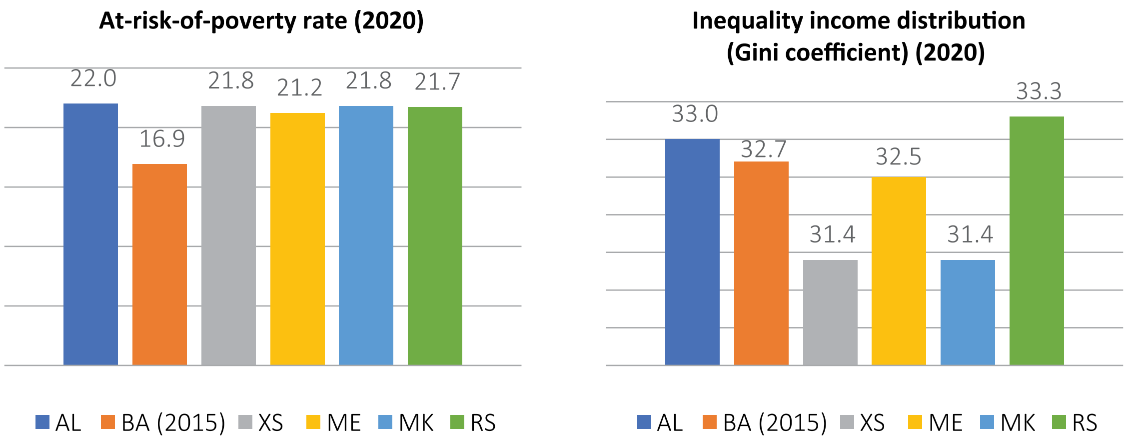


Figure 2.3. Poverty and equality indicators for Western Balkan economies

Source: WBE STAT Databases

2.2. Background and overview of the agricultural sector in WBE

The contribution of agriculture, forestry and fisheries to the gross value added (GVA) ranges between 5.6% in Bosnia and Herzegovina and 21.3% in Albania, compared with 1.9% in the EU in 2021 (Figure 2.4).

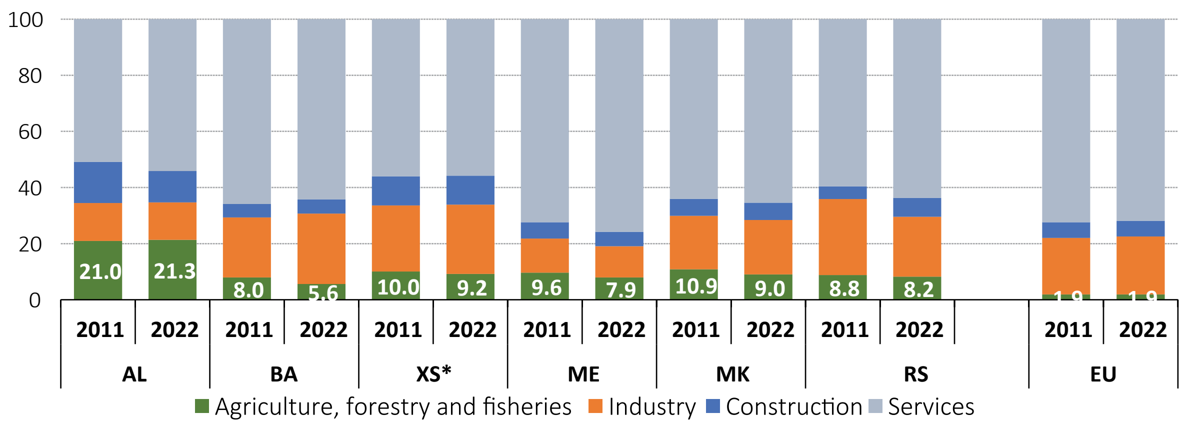


Figure 2.4. Gross value added by economic activity, 2011 and 2022 (% of total GVA)

Source: Eurostat (online data code: nama_10_a10)

The gross value added output in agriculture is the largest in Serbia with around EUR 3 billion, down to ten-fold less in Montenegro with EUR 300 million (Figure 2.5, left). Employment in the sector is generally declining as the share of total employment (Figure 2.5, right); e.g. in Albania it fell from 40% in 2016 to 35% in 2022; in Bosnia and Herzegovina from 18% to 7% over the same period (3.6% of the total number of persons employed in EU, Eurostat, 2023).

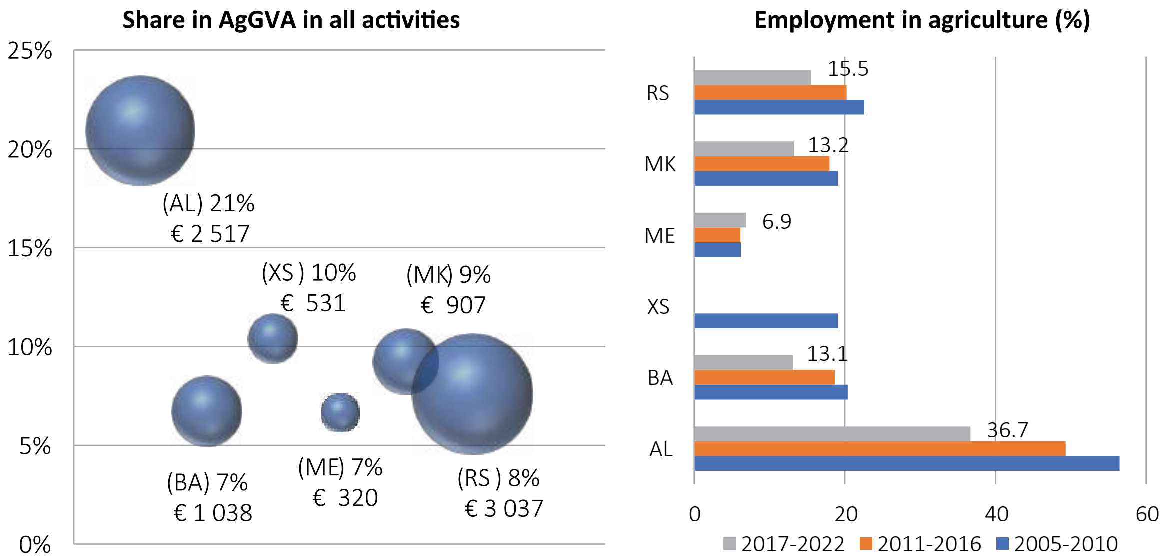


Figure 2.5. Agricultural GVA 2017-2022 (left) and agricultural employment in all activities (right)

Source: WBE STAT Databases

All economies apart from Serbia are net agri-food importers, with imports rising at a faster pace than exports over the years, which makes these economies more dependent on foreign agri-food supplies. Key imports of the economies , except Serbia, in general are cereals, meat, and processed products. Prices of main agricultural products have risen in recent years. The increase in input prices is however much more drastic in 2021 and 2022, especially in energy and fertilizer prices since the war in Ukraine.

The type and level of agricultural production depends on the climatic conditions, terrain and soil type, but also level of economic development and population density in WBE. Half of the total economy area of North Macedonia is land used for agricultural activities, followed by Albania, Serbia, Kosovo*, Bosnia and Herzegovina (over one-third), and Montenegro (less than one-fifth). Within the EU, roughly two-fifths of the total land area is used for agriculture.

Out of the total agricultural area, land use differs across economies ; arable land accounts for 3% in Montenegro, 33% in North Macedonia, around half in Kosovo*, Bosnia and Herzegovina and Albania, and 75% in Serbia (Figure 2.6).

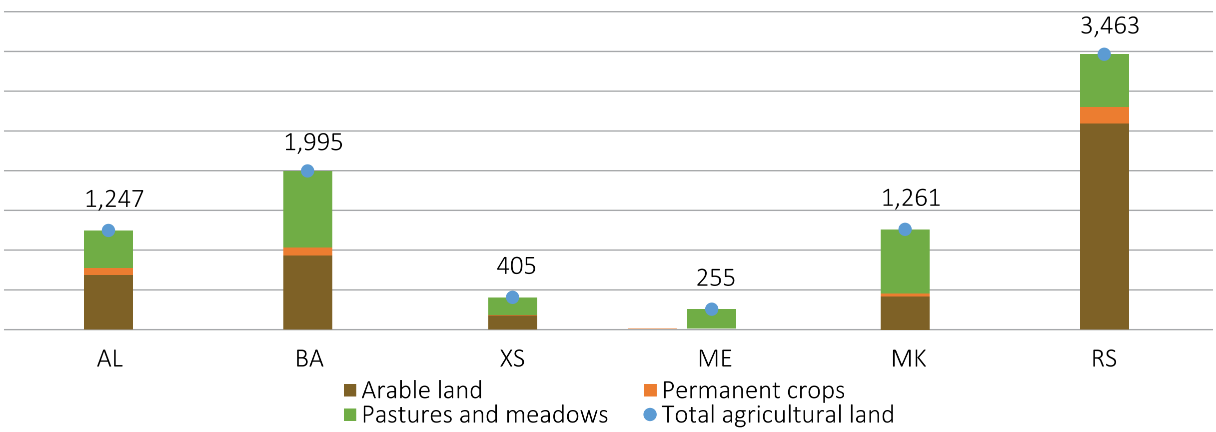


Figure 2.6. Agricultural land, in thousand hectares, average 2017-2022

Source: WBE STAT Databases

The production structure across the economies also widely varies. Cereal production accounts for more than a half of arable land in Serbia, Bosnia and Herzegovina, North Macedonia and Kosovo* (Annex 1). In some cases, such as Republika Srpska, wheat production is partly favoured due to high incentives. Forage crops are dominant in Albania. Although areas under vegetables and fruits account for a lesser share, these subsectors are significant contributors to the agricultural goods output, most notably in North Macedonia, Serbia and Albania.

In terms of livestock farming, there is an evident and lately sharp trend of decline in the number of almost all livestock categories in all Western Balkan economies (Annex 1). The number of cattle, for instance, has fallen by 40% in Albania, 34% in North Macedonia, around 24% in Bosnia and Herzegovina, 21% in Kosovo*, to 16% and 13% in Montenegro and Serbia, respectively, over the period from 2012 to 2022 (WBE STAT Databases, 2023). The only positive trend is the rapidly increasing number of beehives, noticeable in most of the economies .

The production of cereals has generally increased in the past decade, most notably in Bosnia and Herzegovina and in Serbia (Table 2.2). Oilseed crops production is most prominent in Serbia, with an upward trend. Fruit production shows high variation through the years, with extreme weather events affecting it more frequently. Production volume has grown overall, especially in Albania, Serbia and North Macedonia. The declining number of cattle in the region is reflected in the decreased production of milk.

Table 2.2. Agricultural production ('000 tonnes)

Indicator	AL		BA		XS*		ME		MK		RS	
	2012	2022	2012	2022	2012	2021	2012	2022	2012	2022	2012	2022
Cereals	:	691	868	1 423	439	504	5	7	457	538	6 355	8 012
Oilseeds	:	1	7	48	7	0	:	:	5	10	667	1 131
Potatoes	:	263	300	312	:	:	22	32	169	195	578	523
Grapes	:	211	26	20	30	27	25	21	277	266	128	162
Fruit	248	211	204	165	30	68	20	24	204	255	930	1 513
Vegetables	914	1 358	229	186	126	283	34	54	655	757	910	1 174
Milk	957	825	672	559	:	:	150	158	360	324	1509	1468

Source: WBE STAT Databases Note: (:) data not available.

Although there is a gradual upward trend in the yields of most agricultural products in the economy, they still significantly lag behind those achieved in other developed economies and the EU average. Wheat yields in the region range from 3 t/ha in Montenegro to 4.8 t/ha in Serbia. Milk yields range from 3 t/head in Albania to 3.7 t/head in Serbia (Figure 2.7). The average wheat yield in the EU is around 5.5 to 6.0 t/ha, and the average milk yield is 7.3 tonnes produced per cow (Eurostat, 2023).

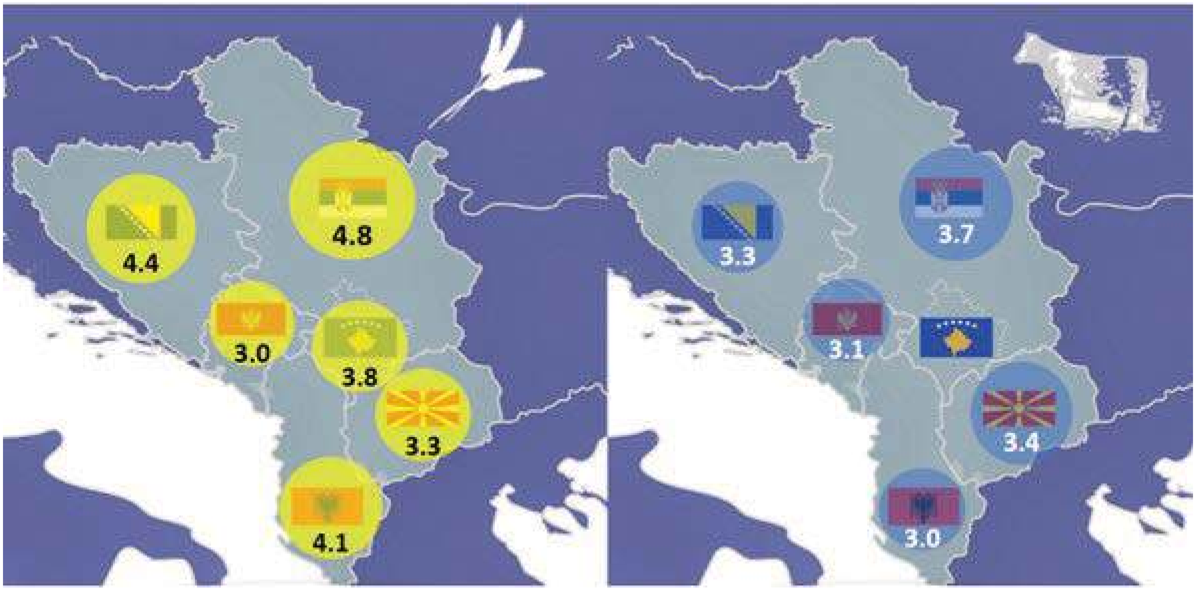


Figure 2.7. Wheat and milk yields in WBE (2017-2022, tonne per ha and per head)

Source: WBE STAT Databases

2.3. Farm structure and producers’ adaptive capacities linked to climate change

Climate change has major impacts on agriculture and rural areas. It affects all components of humans’ livelihood and food security, connected to numerous factors: population, demographics, economic activity, urbanization, education, social equality, consumption patterns, lifestyles, policy and institutions. A large proportion of the population in WB lives in rural areas. Population is aging in most WBE (highest share of young people is in Kosovo* with 24%, while the lowest share is in Serbia with 14%, Eurostat 2023), which, coupled with migration, both rural-urban but also increasingly outmigration on the rise, challenge the stability of agricultural activities. In addition to this, the sectoral and rural development in WBE continues to experience other hindrances– still slow productivity growth, limited access to productive assets, fragmentation of agricultural land, weak value chains, lack of modernization and application of new technologies, not fully functional knowledge and innovation transfer, and high vulnerability to external shocks caused by climate change or market distortions.

Farm structure in the Western Balkans is typically characterized by a large number of small, family-owned agricultural holdings, on one hand, and fewer agricultural companies, on the other. There is, however, high inequality in the sector among farms in terms of physical and economic size, and high concentration of turnover value within the smaller number of larger farms. Women are underrepresented as agricultural employees, which reflects on their reduced economic independence and limited capacity to make decisions on the application of adaptation measures. This 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 these specific adaptation needs, and steps should be enabled to safeguard vulnerable communities and ultimately ensure equitable socio-economic development. Overall, 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 farmers, especially in relation to climate change adaptation and the underlying necessities for farms’ modernization, restructuring, promoting innovation and digitalization.

In **Albania**, updated data on farm numbers and structures are unavailable, but there are 350,000 farms as estimated based on 2012 data (INSTAT, 2013). On average, each farm was using an agricultural area of 1.9 hectares. Approximately 45% of all farms had less than 1 hectare and another 41% of farms were in the 1.1 to 2 hectares range, while only 14% of farms were producing on an area exceeding 2 hectares.

Since 2011, there has been a significant demographic transformation with the urban surpassing rural population in Albania. In the fruit and vegetable sector, a recent study found that those with stronger inclination to migrate tend to be more uncertain about remaining in the sector, while those who choose to stay are more inclined to invest (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 a decline in education and healthcare services. There are significant gaps in educational attainment between urban and rural populations, with median years of school completed at 14.4 and 7.5, respectively, and with secondary education net attendance ratio by 8 percentage points lower in rural areas (INSTAT, 2018).

A study within the Fourth Communication of Albania to UNFCCC (Zhllima, 2021) found that men are better informed and have greater access to knowledge on crop cultivation techniques, pest management, and water management compared to women, with women more informed and prepared for adaptation measures related to livestock management. This indicates a gender-biased asymmetry in access to information, availability of services and equipment, and relationships with suppliers and service providers, pointing to additional actions being needed for enhancing women's role in coping with climate change.

In the absence of an agricultural census since 1960, the number of farms in **Bosnia and Herzegovina** can be estimated through the population census carried out in 2013, when about 360,000 rural households declared to be somewhat engaged in agriculture, and about 55,000 farms selling agricultural products on the market. This indicates a large number of rural households engaged in agriculture only for their own needs, which points to extensive and environmentally friendly practices. About 100,000 farms are registered to use subsidies in three farm registries (managed by two entity ministries of agriculture and Brčko District), giving an additional indication of the number of commercial farm businesses. The average size of agricultural holdings is about 3.5 ha, taking into account that there has been an informal consolidation of agricultural land because larger farms specialized in certain types of agricultural production often use neighbouring land. Farm owners in Bosnia and Herzegovina are getting older, and younger generations rarely continue the family agricultural business. This failure of the generational transfer leads to abandoning of an increasing number of farms, especially in the mountainous parts of the economy.

An important characteristic of the agricultural sector in **Kosovo*** is the dominance 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 using between two and five hectares of agriculture area are the most common with 35% of the total number of holdings. With small farms being dominant, their productivity and sustainability are central to the performance of the overall agriculture as well as for rural economic growth. In the absence of official statistics, an indication of the number of female farm owners is that 5% of the applicants and beneficiaries for direct payments are female. This shows a high gender disparity that needs to be addressed through targeted policies, allowing female farmers to have better access to resources than and equal opportunities as male farmers.

In **Montenegro**, statistical data estimate 43,791 agricultural farms (MONSTAT, 2017), while according to the Registry of Agricultural Holdings 19,622 farms were recorded as of September 2023, out of which 15.15% or 2,974 are owned by women (MAFWM, 2023). The average area of land per farm receiving agricultural support was 2.1 ha. According to current regulations, agricultural holdings that do not use support, both from national and IPARD sources, are not required to register in the Registry of Agricultural Holdings. The majority of farms in Montenegro are family farms, which account for the vast majority of the total number of farms. However, there are also larger agricultural companies engaged in agricultural production.

Detailed data on farm owners in Montenegro are not readily available. However, there is a tendency of aging agricultural population, given that many young people are leaving rural areas and shifting to other sectors. Although agriculture has traditionally been considered a male sector, an increasing number of women are involved in agricultural production and rural activities. There is variation in the level of education among farm owners in Montenegro. While some owners may only have primary education, others have higher education or professional degrees in agriculture or related disciplines.

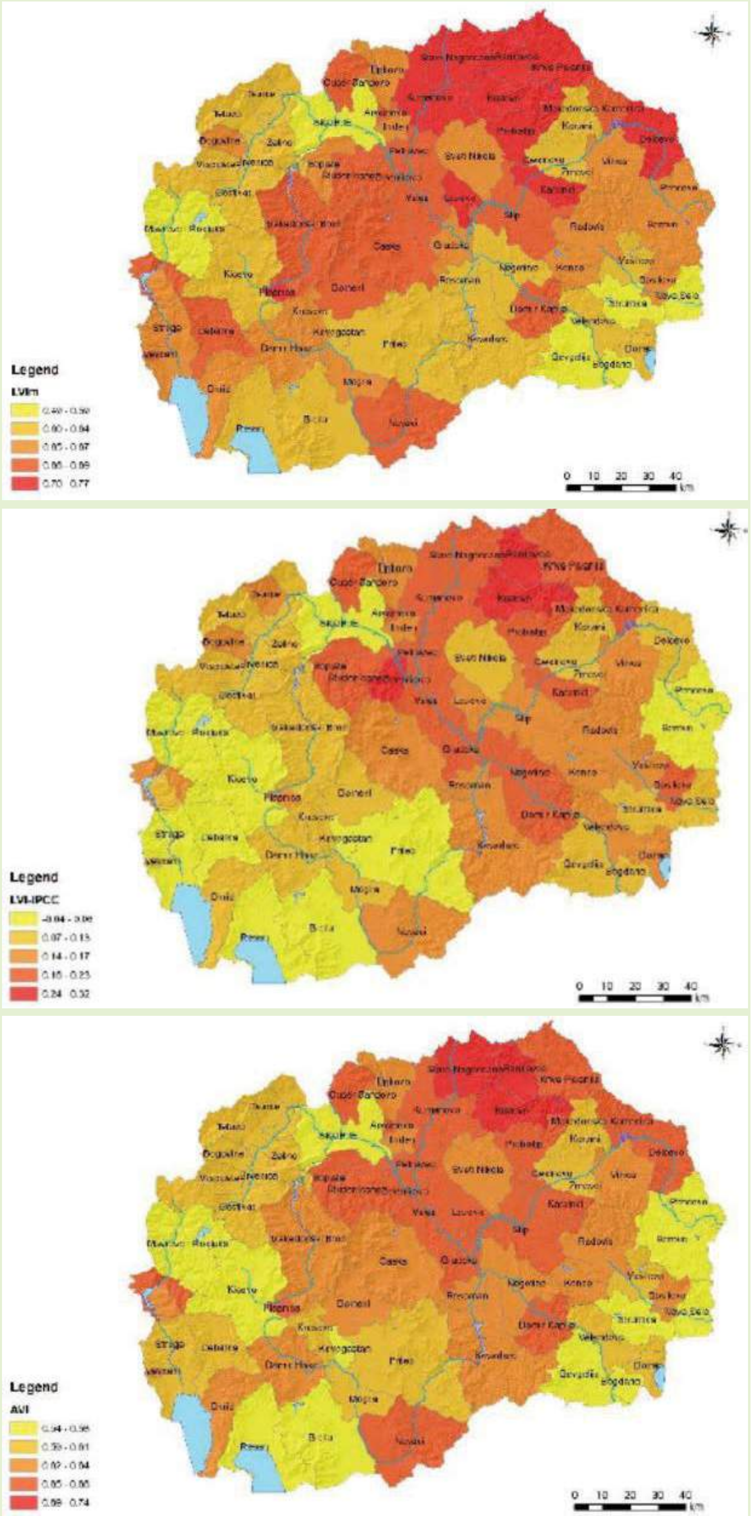
The average farm size in **North Macedonia** is 1.8 hectares (SSO, 2017), with small-scale family farming accounting for the majority of the agricultural sector (178 thousand individual farms versus 280 business entities). Less than 2% of farms are producing on more than 10 hectares, whereas 61% of producers farm on less than one hectare. Over 70% of all farms make less than 4,000 EUR annual output value, generating only 22% of the total output value; inversely, larger farms in economics terms, constituting 30% of the number of farms in the economy, generate the remaining 78% of the agricultural output value. This distribution points out 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 larger farms. It also indicates that the small-sized farms, mostly specialized in field crop production that occupies the most part of the arable land, have low income and low adaptive capacity.

The aging workforce is one of the main issues facing the sector in North Macedonia. The largest age group of the total agriculture labour force is the 55 to 64 age group. Only 4% of agricultural holders are under 35 years of age, according to statistics. Additionally, 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, women account for 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 (SSO, 2017). The level of education is quite unfavourable with 92% of holders of individual agricultural holdings being with incomplete, primary or secondary education. Most of the operators possess significant practical experience, which is usually inherited or gained during the practical work and sharing of knowledge within the community. However, inherited practices are usually traditional and, in many cases, outdated.

Box 1. Livelihood Vulnerability Index in North Macedonia

The assessment of climate vulnerability through the **Livelihood Vulnerability Index** (LVI) determined within the sectoral report of the North Macedonia's Fourth National Plan on Climate Change 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 96 variables in the North Macedonian context connected to exposure, sensitivity and adaptive capacity to climate change. Different methodological choices of composing the final indicator can indicate variability between methods and therefore it is advisable to present different approaches to summarizing the results (Wirehn et al., 2015). Even taking that into account, the level of municipality vulnerability presented by different indices **LVIm**, **LVI IPCC** and **LVI AVI** and is relatively within comparable ranking.

The results revealed the Northeast region municipalities of Rankovtse, Kratovo and Staro Nagorichane as 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 multi-dimensional character of climate change effects requires a comprehensive understanding of the economic, social and environmental vulnerability.



(Source: Sectoral report in agriculture and forestry prepared for the development of the Fourth National Plan on Climate Change, North Macedonia, Climate vulnerability assessment through the LVI, Martinovska Stojcheska et al., 2021)

In **Serbia**, there are 564,541 agricultural holdings with an average farm size of 6.2 ha – family farms on average use 5.2 ha of UAA, while the average size of business farms is 406.3 ha (FSS, 2018). The majority of holdings are family farms (99,7%), which use 84% of the utilised agricultural area. The biggest farms are located in the Vojvodina region with 12,4 ha on average. The income distribution is unequal -the most numerous category (28% of holdings) are holdings with economic size under EUR 2,000 which produce only 3,7% of total standard output; contrary to that, only 1.5% of the farms with economic size of over EUR 50,000 turnover annually, contribute to the total standard output with 28%.

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 shares of permanent female employees in the total number of employees on family farms and business farms is 16% and 23%, respectively. About 43% of farm holders are over 65 years of age, while only 3% are under 35 years of age. Almost a half of farm managers (49%) have no formal education in agriculture and their work is based on experience gained by practice; 45% have high school and only 6% of managers are university-educated.

The utilized agricultural area in Western Balkan economies is characterized by a **large number of small plots**. In Albania farm land is usually divided in plots with an average size of 0.26 hectares; the average plot in Bosnia and Herzegovina ranges from 0.25 to 0.33 ha; in Montenegro, plots under 0.5 hectares constitute 31.6% of total agricultural land; North Macedonia reported that on average land is fragmented into over five spatially spaced plots per holding, with an average size of 0.24 ha on private land, or 0.62 on state-owned land; in Serbia, the average plot is larger, with approximately 0.9 ha (economies reports, Volume II). Such small parcel and farm size in WBE is a big obstacle for implementing modern adaptation techniques and technology in agriculture. Machinery is quite old and outdated, which is another obstacle to implementing adaptation related to cultivation practices. More than 70% of tractors in Kosovo* and North Macedonia are older than 20 years, while in Serbia, 86% of tractors are over 20 years old.

Some efforts encouraging land consolidation are present in the economies ; for instance, in North Macedonia, 4,500 ha at ten different locations are undergoing intensive land consolidation processes, with several of the locations already completed (supported by the MAINLAND FAO project). However, this process appears to be rather slow and expensive. The scattered land plots raise transport costs and make it more difficult to upgrade to modern technologies; however, it also sometimes allows farmers to hedge risks against specific weather events at certain locations. Nevertheless, the fragmentation of the farmland, coupled with the small size of farms and the poor level of producer integration (agricultural cooperatives or other types of producer organizations are still very seldom present and functional), impact agricultural productivity, competitiveness and market potential.

2.4. Data availability related to climate change, social and economic situation

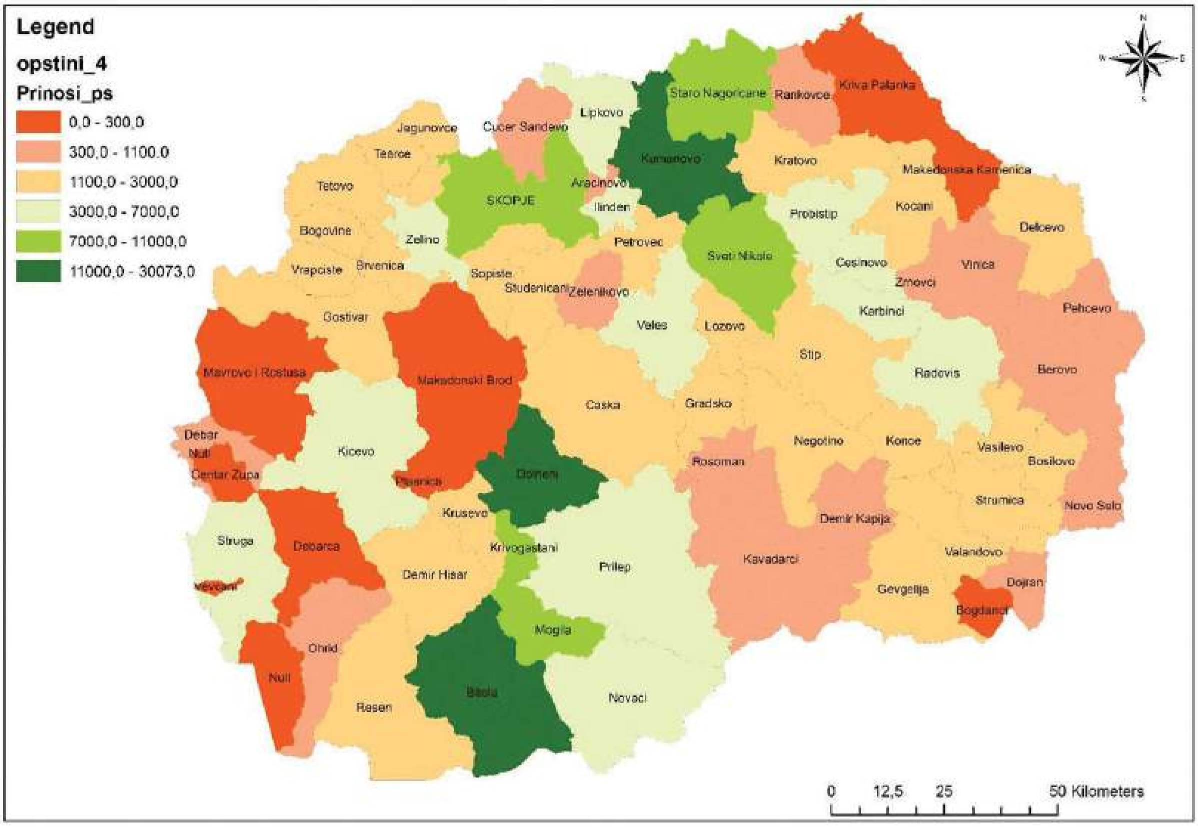
Economies level macroeconomic and agricultural sector data are mostly regularly available in all WBE (Annex 1, Table A.1.8). In order to highlight the regional disparities within the economies , disaggregated data is necessary, which is very limited, especially at Local Administration Unit (LAU) level, which impedes research and modelling possibilities in the Western Balkan regional context (Table 2.3).

Table 2.3. Snapshot at NUTS3/LAU level data availability of key agricultural production

Economy	Production data on wheat, maize, grapes, apples, cow milk and sheep
Albania	61 LAU crops and livestock data
Bosnia and Herzegovina	10 NUTS 3 level (missing data grapes)
Kosovo*	Economies level data
Montenegro	Economies level data
North Macedonia	71 LAU (crops), 8 NUTS 3 level (livestock)
Serbia	29 NUTS 3 level crops and livestock data

Source: Economies experts' assessment on WBE state statistical offices available data

Disaggregated data allow for more detailed analysis and highlight the local specificities of different phenomena. For instance, LAU (municipality) level data on various crops area and production volumes in North Macedonia provide valuable input for modelling different indices calculation (an example of wheat production per municipality is presented in Map 2.1).



Map 2.1. Wheat production in North Macedonia (2018-2022, tonnes)

Source: Own visualization using SSO data (2024)

Recent farm structure data are lacking in most WBE. Agricultural censuses are either not relevant (for instance, Bosnia and Herzegovina has not had an agricultural census since 1960) or are outdated. Farm structure surveys, as intercensal statistical reports, have not been carried out recently either. Many economies now use the farm registries (which in most cases are not fully complete) and number of applicants for direct payment schemes as an indication of the number of farms and their capacities. Data on general socio-economic aspects, particularly with the scope of rural areas, are limited in providing important segmentations for gender, age, education and other aspects. Some economies even experience difficulties in data consistency – the recent change in the statistical methodology of data collection (from expert assessments to farm structure surveys) in Bosnia and Herzegovina has aggravated meaningful analyses of multi-year data series. Other economies (for instance, North Macedonia) still retain both expert assessments and sample surveys approaches, which often give ambiguous and different data and also limit their availability to NUTS 3 (economy regions) level. The Farm Accountancy Data Network (FADN) has not been established yet in some of the economies , namely Albania and Bosnia and Herzegovina. Its ongoing conversion into Farm Sustainable Data Network (FSDN) will broaden its scope into collecting valuable farm-level data addressing the EU Green Deal targets and other sustainability indicators, even more pronouncing the need for such data sources. FADN (FSDN) data are also often difficult to access, especially for the research community in WBE, hindering important research potential. Conversely, these data are widely used in EU economies for many policy-related issues, including climate change adaptation (see for example Van Passel et al., 2017).

3.

Legislative framework, institutional setup and policy support towards agricultural sector adaptation to climate change in WBE

3. Legislative framework, institutional setup and policy support towards agricultural sector adaptation to climate change in WBE

WB economies are signatories to the Paris Agreement and parties to the United Nations Framework Convention on Climate Change (UNFCCC), with submitted nationally determined contribution documents to the UNFCCC, except Kosovo* that, nevertheless, complies with the requirements of UNFCCC. The economies are candidates for European Union (EU) accession (except Kosovo*, which is recognised as a potential candidate) and are driven to follow the EU2020 Strategy, superseded by the Sustainable Development Goals (SDGs) and the European Green Deal. The European Green Deal aims to make Europe climate neutral by 2050. The European Climate Law makes this objective legally binding, setting a new, more ambitious net greenhouse gas (GHG) emissions reduction target of at least -55% by 2030, compared to 1990 levels. In order to achieve our decarbonization objectives, emissions must be reduced in all sectors, including farming.

In parallel to mitigation actions, the EU is taking action on climate adaptation, to face the unavoidable impacts of climate change. The EU strategy on adaptation to climate change was adopted in 2021. This strategy sets out ways to adapt to the unavoidable impacts of climate change and become climate resilient by 2050, by making: i) smarter adaptation (taking adaptation actions based on robust data and risk assessment tools that are available to all, from farmers planning their crops, to pushing the frontiers of knowledge on adaptation); ii) faster adaptation (adaptation must be quicker and more comprehensive since the effects of climate change are already felt, hence focusing on developing and implementing adaptation solutions to help reduce climate-related risk and increase climate protection); iii) systemic adaptation (since climate change impacts across all sectors of the economy and all levels of society, adaptation actions must also be systemic, integrating adaptation into both macro-fiscal and local policy, and climate resilience considerations mainstreamed in all relevant fields, including agriculture as a priority); and iv) stepping up (regional) international action on adaptation to climate change (boosting global climate readiness and resilience through the supply of resources, prioritization of climate action and its increasing efficacy, expansion of international financing, and promotion of cross-national involvement and exchanges on adaptation).

In line with the EU ambition, Western Balkan economies have also committed to align with the European Green Deal's key elements by endorsing the Green Agenda for the Western Balkans (GAWB) at the Sofia Summit in 2020, and subsequently the GAWB Action Plan, at the Brdo Summit in October 2021. The economies undertook to work towards ensuring transformation of the agricultural sector, minimizing its negative environmental and climate impact and safeguarding affordable and healthy food for WB citizens and export markets, including actions related to aligning with EU standards and regulations; promoting environmentally-friendly and organic farming; enhancing cooperation among researchers and businesses to facilitate transfer to innovative and environmentally-friendly technologies and farming methods; stepping up efforts for sustainable development of rural areas; supporting investments in renewable energy production and technologies as well as emissions reductions and adaptation to climate change measures in agriculture.

3.1. Legislative and strategic framework related to climate change

In 2019, **Albania** adopted the National Strategy on Climate Change (NSCC) and its two annexes, the National Action Plan on Mitigation (NAPM) and the National Adaptation Plan (NAP). The NAP strategical goals are to reduce damages from floods, enhance agricultural resilience against floods and secure drinking water quality. 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 the climate-change hazards, with a flagship Law on Climate Change prepared in 2019. Climate change is an important component in the Strategy for Development and European Integration (NSDEI) 2021-2027 and clear activities were defined for coping with climate change within the National Plan for European Integration 2022 (SASPAC, 2023). In addition, the Strategy for Agriculture, Rural Development and Forestry (SARDF 2021-2027) provides special focus on activities related to climate change.

In **Bosnia and Herzegovina**, despite the complex constitutional structure and overall governance, the economy ratified the UNFCCC in 2000 and has taken several steps to enable the fulfilment of the obligations posed by the Convention. The existing legal framework on the agricultural sector was adopted fifteen years ago and only includes broad objectives of rational use and preservation of natural resources, environmental protection and improvement of integral and organic agriculture (in Republika Srpska and FBiH), and of ensuring the rational use and protection of natural resources and biodiversity (BiH). Climate change was only taken into account in the latest agricultural development strategies in Bosnia and Herzegovina, given the recent time of their 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 mitigation. 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 the economy. In 2022, the Council of Ministers adopted the National Climate Change Adaptation Plan (NAP) to the UNFCCC. The 2020-2030 Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina, followed by the Climate Change Adaptation Road Map and Action Plan for Bosnia and Herzegovina, mainly aims at adaptation to climate change (it contains 33 specific adaptation measures for the agricultural sector only). The challenge is the weak transposition of provisions from that plan and their slow implementation.

Kosovo* is not a signatory party to the UNFCCC. As a result, there is currently no legal basis for drafting Nationally Determined Contributions (NDCs), there are no targets set for 2030 and no regular reporting (National Communications on Climate Change and Biennial Update Reports) is undertaken. However, the Ministry of Environment and Spatial Planning (MESP) has issued a set of Administrative Instructions, which deal with specific segments related to the mitigation of GHG emissions and clean development. In November 2023, Kosovo* started preparing the first inclusive and voluntary NDCs (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 Climate Change Law, approved by the Government, reflects a strong commitment to combat climate change and foster climate adaptation across various sectors. The Law foresees the development of Kosovo*'s first Strategy on Climate Change Adaptation by 2024. The Strategy on Climate Change 2019-2028 sets out the policies and measures for reducing greenhouse gas emissions (GHG) and adaptation to climate change, followed by an Action Plan on Climate Change 2019-2021. 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.

Being significantly oriented towards tourism, **Montenegro** declared itself an ecological economy, focusing on 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. There are also action plans that include concrete measures for adapting to climate change and mitigating its impacts, such as the Action Plan for the Implementation of Measures for the Use of Renewable Energy Sources and Energy Efficiency Measures in the Transport Sector, the Action Plan for Helping 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, Action Plan for Energy Efficiency, and others. Montenegro uses domestic budget, international donors, European Union funds and other sources to address climate change. Montenegro is active in international cooperation regarding climate change. The economy participates in UN negotiations on climate change, as well as in regional initiatives within the Western Balkans.

A Long-Term Strategy on Climate Action with an Action Plan was adopted in **North Macedonia** in 2021. It sets the 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 Strategy, in the phase of final drafting, focuses on comprehensive adaptation policies and measures. A Law on Climate Action was drafted and submitted for public discussion in 2023. 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. The National Strategy on Agriculture and Rural Development (NARDS) 2021-2027 follows the overall concept of the EU Common Agricultural Policy (CAP) framework and includes in its strategic goals the application of environmental practices in production that lead to mitigation and adaptation to climate change. Climate change is also increasingly included in other strategic documents, such as the Spatial Plan 2021-2040, the National Development Strategy 2024-2044, the Smart Specialization Strategy 2023-2027, etc.

Serbia has adopted all relevant strategies related to climate change, low-carbon development, water, forestry, and agriculture (Law on Climate Change, Law on Environmental Protection, Law on Waste Management, Law on Packaging and Packaging Waste, Law on Waters, Law on Chemicals, Law on Energy, Law on the Use of Renewable Energy Sources, Law on Energy Efficiency and Rational Use of Energy, Law on Air Protection, Law on Integrated Prevention and Control of Environmental Pollution). As a step forward, the economy is preparing the Spatial Plan of the Republic of Serbia for the period 2021–2035 which will comply with the requirement of adaptation to climate change. Several strategic and programming documents in the Serbian strategic framework contain goals linked with climate change and its influence on agriculture and other relevant sectors. One of the goals within the Strategy on Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 is fully focused on climate change and environmental issues (sustainable resource management and environmental protection, with priority area dedicated to climate change adaptation and mitigation).

Although significant improvement has been made in all WBE towards the efforts of elaboration and harmonization of strategic goals with EU strategies and UN conventions, when it comes to the implementation part, due to various reasons, the results are usually negligible. In most cases, several factors have been reported as the main obstacles: institutional and technical capacities, insufficient cooperation among institutions, and lack of awareness and proactiveness.

3.2. Institutional setup related to climate change

Similar to the legal and strategic base, and also given the cross-cutting nature of climate and climate change causes and effects, the institutional framework for addressing these issues is divided and fragmented across different institutions in WBE.

The institutional capacities related to adaptation to climate change are situated within the relevant line ministries of agriculture and ministries of environment, some specialized institutions in the sectors, agencies, and the academia. In all WBE, it is emphasized that the capacities of these institutions are insufficient. Competences usually overlap between responsible institutions, while intersectoral cooperation is usually insufficient or non-existent. Agricultural adaptation and protection from climate change is a cumbersome and complex task, which requires intense coordination and collaboration among all responsible institutions. The institutional enforcement and strengthening of cooperation among institutions on issues related to agriculture and climate change adaptation is a serious gap and should be immediately bridged.

In **Albania**, the Ministry of Tourism and Environment (MTE) is leading the policies and coordinating the integration of climate change issues in agriculture, tourism, health, energy, transport, forestry, water sectoral policies, etc. MTE has been appointed as the Designated National Authority (DNA) in the framework of obligations under the UNFCCC and the Kyoto Protocol. The Ministry of Agriculture and Rural Development (MARD) is the one responsible for land use. In addition, Ministry of Energy and Infrastructure is dealing with energy issues and some responsibilities lie with the Ministry of Health and Social Protection and Ministry of Foreign Affairs and European Integration. At the higher level, the Inter-Ministerial Working Group on Climate Change 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 the local level, mayors are responsible for planning and responding to civil emergencies in their respective municipalities, but budgetary and institutional capacities of the local government units are still very limited. Last but not least, due to a limited awareness of the business community and farming community on green economy, bottom-up initiatives are still not functioning.

In **Bosnia and Herzegovina**, climate and climate change are the focus both of the ministries of agriculture but also of the ministries responsible for ecology and environmental protection. The ministries of agriculture in their organizational structures do not have departments/sectors/divisions that explicitly deal with climate change issues, and they are usually attached to the units responsible for agricultural land.

In **Kosovo***, various institutional setups exist across different, national and local levels, responsible to manage, mitigate, and adapt to climate change impacts. The Ministry of Environment, Spatial Planning and Infrastructure is responsible for the monitoring of the implementation of the Climate Change Strategy. The Ministry of Agriculture, Forestry and Rural Development oversees the agricultural and rural development policy.

In **Montenegro**, the Ministry of Ecology, Spatial Planning and Urbanism is in charge of coordinating environmental protection policy, including climate change management. Additionally, the Environmental Protection Agency provides support, supervision and control over the implementation of environmental protection measures. The Ministry of Agriculture, Forestry and Water Management manages the policies of agriculture and rural development, forestry, fisheries and water management. Montenegro has established a high-level council that focuses on issues of sustainable development, gathering representatives of several institutions, chaired by the President of Montenegro. The Council was formed in 2008 by the Government. 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. An ongoing project financed by the Green Climate Fund (2020-2024) aims to strengthen the institutional and technical capacities of the institutions responsible and involved in planning adaptation to climate change, and the creation of the needed databases for effective decision-making and effective resource mobilization strategy.

In **North Macedonia**, 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's responsibilities include undertaking measures and activities for environmental protection, preparing a national plan for climate change, conducting analysis and projections of greenhouse gases inventory, emissions and their reduction, monitoring the implementation of the planning documents related to climate change. The Ministry of Agriculture, Forestry and Water Economy (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. Although there is a formally established umbrella National Committee for Climate Change since 2000, whose purpose is to act as a 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 still does not fully function in practice.

In **Serbia**, climate change policy management is under the competence of the Ministry of Environmental Protection, while the legal framework is made up of certain laws in the areas of responsibility of other ministries (Ministry of Agriculture, Forestry and Water Management, Ministry of Economy, Ministry of Mining and Energy, 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 of air and water quality, management of the National Laboratory, management of environmental data, cooperation with the European Environment Agency (EEA) and the European Information and Observation Network (EIONET), etc.

In all WBE, the planning and implementation of instruments and measures related to climate change mitigation and adaptation strategies, as well as their monitoring, generally 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 on climate action.

Technical capacities are usually situated in specialized institutions like the hydrometeorological services, extension services, agencies, and scientific organizations. In several WBE, the technical capacities of the hydrometeorological institutions are continuously enhanced. Still, there is an obvious need for data transparency, well-structured meteorological and climatological data, as well as systems for the distribution of climate services to stakeholders which is of crucial importance for vulnerability assessment in the agricultural sector and adaptation.

Extension services have a crucial role in the process of dissemination and oversight of the application of adaptation measures in practice. In Serbia, 25% of farms in Central Serbia had consultations with extension services in 2022. In Albania, an extensive network of AgriTechnology Transfer centres spread throughout the economy oversees the transfer of advanced technologies to farmers. In North Macedonia, the recently adopted Law on Advisory System for Agriculture and Rural Development (December 2023) provides the legal framework for continuous training and certification of both publicly funded advisors from the National Extension Agency and private advisors.

Scientific and educational institutions are important segments in the whole cycle of adaptation to climate change, whose responsibilities are to identify the challenges, monitor, find solutions, raise awareness, and disseminate results and knowledge. Unfortunately, over the past decades, scientific institutions have been strongly neglected in all aspects. At the moment, only a very small number of institutions in WBE have certain capacities to cope with the challenges posed by climate change in agriculture.

3.3. Agricultural policy measures and support related to climate change

The main challenge is that the commitment on climate change adaptation declared at the highest level and as priority in the policy frameworks in WBE does not correspond to the gap in its implementation. Although climate change adaptation is increasingly recognized in agricultural and rural development policies, with a wide array of declared instruments and measures that are linked to climate change mitigation and adaptation, preserving biodiversity and sustainable use of resources, as well as strengthening the resilience of rural population and better quality of life in rural areas, actual budgetary allocations to support the implementation of relevant measures are low, which indicates that the commitment to active action in this area is more symbolic than actually real. Additionally, the economies do not earmark financial resources to climate change adaptation, which limits more substantial analysis.

Evidence from the continuous monitoring of the developments on agricultural and rural development policy in the Western Balkan economies ' budgetary transfers (using the unique Agricultural Policy Measures Classification[3]) gives an indication of the structure of support and its relation to the strategic framework. Overall, the total budgetary transfers to agriculture have increased in all WBE over the years. The first pillar with market and direct support measures dominates in all economies, except for Albania and Montenegro. Within the rural development measures, the main focus is on competitiveness.

Although all economies have increasingly prioritized environment-related strategic objectives, the implementation of such measures is fully lacking or is not earmarked (for instance, in Albania and Kosovo*) or is insignificant, reaching little over 2% of the total agricultural budget in North Macedonia and Montenegro (Martinovska Stojcheska et al., 2024). Similarly, low support is dedicated for enhancing the rural economy and population (payments for creation and development of non-agricultural activities in rural areas, rural infrastructure, basic services and village development). The Instrument for Pre-Accession in Agriculture and Rural Development (IPARD) for the period 2021-2027 currently focuses on the measures on investments in physical assets, farm diversification and business development, but in IPARD economies (Albania, Montenegro, North Macedonia, and Serbia), more concrete support in the form of investments aimed at mitigating and adapting to climate change is awaited through the measures not yet accredited, targeting agri-environment – climate and organic farming, advisory services, knowledge and innovation, and local development strategies.

3 Series of studies implemented by SWG in collaboration with national experts, available at: https://seerural.org/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4.

Status of soils in WBE linked to climate change adaptation in agriculture

4. Status of soils in WBE linked to climate change adaptation in agriculture

4.1. Exposure and sensitivity of soils to climate changes and their influence on overall soil health in WBE

Soils are an essential natural resource that is the base for food production, safeguarding food safety, and the overall ecosystem functioning. There is a significant set of reports and monitoring data that proves the presence of accelerated climate change in the region, which seriously outweighs the capacity for adaptation in the agricultural sector. The climate scenarios project a further increase in the average air temperature and a decline in the yearly sums of precipitation, which increases the level of exposure of soils to the changing climate.

In the past decades, agricultural production has become more intensive putting serious pressure on soils and other natural resources. In addition, the inputs and investments have increased as well, which has influenced the level of sensitivity of the sector. In an environment of enhanced unfavourable climate conditions and intensive exploitation, soils experience a serious impact, which is in many cases unsustainable in the long run. Furthermore, frequent extreme climate events are expected which as a consequence will severely affect agricultural soils. To evaluate the level of impact of climate change on soil health, a set of climate extremes commonly present in the region was evaluated with a focus on the area and soil types affected. Although WBE are spread over a small area, the degree of impact of climate extremes on soils is rather variable.

Floods are weather extremes that seriously affect soil health in the WB region, causing serious problems on highly productive soils. Large areas are affected by floods, like Bosnia, where areas under flood risk are estimated to be over 322,000 ha. In Serbia, the flooded areas in 2021 were estimated to be 15,000 ha, while in Montenegro, the intensive flood events in 2014 affected around 30,000 ha of agricultural land. On a smaller scale, floods are present in Kosovo* and Macedonia as well, although the estimated areas prone to flooding are not negligible. Floods rapidly destroy soil fertility for a long period especially flash floods which drag an inert material or contaminants that accumulate on the soil surface. Most affected are the lowlands of the valleys where torrential water from the hills rushes into the plain. Almost 32% of coastal areas in Albania are expected to be affected by regular flooding. In Serbia, areas alongside big rivers and watercourses are most prone to fluvial floods, which regularly occur causing serious damage to crops and infrastructure. As a result of highly intensive rainfalls, almost all rivers in Bosnia were overflowing in 2014, causing serious damage to soils. As a response, the economy prepared Flood Hazard Maps and Flood Risk Maps for the catchment area of the Sava River and its tributaries, Vrbas and Trebisnjica. Most affected soils from floods are the soils of the flat areas in the valleys like Alluvial soils, Gleysols, Cambisols, Vertisols, and Luvisols.

Drought events are becoming more frequent and prolonged in all WBE during summer periods and are usually combined with high temperatures (heat waves). In such conditions, soil moisture rapidly decreases due to evaporation, causing ascending movement of groundwater causing a potential risk of salinization and alkalization. Soil biological functions and nutrient turnover are seriously affected. Estimates based on the Standard Precipitation Index (SPI), reveal an increased frequency of drought in the last several decades in Serbia. Based on the estimates performed with the SPI index and several other indices, FBiH and North Macedonia created a Drought Assessment Map. On the base of the same methodology, Montenegro reports more frequent droughts, with significant events in 2003-2011, particularly the 2011 drought in the Zeta-Bjelopavlići region. Large areas are affected by drought events in the six WBE, with a total area of 4,904 km^2 in FBiH, and 7,678 km^2 in North Macedonia affected by drought events. To cope with drought, Serbia is planning to prepare a National Drought Plan (UNCCD, 2020). Drought is a weather extreme which seriously affects almost all soil types, especially those with shallow soil profile like Regosols, Leptosols, and soil in the planes with shallow ground water tables, like Fluvisols and Gleysols.

Box 2. Best practice – Agro Iliria in Albania

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 north-eastern part of the economy.

Climate change is expected to have a major impact on saline soils that are likely to increase, as well as on the reduction of soil organic matter, as a result of soil organic carbon that could be reduced due to increasing temperatures and accelerating mineralization processes.

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 the saline soils of Rremas in Lushnje. Due to the success of these practices, the company has the intention to expand this cultivation on another 500 ha in the same area. The practices implemented include the creation of rectangular soil beds, 30 cm high, that were 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 rectangular beds reduce that risk. This is supported also by the rooting system of pomegranates and goji berries that does not penetrate into the deep saline soil layers; instead, it is mostly concentrated inside the rectangular beds. It is expected that the area where this innovative practice is implemented will expand by at least another 500 ha.

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

Soil erosion is the most common form of land degradation in all WBE, which is mostly due to the specific geomorphology, vegetation cover, and management practices. The altered rainfall regime due to the profound climate changes, coupled with hot and dry weather and increased aridity, results in a loss of the soil organic and vegetation cover, which accelerates soil erosion. The estimates are that almost 7.8% of the territory of Serbia is affected by soil erosion, while in BiH the most part of the economy's territory is prone to soil erosion since more than 80% of the terrain in BiH has slopes greater than 13%. The most recent analysis in North Macedonia shows that approximately 50,000 ha falls within the first three most severe categories of soil erosion. It seems that the problem with soil erosion is the most alarming in Montenegro, where 94% of the economy is mountainous with around 300 registered torrential basins, spanning over 460,000 ha. Soils on hilly relief forms and slopes, like Regosols, Leptosols, Calcaric Leptosols, Cambisols etc. are the most affected. Soil erosion is a devastating degradation process causing the ultimate loss of the fertile soil layer, hence comprehensive action is needed on farm and catchment levels, including all stakeholders. However, only Albania (50,000 ha) and Serbia (10-20%) have reported implementing erosion control measures in practice, while in the other WBE, such measures are implemented only on a limited area.

Forest fires are another extreme event fostered by climate change, which has direct and indirect effects on soil health. In all WBE, forest fires affect vast areas every year. In the past several years, a huge area (70,000-100,000 ha) in BiH was affected by forest fires, while in the period of 10 years, forest fires have affected over 18,000 ha of forest in Montenegro, causing serious loss of wood mass. After such events, bare land usually remains on sloppy terrains and is directly exposed to rainfall, causing accelerated soil erosion. A systematic and organized approach to prompt remediation of vegetation in those spots is urgent. But, such terrains are usually inaccessible for afforestation, so the vegetative cover is usually naturally driven and slow. All soil types on hilly and mountainous regions are prone to this climate extreme, like Cambisols, Dystric Leptosols, Regosols, Leptosols, Colluvial soils, etc.

Landslide is a climate-driven process that affects soils in large areas in WBE. Unsustainable management practices coupled with specific environmental conditions, usually triggered by heavy rainfalls, are the main driving force for landslide occurrence. For instance, landslides in Serbia occur on 30% of the economy's territory, while in BiH active landslides are estimated at about 1,800 locations, affecting large areas. Montenegro faces a considerable risk of landslides at various locations, especially in the south and southwestern slopes of Rumija, Sutorman, Lovćen, Orjen, and Vrmac, while in North Macedonia the estimated number of landslides is > 400 locations. More than 9% of the territory in Albania is prone to slope instability. The consequences of these extreme events are devastating for the soil, and the adjacent infrastructure, posing a threat to human lives.

4.2. Overview of the producers' adaptive capacities relevant for sustainable use of soils in WBE

The impact of climate change in the WB region is evident and the expectations are that it will worsen in the next decades also increasing the level of vulnerability of agriculture to climate change. The level of adaptive capacity of farmers is an essential precondition for implementing adaptation measures for minimizing the risk of soil degradation.

The agricultural sector is very complex, mostly due to the huge number of households applying various management practices and the small average farm size. The workforce is becoming a critical factor in the development of the agricultural sector since the young population is migrating to bigger cities and abroad. The average age and educational structure of farmers is a serious limitation for the adoption and application of new knowledge and technologies necessary for the implementation of sustainable soil management measures and measures of adaptation to climate change.

Sustainable adaptive practices for soil protection in WBE are spread over very limited areas or not implemented at all. Traditional land cultivation techniques are still prevalent, due to challenges related to parcel size, technical capacities of farmers, and terrain limitations. Reduced tillage and contour ploughing are applied on a very small area, except in Serbia, while non-tillage is not implemented at all in most of WBE, while cover crops as a replacement for cultivation are usually limited to orchards and vineyards.

Mineral fertilizers are usually applied in intensive production systems, but in many cases voluntary, without previous soil testing which might lead to serious economic and environmental consequences. Organic fertilizers in some economies like Bosnia, Albania, and Serbia are applied on over hundreds of thousands of hectares, like the case of Serbia, where organic fertilizers are applied on 49% of the farms (373,871 ha), and Albania with over 250,000 ha. Unfortunately, in many cases, manure storage facilities and application practices are usually incorrect, which results in the loss of benefits of manure application, endangering people's health and the environment. Soil laboratory testing schemes supported by the government are present in some WBE. A positive example is the soil testing laboratory in Fushe Kruje Albania, and the soil laboratory testing scheme of areas aimed for perennial crops plantations in North Macedonia, supported by the MAFWE. Rough estimates are that such schemes cover more than 100,000 ha in Albania, and almost 70% of farmers in the past 10 years. Online services and other forms of precision agriculture should be the focus of the adaptation of soil to climate change. In some cases, certain steps forward are already in place, like the GEO-Portal in Serbia, offering digital data and services for more than 11,000 farmers. Similar online services were established in some regions in North Macedonia, offering services to producers for optimizing irrigation scheduling and plant protection.

Training programmes for continuous development of human capacities is a basic prerequisite for the successful implementation of modern adaptation technologies. However, a systematic approach is lacking, which is a big obstacle. For instance, in 2012, only 3.1% of the farms in Serbia were covered with targeted training programmes, while rough estimates are that less than 5% of farmers attended any form of lifelong or vocational training programmes. The most recent IPARD III foresees a training programme for each of the measures supported. Another initiative is the regulation of the advisory system for agriculture and rural development supported by MAFWE of North Macedonia, for the training of certified trainers who will be engaged in the strengthening of extension services in the economy.

On-farm measures for land improvement in WBE are implemented in small areas and are usually spontaneous without continuous and systematic governmental support. In Albania, olive growers in hilly regions design their plantations considering protection from soil erosion. In some parts of Serbia, on-farm erosion control practices encompass 10-20% of farms. In general, on-farm land improvement and protection measures are not a priority for most of the farmers and are implemented only occasionally and sporadically.

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

To achieve its general vision of "good soil health by 2050", the EU Soil Strategy sets a wide range of long-term and medium-term objectives and actions that tackle almost all roles and functions that soil has in the environment and society. The focus is on sustainable soil management practices to prevent soil degradation, mitigation and adaptation, circular economy, soil biodiversity protection, and soil research and innovation. In addition, the Draft Directive on Soil Monitoring and Resilience (Law on Soil) foresees a wide set of actions and requirements related to soil monitoring and soil health protection. Such an ambitious legal and strategic framework adopted in a relatively short period of time mainstreams soil-related issues, and at the same time poses serious challenges to WBE to meet these newly set requirements and obligations.

One of the main challenges is the lack of administrative capacities as a basic prerequisite to mainstream the EU Soil Strategy goals and requirements into the national legal framework and the needed tools and instruments to implement them in practice. To bridge this challenge, it is of particular importance for all WBE to invest efforts into strengthening institutional and individual capacities at the national and local levels, as well as to enhance the technical capacities of all relevant institutions in the area of soil monitoring and soil health protection.

Specific infrastructure for soil governance usually does not exist, so various departments and sectors of ministries across the economies deal with soil and soil-related issues, in addition to their other duties. Soil governance is a complex task that results from the numerous pressures coming from various drivers in the society, which requires the involvement of numerous institutions with sufficient capacities and adequate coordination at all levels, to enable efficient protection and sustainable soil management.

A lack of cross-sectoral collaboration for successful adoption of the requirements of EU legal documents and mainstreaming of soil and soil-related issues like carbon farming, low carbon economies, green transition, etc., has been identified as one of the most serious challenges in all WBE. The EU underlines the importance of research and innovation for sustainable soil management, and fostering collaboration among key stakeholders. However, the communication gap that exists between policymakers and scientific institutions is a challenge that prevents the flow of information and expertise among institutions and prevents policymakers from having a prompt insight into the latest research findings, which is crucial for evidence-based policy development. Bridging this communication gap is essential to ensure that decision makers are informed by scientific knowledge and that research is aligned with relevant issues.

Support for the sustainable growth of food production and greener farming practices, particularly those relevant to soil health preservation, is another identified challenge. Examples of these actions include organic farming, crop rotation, and preservation of carbon-rich soils. Specific payments should be provided to farmers that adopt climate-sensitive and nature-sensitive practices in line with the European Green Deal objectives and Soil Strategy for 2030. Such financial schemes will contribute to overcoming the reluctance of land managers and farmers to adopt new technologies, which is identified as one of the challenges in some of the WBE. To support the implementation of such sustainable practices in practice, a substantial financial support for agri-environment-climate and organic farming measures should be integrated in the not yet accredited measure within the IPARD III in WBE.

Numerous programmes and strategic documents already address some of the goals and objectives of EU strategic documents in WBE and emphasize the challenges and gaps that need to be overcome. For instance, the new Strategic Plan for Rural Development of BiH (2018-2021), foresees several measures related to better management of soils and their adaptation to climate change. One of these measures is: Support for organic production, environmental protection and reduction of the impact of climate change. The BiH National Adaptation Plan (NAP) foresees a set of measures for effective soil protection in line with EU legislation. Unfortunately, many of these measures are not at all or are only partially implemented in practice.

Digital transformation of agriculture is one of the key points in the newly adopted National Strategy on Agriculture and Rural Development in North Macedonia (NARDS 2021-2027) for achieving sustainable natural resources management and mitigation of the negative impacts of climate change. This is in line with the EU Adaptation Strategy goal for digital transformation as a critical point in achieving the Green Deal objectives. However, the National Programme for Agricultural and Rural Development for the period 2023-2027 foresees only one measure related to soil protection which is quite challenging for implementing the foreseen strategic objectives. The EU Adaptation Strategy to climate change emphasizes the necessity of smarter adaptation, improving knowledge and managing uncertainty, fully in line with the Action Plan for the Third National Report on Climate Change in North Macedonia.

Several policies and strategic documents have been developed and approved in Kosovo*, but they remain to be implemented. Under such circumstances, a comprehensive document is needed that will systematize all the activities related to climate change as well as set the appropriate priorities.

The recently developed and adopted Strategy on Agriculture, Rural Development and Forestry (SARDF 2021-2027) in Albania, raised concerns that “good agricultural practices are not systematically promoted”, and weak manure management is a cause of soil and water contamination. The Nitrates Directive has not yet been transposed in WBE. There have been challenges with transposing the Codes of Good Agricultural Practices and the No Action Programme, which focus on agricultural land and contribute to soil protection and mitigation of degradation processes coming from the negative impacts of climate change identified in some WBE.

Soil monitoring, which is also in the focus of the EU with the newly proposed Directive on Soil Monitoring and Resilience, is not addressed in any of the existing legal and strategic documents in WBE. This is mostly due to the lack of awareness among the policymakers of the importance of soil monitoring, the inexistence of specific legal documents like the laws on soil protection in WBE, and insufficient communication between ministries and the academia/research community.

Serbia, North Macedonia, and Montenegro have set up their nationwide Land Degradation Neutrality targets (LDN) to achieve land degradation neutrality by 2030 (UNCCD, 2020). The implementation represents a challenge for these economies , in particular mainstreaming the activities to achieve land degradation neutrality targets in the current legislation, spatial planning, and strategic documents.

4.4. Sustainable measures and best management practices already applied for the protection of agricultural land

There are many examples and initiatives of applying best sustainable management practices for the adaptation of soil to climate change in all WBE. Most of them have already been tested in practice and some of them have already been adopted by farmers. Sustainable measures and best management practices in WBE focus on:

- Optimization of fertilizer use and soil cultivation practices to enable preservation of soil fertility
- Soil moisture preservation and irrigation scheduling
- Introducing carbon farming practices
- Soil erosion control, etc.

In all cases, the main intention is to prevent soil degradation processes which can be additionally aggravated by the negative influence of climate change. The efforts are to implement natural-based solutions, which do not imply high-tech expensive approaches, but measures that are effective and easily implemented.

Some of the sustainable measures are already adopted by certain groups of producers, like cover crops in Montenegro among vine producers, or apple producers in North Macedonia. Drip irrigation is also becoming a common practice among the producers of highly intensive crops, like fruit producers or vegetable producers in greenhouses. In the past few years, as a result of a decrease in the market prices of irrigation systems and governmental support, drip irrigation has become a common practice among producers especially in North Macedonia, Kosovo* and Albania, due to the dryer climate. However, the general impression is that best practices are still not widely implemented, except those that are simple, cheap and very effective, or those that cross-compliance measures have supported with incentives. For instance, crop cultivation techniques like reduced or contour tillage are present in very small areas or not implemented at all. Soil testing is another example that is not commonly implemented among growers, due to a lack of awareness and tradition. Although there is a growing trend in organic farming in most of WBE, the share of the area under organic production compared to the used agricultural land is small.

It is important to note that in the recent period, sustainable measures have become part of strategic documents and programmes of almost all WBE. For instance, in North Macedonia, the NARDS foresees certain adaptation and mitigation measures. One of the measures that will be supported with the most recent Instrument for Pre-Accession Assistance Fund for Rural Development (IPARD 2021-2027) in Serbia, Montenegro, and North Macedonia includes agri-environment-climate and organic farming, which implies several agro-ecological and adaptive sub-measures, like green cover in perennial crops for reducing soil erosion and improvement of soil quality, crop rotation, and organic farming.

Nature-based solutions are becoming very popular in Serbia, especially those that have an impact on the protection of soil health like afforestation and restoration of forests, sustainable forest management, 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. The Draft Climate Change Adaptation Programme with Action Plan (2023) in the Republic of Serbia contains a set of natural-based solutions aimed at increasing the resilience of meadows and pastures.

In the past few years, precise agriculture has become very popular among the scientific community and policymakers. There are numerous examples of already implemented sophisticated practices in agriculture in North Macedonia, like meteorological stations and soil moisture sensors for optimizing soil moisture and irrigation scheduling. Fertigation is another example of on-farm adaptation measures, enabling application of optimal quantities of nutrients in small portions with irrigation water.

The ministries of agriculture, forestry and water management in Montenegro and North Macedonia are planning to install platforms for precision agriculture equipped with sensors to measure meteorological and soil parameters at various locations.

However, despite all the positive examples, there is still room for improvement. For instance, the organic by-products and post-harvest remains are still unresolved issues affecting soil health. The burning of plant residues, although legally banned, is still a common practice to deal with stubbles and other organic material in most WBE. Composting of these valuable sources of organic matter is a practical solution that is still not implemented in practice. Manure management and application are usually improper and regular manure application lags in practice.

4.5. Already adopted mechanisms and opportunities for effective adaptation measures for soil health protection

Adaptation of agriculture to climate change is a complex process, which relies on several building blocks. Institutional support for farmers in implementing agri-environmental and adaptive measures through well-developed financial mechanisms is of utmost importance. In most WBE, IPARD and direct payments are the two common mechanisms that support the implementation of good agricultural practices for soil conservation and rural development measures, following the principles of the EU Common Agricultural Policy (CAP). Subsidies are distributed through annual programmes for direct payments and in North Macedonia and some other WBE are conditioned with implementation of a minimum set of good agricultural practices. Support is also provided through rural development programmes, which among others, supports investing in physical assets of agricultural holdings, including investments for the purchase of new machinery and irrigation equipment.

The new IPARD III in the Republic of Serbia, North Macedonia, and Montenegro foresees a new agri-environment-climate measure that consists of four operations aiming to enhance cultivation methods through the support of crop rotation and grassing of the inter-row area in permanent cropland; protect the biodiversity and ecosystem services with the maintenance of pollinator strips and contribute to climate change adaptation and mitigation principally by supporting the sustainable use of inputs and improving soil management practices. Incentives for organic farming are another mechanism that contributes towards the protection and improvement of land and soil as a natural resource.

In Montenegro, the Agrobudget is a comprehensive framework that encompasses various non-refundable incentives funded by the national budget to promote the growth of agriculture and rural areas. A good example of financial mechanisms for Montenegro are two IPA projects in 2012 and 2013, implemented by the World Bank. These projects provided Montenegrin farmers and agribusinesses with opportunities to access grants resembling the EU IPARD.

The legal and strategic framework is the second building block for efficient adaptation of soil to climate change. The recent agriculture and rural development strategies in North Macedonia and Serbia particularly outline the need for sustainable and responsible use of natural resources as a prerequisite for adaptation to climate change. In BiH, the Climate Change Adaptation and Low-Emission Development Strategy (2020-2030) was adopted and foresees measures for mitigating and adapting agriculture to climate change, as well as the need to strengthen the capacities at all levels. But not much progress has been made in the implementation of these strategies and the realization of the foreseen measures. In addition to this, the lack of special legislation for dealing with soil-related issues in agriculture is another requirement. The need for special soil legislation is outlined as a priority in all WBE, in line with EU regulations (EU Soil Strategy, EU Mission A Soil Deal for Europe, proposed Law on Soil Health). Except for Serbia, no other WB economy has prepared a law on soil and soil protection, in all other WBE, legislation related to soil is scattered among different laws. The Law on Agricultural Land in North Macedonia is rather outdated, and tackles only certain issues related to the sustainable use of agricultural soils. Kosovo* still needs intervention in policies to promote agricultural practices with the environment systematically.

Implementing adaptation measures seeks the existence of well-developed technical capacities and infrastructure. Training facilities and programmes are needed, so specialized centres like the Agricultural Technology Transfer Centre Fushe Kruje (QTTB Fushe Kruje) in Albania can serve as a good example as a centre of excellence for the dissemination of good and sustainable soil management practices.

In this part, several good examples can be outlined. MAFWE in North Macedonia has successfully finalized the creation of the Macedonian Soil Information System. The agro-ecological zoning in both BiH and North Macedonia outlines the best zones for growing certain crops according to the current environmental and socio-economic conditions. Hydrometeorological systems in most WBE in terms of their technical capacities are rather modernized and will be upgraded with additional platforms for monitoring soil parameters. Reliable and timely weather forecasts are extremely valuable in the process of adaptation to climate change, so the future efforts of the hydrometeorological service should be towards establishing online climate services, for fast dissemination and early warning of the producers about possible climate extremes. Laboratory testing of soils is a measure that is supported in WBE and is becoming a standard procedure. Permanent control of soil quality and optimization of nutrients is multiply beneficial for the soil, plant, environment, and farmers.

In Serbia, 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 increased almost every year. Such systems can contribute towards the dissemination of good practices among the producers. On the other hand, in Kosovo*, the public or private advisory systems still do not promote good practices for climate change adaptation.

In the past two decades, the expansion of digital technology, communications, and new technological solutions have enabled the adoption of new approaches and solutions for better and more accurate monitoring of environmental processes and optimization of commodities used in agriculture. The terms precision agriculture, digital mapping, remote sensing, etc. are becoming common among environmentalists, agricultural producers, and managers. These new technological solutions have already found their place in the area of monitoring and protection of natural resources degradation, and the effects of applied adaptation measures. For these reasons, particular attention should be paid in all WBE towards the enhancement of technical and intellectual capacities to adopt these new technologies and approaches in soil health protection and adaptation to climate change.

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

Data related to soil quality, soil types spatial distribution, the extent of land degradation and applied management practices are in the heart of the process of effective adaptation of soils to climate change. The existence of soil datasets, their quality in terms of spatial and temporal resolution, area covered, parameters measured, and methods used, as well as their format and availability, are very diverse across WBE.

The only regional soil dataset (excluding Albania) is the Soil Map on a scale of 1:50000, which was a long-term project of the former Yugoslavia. This soil survey was based on a joint methodology and soil classification and is the most harmonized soil dataset. However, the current format and availability are not consistent and vary among economies . Besides this, the only consistent soil datasets for the WB region are global data sets, such as Copernicus Programme data, ESDAC, etc.

At the national level, in Albania, the Agri Technology Centre (QTTB) is the responsible institution for soil surveys, establishing a digital graphical database with soil data for more than 400,000 ha.

In BiH, the Federal Institute for Agropedology of FBiH and the Institute for Agroecology within the Agricultural Institute of the RS, are the key institutions with capacities for soil monitoring. These scientific institutes perform professional and other tasks, such as mapping and determining soil fertility control, and soil contamination monitoring. The availability of data on soil in BiH is very limited. Only a small part of this data is in digital format (GIS), like pedological soil maps, land use maps, physical and chemical properties of the soil, but these are not publicly available.

Soil monitoring competencies in North Macedonia are located in several scientific institutions, like the Institute of Agriculture, Tobacco Institute, Faculty of Agricultural Sciences and Food, and Faculty of Forestry. Soil data in the economy are rather limited and outdated which is due to the prolonged inexistence of a national soil quality monitoring programme. Data for certain soil degradation processes and climate extremes are modelled.

The existing historical soil datasets are collected and systematized in digital format within the Macedonian Soil Information System (MASIS). Soil data collected during the long-term Land Productivity Potential Programme are at the moment archived as a hard copy in the Ministry of Agriculture, Forestry and Water Economy (MAFWE) and are not publicly available. Some valuable soil-related datasets in digital format have been recently developed, like digital terrain models (DTM) (0.5-m resolution) for the whole economy territory and its derivatives, SENTINEL satellite images starting from 2014 in a 10-m resolution etc.

In Montenegro, under the leadership of the Biotechnical Faculty, soil data from several thousand soil profiles meticulously collected for over nearly three decades of soil survey were converted in digital format, which has enabled the construction of a digital pedological map integrated with an extensive soil database. Montenegro conducts annual soil condition monitoring, including testing for hazardous and harmful substances in the soil. The results of this monitoring are documented in the annual information on the state of the environment prepared by the Environmental Protection Agency.

In Serbia, soil and land data relevant for the design of soil adaptation measures and measuring of their effects, available in GIS format include soil maps, land use and land cover maps, soil physical properties, soil chemical properties, soil organic carbon content, contamination, soil sealing, salinization, acidification, drought, and floods (Vidojevic et al, 2022). Although soil erosion affects about 90% of the total area of the Republic of Serbia, data are outdated and are available only in hard copy.


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5.

Status of water resources and their importance for agricultural production and climate change adaptation in WBE

5. Status of water resources and their importance for agricultural production and climate change adaptation in WBE

5.1. Water resources in WBE and their importance for agricultural production

Water resources play a very important role in WBE, with agriculture as one of the main sectors directly depending on water. In addition to agriculture, water resources in WBE are also very important for the industry, for electricity producing, supplying the population with drinking water, tourism, etc.

The analysis of the economies reports on the status of water resources in the WB region (Volume II) shows relative abundance in water resources. The highest annual water potential resources are reported in Serbia, and the lowest on the territory of Kosovo*. The water potential in WB region mainly comes from surface water, precipitation and groundwater. Also, a significant part of the water potential in Serbia and Bosnia and Herzegovina comes from transboundary waters.

Precipitation is a very important resource for the water potential of the WB region. The average annual precipitation varies from economy to economy, as well as among the regions in each economy. The impact has intensified in recent years, primarily due to the atypical and extreme impacts of climate change. Groundwater and their reserves in the WB region have not been adequately explored, and generally they are presented using some estimated data or data from the literature.

The mean annual discharge of all rivers in **Albania** is about 1,300 m^3/s. This corresponds to a specific discharge 29 l/s/km^2, 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, with a very limited amount discharged also into the Black Sea (only 1.7% of Albanian territory is part of the Danube basin). Underground aquifers contribute 23% to the annual total flow of water (Selenica, 2000; Selenica, 2009). The total mean annual precipitation in Albania is about 1,485 mm per year and declines from west (1,000 mm) to east and from north (over 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). The total water per capita in Albania is equivalent to 8,600 cubic meters per year.

In hydrographical terms, **Bosnia and Herzegovina** (BiH) belongs to the Black Sea and Adriatic Sea basins. There are seven river basins in BiH: Una, Vrbas, Bosna, Drina, Sava, Neretva and Trebišnjica, and Krka and Cetina. With an average rainfall of about 1,250 mm, the territory of Bosnia and Herzegovina is one of the wateriest areas in Europe, especially in 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. 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 in some watersheds they also participate in underground inflows from the territories of other economies . About 722 m^3/s (62.5%) runs to the Black Sea Basin from all the tributaries of the Sava River in Bosnia and Herzegovina, while about 433 m^3/s (37.5%) runs from the Trebišnjica and Neretva and Cetina basins to the Adriatic Sea.

The territory of **Kosovo*** is divided into four river basins: Drini i Bardhe, Ibri, Morava e Binçës and Lepenci which then flow 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. Kosovo* is uniquely dependent on internal water resources with a very low dependency ratio. The only water that enters the economy other than precipitation is the water entering Gazivoda Lake from the Ibar River. Internal renewable water resources in Kosovo* are 3.3 billion m^3 per year, while external renewable water resources being only 0.3 billion m^3 per 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. The total water consumption for all needs in Kosovo* is 344 MCM/year or 193 m^3/capita/year. From the total water consumptions amounts, drinking water accounts for the largest share with 178 MCM/year, followed by agriculture with around 140 MCM/year and industry with around 26 MCM/year.

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. 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 groundwater potential in Montenegro is estimated at around 14,000 litres per second. 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.

North Macedonia covers part of the Vardar, Crn Drim, Strumica, and South Morava river basins. In its entire territory, 84% of all 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 6.4 billion m^3, i.e. 4.8 billion m^3 in a dry year. The average annual precipitation is approximately 730 mm/year, and by catchment areas, the 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 (Water Management of the Republic of Macedonia, 1999; Cukaliev, et al., 2005; Radevski, 2009). The total water needs in the economy are estimated at 2.03 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).

In **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 belongs to the Black Sea basin. The flows of international rivers are significant and dominant compared to domestic rivers, generated on the territory of Serbia. About $63.7 \cdot 10^9$ m^3 of water precipitates annually, about $16 \cdot 10^9$ m^3 runoff, while the rest returns to the atmosphere through evapotranspiration. 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%). Taking into account transitional water, the total annual renewable water resources per capita are 18,490 m^3 (FAO Aquastat database, 2020). Normal annual precipitation total is 896 mm. The amount of precipitation increases with altitude. Drier areas with precipitation below 600 mm are located in the northeast. The areas with the highest precipitation are located in the west and southwest, where the annual precipitation ranges from 850 mm to 1,000 mm.

The analysis indicates that in general water resources in WBE meet the needs for all purposes. However, economies from this region continuously have 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 the atypical and extreme impacts of climate change (CC). Given that precipitation reduction is expected due to CC, proper water management and irrigation will be essential for the stability and productivity of agricultural production.

5.2. Irrigation status in WBE

The favourable climate conditions and land characteristics in the WB region create a basis for intensive agricultural production of specific highly cost-effective crops. However, due to uneven distribution of precipitation in time and space, irrigation is a necessary condition for successful and sustainable agricultural production in all these economies.

Irrigation and drainage management has a long history in the Western Balkan region. Concrete measures in the part of the construction of the hydro-meliorative systems were taken immediately after World War II. Today, the situation with hydro-meliorative systems and irrigation in some economies in the WB region is not satisfactory. Namely, there are large areas built and equipped for irrigation, which are not used from various reasons (the obsolescence of the irrigation systems, damaged equipment and infrastructure, reduced number of professional staff, fragmentation of the areas, institutional and technical changes, etc.). According to Sinha et al. (2022), irrigation and drainage sector development is at its historic low in terms of total area irrigated, and has declined from previous levels in several Balkan economies . The analysis of individual reports on the status of water resources in the Western Balkan region (Volume II) shows that utilization of the hydro-meliorative systems (HMS) for irrigation in WBE varied from economy to economy, ranging from 70% in 1987 to 24% in 2021 in North Macedonia, and from 54% in 1999 to 14.5% in 2022 in Kosovo*. Similar trends of decreased HMS utilization are noted in other economies too, while in Serbia results show a significant increase in the use of HMS from 9.8% in 1999 to 95% in 2012, which can be connected with direct investments from about 100 million euros in the development of irrigation and several new systems over the last two decades.

Furthermore, there is different data about irrigation land in WBE. For example, according to data from the State Statistical Office (2017), in North Macedonia there is a larger irrigated area than the area covered by hydro-meliorative systems, or almost 27% of the utilized land in the economy is irrigated. This result is much closer to the situation in the field, based on data analysis from statistical surveys. Also, the analysis indicates larger irrigated areas in some WBE than data for HMS. Generally, it is necessary in the future to define a standard methodology for estimating irrigated areas and possible irrigated areas, water extracted for irrigation purposes, as well as water use efficiency of each irrigation system separately.

Regarding the irrigation status in **Albania**, on a national scale approximately 360,000 ha have been equipped for irrigation, but less than 210,000 ha or less than 60% are irrigated. Except for wheat, all other crops are irrigated, and the main method of irrigation applied in the economy is the surface irrigation where the furrow method dominates. This is an obsolete method that uses large amounts of water, and the water use efficiency is very low. Practices are generally designed for seasonal irrigation with water quantities varying between 2,000 and 7,000 m^3 per hectare. Furthermore, Albania has an estimated number of 626 reservoirs that provide 55.4% of the 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 poor condition and in need of rehabilitation. 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.

Until 1992, irrigation systems in **Bosnia and Herzegovina** covered a total of 19,570 ha. Many of the systems were not in function completely. After 1996, the situation got even worse due to war damage and negligence. If the arable land in BiH (without natural meadows) was about 1,100,000 ha at the time, irrigation systems were installed on 1.8% of arable land and 191,620 ha or 17.4% were to be irrigated (IWMS RS 2014). Today, the situation with irrigation is very specific. The State of Bosnia and Herzegovina represents the central authority, but has only limited and specific powers, whereas the two entities, Federation of Bosnia and Herzegovina (FBiH) and Republic of Srpska (RS) and the Brčko District (BD) are politically, administratively and legally largely autonomous. Incomplete data in FBiH indicate that only about 3,000 ha are irrigated. It is suggested that surface irrigation systems are to be built in the upcoming five-year period on 5,000 ha and drainage systems rehabilitated on an area of about 20,000 ha. According to the 2006 Framework Water Management Development Plan of the Republic of Srpska, it is possible to irrigate 158,000 ha of agricultural land. According to the Strategy on Integrated Water Management of the Republic of Srpska (2012), it is considered that this is an overestimate of data and that it is possible to cover 79,912 ha (7,262 ha existing + 72,645 ha new). The same document states that 4,432 ha are covered by irrigation systems, but only 1,700 are functional. As a result of significant public investments in irrigation systems, from 2019, about 23,418 ha of arable land is covered by irrigation systems. In the Brčko District, 4 hydro-meliorative systems have been constructed, which include only the drainage of excess water from agricultural areas, while large irrigation systems have not been constructed. It is estimated that individual small irrigation systems cover about 500 ha. Generally, about 26,918 ha of agricultural land in Bosnia and Herzegovina is irrigated, which is around 43% of the possible irrigated area for 2019.

Irrigation in Kosovo* is divided into 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 Users Associations (WUA). These two systems have been coexisting for a very long time. The water sources used for irrigation are surface water bodies with 70% (rivers, streams, lakes) and around 30% are groundwater bodies. The main irrigation techniques that are used in agricultural production in Kosovo* are surface irrigation with 53.5%, followed by sprinkler irrigation with 31.4% and drip irrigation with 15%. According to a survey by the Ministry of Agriculture in 2005, informal irrigation surfaces are about 8,225 ha, while according to the 2021 Green Report, these surfaces are 5,506 ha. The Agriculture Census in 2014 recorded that out of the total agricultural land, 5.5% is irrigated (22,888 ha). The main irrigated crops 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, 5.3% of the total utilized agriculture land was irrigated (21,765 ha) or around 10% of cultivated/arable land (180,381 ha).

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 post-nationalization redistribution of land 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, although they are not in use. 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. Presently, 10.78% of agricultural utilized land, totalling 5,204 hectares, is under irrigation. Vineyards take the lead in terms of irrigated land, with substantial coverage of 96.24%. In contrast, meadows and pastures are the least irrigated area, with coverage of only 0.11%. Rivers, lakes, reservoirs, and groundwaters serve as primary sources of water for irrigation, with numerous farmers employing small-scale irrigation systems connected to local water bodies. Analysing the various irrigation methods, sprinkler irrigation and localized irrigation emerge as the most cost-effective in Montenegro. According to the official statistics, approximately 20% of arable land in Montenegro is irrigated, with actively irrigated agricultural land accounting for 6%.

In **North Macedonia**, 27 large and 110 small dams have been built, covering a total reservoir area of about 2.5 billion m^3. Irrigation schemes were mainly constructed in the period between 1958 and 1980, covering an irrigation area of 163,000-174,000 ha (according to various sources). About 126,617 ha are covered by a detailed irrigation network (Water Management of the Republic of Macedonia, 1999; Cukaliev et al., 2005; Radevski 2009). In the past period, the built area under irrigation systems has decreased to 135,912 ha, while the possible area for irrigation is 91,469 ha. The efficiency of using the built-up area is only 24% of the areas that can be irrigated. The technical solutions for about 65% of the constructed areas for irrigation use sprinkler irrigation, whereas surface techniques are the preferred choice for about 35% of the areas (Radevski, 2009). The use of drip irrigation in North Macedonia has intensified after 1990s, and today, almost all orchards and vineyards, as well as most vegetable crops are covered with drip irrigation system (Tanaskovikj and Cukaliev, 2014). Water for irrigation is mostly taken from reservoirs (75%), with the remainder coming from wells and rivers. Around 15,000 ha are irrigated with water from rivers, the main resource being the Vardar River (UNECE 2011). State Statistical Office (2016) reports the total irrigated area of 84,434 ha. The highest representation of irrigation 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, followed by vineyards, industrial crops, etc. On the other hand, field experiences and expert assessments indicate that irrigated areas are larger than reported by statistical data.

In **Serbia**, irrigation schemes as public property were built on an area of 182,252 hectares (with AP KiM), that is 117,928 ha without KiM in the 1980s. The utilization of irrigation systems varied from 9.8% in 1999 to 95% in 2012. A 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. Although the number of irrigated hectares under vegetables, orchards and strawberries has almost doubled, the percentage share of these crops has changed compared to 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 that 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 at 3.7%, fodder crops (1.8%), legumes at 1.2%, sunflower (1.3%), and rapeseed (1%), vineyards only 0.4% and the remaining crops are irrigated on 10.1% of the area. Farmers predominantly use surface irrigation systems (furrows) (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 the remaining water sources.

Table 5.1. Agricultural and irrigated land in WBE

Economy	Agricultural land (ha)	Total irrigated land (ha)	% of agricultural land
Albania	1,173,000	210,000	17.9
Bosnia and Herzegovina	1,925,000	26,918	1.4
Kosovo*	420,327	21,765	5.2
Montenegro	334,000	5,204- 20,040	1.6- 6.0
North Macedonia	1,262,000	84,434	6.7
Serbia	3,437, 423	159,587	4.7

Source: Economies reports (Volume II)

Drainage and flood protection play an equally important role in extending the cropping area and the cropping season in WBE, but this also remains underdeveloped or poorly maintained in many places. Some of the economies report results for drainage and used drainage area in the WB region (Table 5.2). Many of the economies in the WB region reported reduction of the drained area. In some economies over 50 percent of the drained area is not in operation. Therefore, greater investments for drainage systems are needed in the future, especially in the rehabilitation and cleaning of the existing canal network.

Table 5.2. Drainage area in WBE

Economy	Drainage area in the economy (ha)	Used drainage area in % (present situation)
Albania	about 50,000	/
Bosnia and Herzegovina	89,599	40-45%
Kosovo*	70,000	/
Montenegro	24,519	/
North Macedonia	81,930	50%
Serbia	2,536,000	67%- 85%

Source: Economies reports (Volume II)

5.3. Drought and flood risk assessment and crop water requirement in WBE

Almost half of the territory of Western Balkan economies is agricultural land. As mentioned before, this sector largely depends on water. Many authors reported (Županić et al., 2021; Knez et al., 2022; Sinha et al., 2022) that changes in the precipitation regime, intensive risks of drought, and extreme weather conditions have significant implication for the stability of this sector in the WB region.

Drought is a natural phenomenon defined as sustained and extensive occurrence of below average water availability (Jakubinski et al., 2019). Drought, as an adverse climatic phenomenon, has often occurred in recent years in Western Balkans economies . Furthermore, drought is predicted to have a more negative impact on agriculture than foods and landslides (Županić et al., 2021;). Due to climate change, the risk of intensification of dry periods will increase, while the need for water for all purposes will grow (Cukaliev et al., 2004; Tanaskovikj et al., 2011). The need for irrigation of agricultural crops will depend on the current and expected changes in climate and rainfall patterns across the region.

The impact of climate change in the WB region is expected to be modest in the short term but to accelerate markedly from the mid-century on, making the entire region hotter, the north wetter, and the south drier. Average temperatures will rise by 0.5-1.5˚C, slightly less in the north and more in the south. With a predicted temperate continental climate, this may lead to increasing snowmelt, resulting in potential for floods. Precipitation will increase in the north and decrease in the south, with higher levels in early spring and late autumn, and lower in summer. There will also be more drought days (Sinha et al., 2022). The effect of warmer temperatures on evaporation, together with the decline in precipitation, will make the region drier (Knez et al., 2022). Decrease in yields and higher competition for water in WBE will follow.

A study by Kerpaçi and Abullahu (2021) found a great disparity between northern and southern regions of **Albania** in terms of rainfall distribution. Those affected mostly by drought include the coastal plains and the valley of Korça in the southeast. Overall, the northern area, especially the one in Shkoder are characterized by larger amounts of rainfall. Potential evapotranspiration values vary from 890-1,080 mm in lowlands, 850 mm in hilly areas and 800-850 mm in mountain areas (Bardhi et al., 2012). 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 winter, with an 8% decline of 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 summer, followed by autumn and winter. In summer, precipitation is predicted to fall from 5.6% to 8.0% by 2025 and from 9.1% to 20.0% by 2050. Rainfall in winter is likely to remain relatively stable with precipitation estimated to decrease from 0% to 1.6% by the year 2025, and from 0% to 1.8% by 2050. Floods are also a very big problem for Albania. The percentage of communes that have experienced at least one flood is about 54% of the total number of communes. There has been a general increasing trend over the last 20 years. Floods and flash floods have also had a big impact in the agricultural sector causing an average of more than 7,000 hectares of land damaged every year with a maximum of more than 40,000 hectares.

In terms of **Bosnia and Herzegovina**, there is usually no drought in most parts of the economy from October until late May. Generally, the need for potential evapotranspiration is covered by precipitation. July and August are usually drier months especially in southern parts. 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, which in 1952 a catastrophic drought with an annual soil water deficiency of over 400 mm. Very gentle droughts or no droughts at all were found in the Bihać area. Severe droughts have caused enormous damage to agriculture in the years 2000, 2003, 2007 and 2011. Bosnia and Herzegovina is located in the part of Europe that is most exposed to climate change. Climate change is causing a significant increase in temperature and changes in the precipitation regime. Bogdanovic et al. (2012), reported that precipitation in Bosnia and Herzegovina has increased in some areas, and declined in others. According to the results from the complied study reports of CC in WBE (2023), 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.

In **Kosovo***, there have been many periods of short-term drought, and a significantly dry year occurs on average once in six years. 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. 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. Reference evapotranspiration ET_0 in the largest part of the economy it 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 of precipitation for this period is between 50-70 mm/month. Predicted changes for precipitation and temperature at the 2050-time horizon in Kosovo* area are based on Service for Water Indicators in Climate Change Adaptation (SWICCA) calculated by the Kosovo* Irrigation Master Plan (KIMP). According to this forecast, 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/inhabitant) may result in a shortage of water supply in Kosovo* by 2050.

The climatic conditions in **Montenegro** give rise to two distinct phases in the soil water regime throughout the year: a period of excess water from October to May, characterized by abundant rainfall, and a subsequent period of water deficit during the growing season due to insufficient precipitation. Regulating the water regime is crucial for mitigating 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, 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. The agricultural sector is very vulnerable to climate change due to its dependence on specific temperature conditions and water availability, and is exposed to natural 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. Regarding the effects of CC on temperature and precipitation, some data (Bogdanovic et al., 2012) report that Montenegro has been experiencing more frequent extreme heat since 1998, but annual precipitation has remained fairly constant with some fluctuations around the norm, and some analysts detect a slight downward trend.

In terms of **North Macedonia**, dry periods with different intensity and duration are common, even in flood years. For example, during an average of 20 years, 10 years are intensely dry, 9 are average, and 1 is characterized as wet. 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 on the entire territory of the economy is negative, except for a few small areas in the far west. This lack of water from natural sources can exceed -450 mm. Such weather conditions have a negative effect on production conditions in agriculture. In North Macedonia, where the frequency and intensity of floods and droughts has already increased, the sharpest declines in precipitation are expected to occur in summer, along with the greatest increase in temperature; winter precipitation is expected to remain unchanged. In conditions of climate change (Cukaliev, 2014), 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. The Third National Report under UNFCCC (2013)says 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 crops to climate change, especially focused on irrigation.

The average value of potential evapotranspiration for **Serbia** was 824 mm for the period 1991-2020. For the same observed period, the average climatic water deficits amounted to 280 mm. In most of the economy, the climatic deficit was in the range of 260-370 mm. According to de Martonne's drought index calculated for the period 1991-2020, irrigation is not required in the western areas in Serbia, while in the remaining areas supplementary irrigation is needed (IM 20-30). The areas of northeast and southeast are the most critical because the values are approaching the limit for irrigation being mandatory for successful crop production. July and August are especially critical, since IM value is then in the range 16-20, which indicates that irrigation is indispensable in the southeast of Serbia. Furthermore, 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; floods), although some positive impacts on agriculture are also expected (prolonged growing season). 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 average profit), while losses in viticulture are moderate (damage 10%-30%). Producers involved in fruit growing suffer the most damage (30%-50%). 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. According to a 2013 report by WMO, UNCCD, FAO & UNW-DPC, economic losses in agriculture caused by floods were estimated at between 38.75 and 106.25 million EUR, while for drought, they were around 500 million EUR.

Unfavourable environmental conditions in the context of escalating climate change create an environment in which the production of agricultural crops in most of the economies in WB is almost impossible without additional irrigation. Data about irrigation water demand for some crops in the WB region, based on the economies reports (Volume II) are presented in Table 5.3. Irrigation water requirements in WBE vary from economy to economy, applied irrigation techniques, technology of production, season of production, etc. The highest irrigation requirements should be provided in rice and alfalfa production, followed by maize, fruit production vegetable crops (tomato, pepper), etc.

Table 5.3. Irrigation water requirement, techniques and regime by group of crops

Economy/Crop	Irrigation water requirements by season (mm)	Applied irrigation techniques	Irrigation efficiency	Irrigation application rate (mm)	No. of applications during the season
Bosnia and Herzegovina/Maize	302	Sprinkler	60-70%	50	6
Bosnia and Herzegovina/ Vegetables	115-160	Sprinkler/drip/ furrow	~70%	/	>20
Bosnia and Herzegovina/Orchards (apple, pear)	185-320	Drip irrigation	~70%	/	>21
Bosnia and Herzegovina/Vineyards	70-140	Drip irrigation	/	/	/
Montenegro/Maize	345	Sprinkler	60-70%	50-60	6-7
Montenegro/ Vegetables (tomato)	389	Drip irrigation	70-90%	15	25
Montenegro/Orchards	264	Drip irrigation	70-90%	20	13
Montenegro/Vineyards	133	Drip irrigation	70-90%	15	9
Kosovo*/Maize	285	Sprinkler	80-85%	60	5
Kosovo*/Vegetables (tomato, pepper)	360	Sprinkler/drip	80-95%	10-12	20-40
Kosovo*/Orchards (apple, plum, cherry)	380	Drip irrigation	80-95%	18	20
N. Macedonia/Maize	420	Sprinkler	60-70%	60-70	6-7
N. Macedonia/ Vegetables (tomato, pepper)	360	Drip irrigation	70-90%	12	30
N. Macedonia/ Orchards (apple, pear)	390	Drip irrigation	70-90%	18	20
N. Macedonia/ Vineyards	277	Drip irrigation	70-90%	18,5-13,9	15-20
Serbia/Maize	210±70	Sprinkler		20-40	0-8
Serbia/Vegetables	130±60	Sprinkler/drip/ furrow	~70%		>20
Serbia/Orchards (apple, pear, cherry)	295±80	Drip irrigation	~70%		>22
Serbia/Vineyards	76±40	Drip irrigation			

Source: Economies reports (Volume II)

5.4. Existing farmers' adaptive practices for water use under climate change in WBE

According to the Balkan Barometer (2019) and Special Eurobarometer 490 (2019) reports, about 65% of WB citizens consider climate change a threat, unlike EU citizens, where 93% consider climate change a serious problem. For example, the citizens of North Macedonia will most likely hold the state responsible (31%), while Albanian citizens believe that companies are the most responsible for climate change (27%). An interesting fact is that Montenegrins believe that they are personally responsible for climate change more than the representatives of any other economy in the region (reported Županić et al., 2021).

Agriculture is a sector that can be considered the most vulnerable to climate change. According to Olesen and Bindi (2002), future projections of climate change and their impact on agriculture at the European level indicate that there will be more losses in the southern areas, including the Balkans. Key risks include reduced and increased yield variability, as well as reduced areas suitable for growing traditional crops. The negative effects of climate change on yields could be reduced if adaptation options were applied, but this would require 40% more water (Giannakopoulos et al., 2009).

Adaptation is a risk management strategy that intends to respond to the inevitable effect of climate change and increase resilience – the ability to respond to a change in function or condition in the environment by resisting damage and recovering quickly (Bogdanovic et al., 2012). An increasing number of policy documents, national reports, and research papers in WBE are focused on adaptation measures in agriculture and in the water sector. Although implementation is still lacking, these documents indicate that irrigation is considered the best available adaptation option, achieving significant yield increases, while the need for improvement of water use for agricultural practices is steadily increasing.

Farmers in **Albania** are aware of the benefits of irrigation. Improvements have been made in intensive horticulture cultivations with the introduction of drip irrigated pressurized systems. Other such improvements are available in almost all the greenhouses that have expanded enormously over the last years. Many of them also implement fertigation methods. According to the results, about 30,000 ha in more than 10,000 farms in Albania practice drip irrigation, while micro-sprinkler irrigation is implemented on 10,000 ha. On the other hand, field crops such as maize and forages are still irrigated by furrow gravitational methods where efficiency is low. Furthermore, irrigation scheduling practices are used on limited areas, mainly by water user associations, while soil moisture sensors and tensiometers are used in experimental sites. Also, soil moisture conservation methods by using organic mulch materials is applied as adaptive practice in around 100,000 ha and on a thousand of farms. Generally, training of farmers to introduce adaptive practices has been conducted in the most intensive agricultural areas.

In **Bosnia and Herzegovina** certain adaptive practices of proper water use under climate changes exist: improved irrigation water management (in different irrigation methods), as the main measure, including capturing water from watercourses or groundwaters and 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; changing in sowing density, anti-hail nets, land drainage and practices for protection against water erosion, etc. (Trbić et al, 2021, Marković et al, 2019). Generally, adaptation approaches are focused 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. 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 (Čadro et al, 2019). Data of reference evapotranspiration are used (ET_0) from the hydrometeorological institutes in the economy, and the occurrence of rain to coordinate the start of watering and determine irrigation regimes. Furthermore, there are funds for subsidies for irrigation equipment and anti-hail protection which are allocated annually from the state budget. In recent years, many projects in the field of water management and water conservation methods have been financed in the economy with the aim to improve water use efficiency.

The irrigation sector in **Kosovo*** was supported by different projects in the rehabilitation of the irrigation infrastructure and capacity building related to best irrigation practices. One of these projects is the Irrigation Rehabilitation Project (KIRP II) funded by the EU, focusing on capacity building of MAFRD, municipalities, irrigation providers and farmers. Furthermore, the ongoing Integrated Water Resource Management project founded by the Swiss Agency for Development and Cooperation (SDC) supports different stakeholders in Kosovo* to establish an integrated water resources management approach. In addition to the training, 90 farmers also received grants for modern irrigation equipment. The issue of how much this knowledge and adaptive practices for proper water use are applied by farmers is quite debatable within the public irrigation schemes as they are still charging their farmers per hectare instead of water amount used. Farmers who use water outside public irrigation schemes divert water from surface water bodies or wells, using mainly drip irrigation, especially commercialized farms. About 3,300 ha or 15% of the total irrigated area is under drip irrigation, while 2,000 ha are drip fertigated. Almost all orchards, and partly vegetable crops are irrigated by drip irrigation. Micro sprinklers are used in seedling production, greenhouses, and for frost protection. Irrigation scheduling practices, soil moisture sensors and tensiometers are usually used where training programmes and courses were realized. Weather stations are used for irrigation only in commercialized farms, while individual agricultural holdings use info from the media.

The agricultural sector in **Montenegro** heavily relies on irrigation to ensure consistent crop yields, sustaining the livelihoods of many farmers. 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. Drip irrigation is mainly the recommended method for improving water use efficiency, and around 11% of the total utilized agricultural land in Montenegro is covered by this technique, primary in vineyards. Combining irrigation with the application of fertilizers through irrigation is common practice when the drip system is used. Furthermore, some farmers, where training programmes and courses were conducted, use data from soil moisture sensors and weather forecasts to schedule irrigation based on the specific needs of their crops, reducing over-irrigation. Also, collecting and storing rainwater for irrigation during dry periods helps conserve freshwater resources, while the use of organic or inorganic mulch material for reducing evaporation, conserving soil moisture and improving water use efficiency is common practice in vegetable and strawberry production. Results show that using UV-resistant nets is generally used by farmers who are aware of the advantages of this measure, but also have sufficient financial resources. Lifelong learning programmes within universities, vocational training programmes related to water and targeted training courses for farmers and young professionals are also some practices used for dissemination of adaptive measures to students, farmers and all stakeholders in the economy. 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.

The huge importance of irrigation for the climatic conditions of **North Macedonia** is evident in the results by Iljovski and Cukaliev (2003) for crops that can survive without irrigation (only with natural rainfall and agrotechnical measures); autumn grains (wheat, barley) which are atypical crops for irrigation, have a doubled yield with only two irrigation application rates in April and May. Modern irrigation practices and adaptation measures in conditions of climate change need to be improved in the future. Namely, surface irrigation is still dominant in North Macedonia with 59%, drip irrigation is second with almost 10%, and about 7% of the irrigated area is covered by sprinkler irrigation (SSO, 2017). Field experiences testify that drip irrigation covers a larger area than the statistical sources, i.e. at least 50,000-60,000 ha of which 30,000 ha are under drip fertigation. Results of research with different crops show up to 70% fertilizer use efficiency (FUE) in drip fertigation systems in comparison with traditional practices. As for water use efficiency, it is over 90% higher in drip fertigation treatments compared to furrow irrigation and traditional fertilization (Tanaskovikj et al., 2016; Tanaskovikj et al., 2019). In the last 20 years, intensive efforts have been made to improve the capacities of producers. To this end, many activities have been supported by various donors (UNDP, USAID, GTZ, IAEA, IPA, GEF, many domestic donors, etc.), providing adequate equipment, both for conducting research and for farmer fields. A large number of farmers are trained for 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, its conservation and adaptation to climate change. Results show that on 10% of the total utilized agricultural land, farmers use proper irrigation practices such as soil moisture sensors, tensiometers, weather stations, and irrigation programmes. Furthermore, around 5% of the total utilized agricultural area, mainly in vegetable production, uses plastic mulch material for conserving soil moisture, while organic mulch is used for experimental purposes. UV nets and cover crops are mainly used in experimental fields, but also there are several new orchards and vineyards, even greenhouses in the economy where farmers have applied these adaptive practices.

Image 5.1. Applied adaptive practices in WBE – cleaning irrigation and drainage channels, drip irrigation and fertigation, tensiometers, soil sensors with data logger, UV nets, inorganic mulch

Source: Economies reports (Volume II)

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), 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, drainage and improvement of practices for protection against water erosion. According to experts' assessment, with modern irrigation systems (especially on larger estates), fertigation is applied to about 80%, 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. Based on expert judgement, up to 50% of irrigation systems use irrigation scheduling, and up to 30% have soil moisture measuring sensors. Tensiometers are used to the same extent. Many experts use data of the reference evapotranspiration (ETo) 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 depths. 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. Commercial advisory services, organized by companies selling mineral fertilizers and irrigation equipment, has been expanding more and more.

5.5. Policy and institutional framework for water use in agriculture in WBE

Water resources in the WB region, will be under more intensive pressure from climate change in the near future. Therefore, WBE are already taking appropriate adaptive measures to reduce the negative effects of climate change on this sector. These measures include individual adaptive capacity measures (farmers' adaptive practices, presented above), as well as systemic and institutional-level activities and capacity building for managing water resources and adaptation of agriculture to climate change.

Changes in the water resources are becoming an increasingly pronounced problem for economies prone to drought, such as WBE. Therefore, in addition to individual adaptive measures, it is necessary to develop appropriate systemic and institutional-level measures for stable water resources management in WBE, as well as continuous support and investments in the water resources sector. Generally, 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.

It is important to note that Western Balkans emphasize the importance of enhanced cooperation between decision-makers, scientific community, investors, private sector and farmers. Continuous monitoring and reporting on soil moisture and crop condition are keys in the fight against drought. However, a major Western Balkan stimulus is needed to meet the challenge of climate change fully. Investment policy decisions will significantly affect the intensity of carbon emissions and climate change in general. Bearing in mind WBE's geographical and economic interconnectedness, many issues related to adaptability, water resources management, and energy infrastructure pose a particular challenge (Županić et al., 2021).

The economies of the Western Balkans are in the process of joining the European Union, which, among other things, requires WBE to harmonize their policies, especially with the EU legislative framework on climate change (Županić et al., 2021). Regarding the water sector and agriculture, the main focus during the process of harmonization will be on institutional and infrastructure investment, as well as regulations in sectors. Furthermore, the agricultural sector in the WB region is in the process of structural transformation and aligning with the Green Agenda. The expected results from this process are to harmonize the national water sector with the Water Framework Directive, and related EU green directives (Sinha et al., 2022). As candidates for EU accession, all economies are also motivated to respect the Paris Agreement (Vuković and Vujadinović, 2018). Furthermore, Western Balkan economies have participated in projects funded by the United Nations Development Programme Global Environment Facility, and as a result have enhanced their capacities to manage climate change adaptation. Through the process of complying with UNFCCC assessment and reporting requirements, WBE have already demonstrated an increasing awareness and knowledge of climate change (Županić et al., 2021). Also, Western Balkan economies are members of the Drought Management Centre for South-Eastern Europe, the mission of which is "to coordinate and facilitate the development, assessment and application of drought risk management tools and policies in South-Eastern Europe with the goals of improving drought preparedness and reducing drought impacts" (Bogdanovic et al., 2012).

The water resources problem in WBE is more regional than national in scale, and effective adaptation in the region cannot occur on a strict economy-by-economy basis. This means that Balkan economies must work together on regional adaptive strategies, and that their capacity to cooperate on mutual problems is a major element in their overall adaptive capacity (Bogdanovic, et al., 2012). The South-East European Climate Change Framework Action Plan for Adaptation is a good example of a common platform for subregional cooperation on climate change.

Most of the Western Balkan economies require major reforms to their overall institutional, policy, regulatory, and financial aspects of their water and agriculture sectors, which are at varying stages of development. In addition, to mitigate and adapt to growing climate risks and transform these sectors, they need to: understand the diversity of farm types, irrigation water sources, and climatic conditions in the WB, and how they influence irrigation and drainage outcomes; and based on that understanding, rethink the investment approach to irrigation, drainage, and agriculture sectors in order to achieve greener, more sustainable, climate resilient, and more inclusive rural development (Sinha et al., 2022).

Investments in new irrigation systems should be planned continuously and built according to priorities. Improvement of irrigation systems should be done not only in terms of rehabilitation of the current systems through construction works, but through in-depth changes in the entire approach to irrigation and management of the systems, inventory of existing facilities and equipment, fully integrating and harmonizing bases and systems (LPIS, SCADA), raising the level of public awareness about the importance of irrigation systems in agriculture, etc. Generally, the competencies in the water sector in WBE are distributed among several institutions, which poses a problem for the proper implementation of reforms and investments in the water sector. Mainly, ministries of agriculture are in charge of water management in the agricultural sector in most WBE (excluding BiH).

In **Albania**, 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 integrated services of water resources provisions. The National Water Council (NWC) is the central decision-making authority that determines national policy on water resources. Albania has improved its water sector both in terms of legal and regulatory frameworks. The Government has adopted a National Strategy on Water Resources Integrated Management (2018–2027), with five strategic objectives: sustainable use of water resources, attainment of good water quality in all water resources, disaster risk reduction and management for 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. Also, Albania approved its National Strategy on Irrigation, Drainage with Action Plan 2019–2031, which identifies the 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.

The institutional framework for water management and agriculture in **Bosnia and Herzegovina** is complex. The Ministry of Foreign Trade and Economic Relations was given the authority to deal with environmental issues and natural resources issues in international relations at the state level. Responsibility for water management and agriculture is with the entities and BD, issues of water management and agriculture are dealt with through their regulations. 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 UNFCCC. NAP is a comprehensive document that was prepared on the recommendation and in accordance with the guidelines of the UNFCCC, providing analysis and assessment of vulnerability and risk from climate change and defining specific activities and measures for adaptation to climate scenarios. Furthermore, there are some other strategic documents related to climate action in the water sector and adaptation measures: Water Management Strategy of the Federation of Bosnia and Herzegovina 2010-2022; Agriculture and Rural Development Strategy of the Federation of Bosnia and Herzegovina 2021-2027 (draft); Strategy on Integrated Water Management of the Republic of Srpska, Irrigation of Agricultural Areas; Study of the Feasibility and

Economic Justification of Building an Irrigation System for Hydro-Technical Melioration in the Area of Brčko District of BiH; Water Management Plan for the Sava River Basin in Republika Srpska (2017-2021); Water Management Plan for the Trebišnjica River Basin in Republika Srpska (2017-2021), etc.

The current institutional framework for water management in **Kosovo*** involves a large number of government institutions starting from the Assembly as the legislative body with the Committee for Agriculture, Forestry, Rural Development, Environment and Spatial Planning and Environment. Competencies on water management are divided among six ministries and local authorities. 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 water management issues and proposes measures for development, use and protection of resources and the water system. The legislative basis for water protection and water resource management is the Law on Waters (2013). The competent authority for water management in Kosovo* is the Ministry of Environment, Spatial Planning and Infrastructure (MESPI), while the Ministry of Agriculture, Forestry and Rural Development (MAFRD) is responsible for irrigation water. Other important legislative basis currently regulating the water management sector includes the Law on Environmental Protection and the Law on the Irrigation of Agricultural Land.

Montenegro, as a signatory to the Declaration on the Green Agenda aligned with the European Green Deal, 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 mandating entities using water for irrigation to install devices, monitor water quantity and quality, and ensure technical accuracy. Water for crop irrigation must meet the prescribed quality standards. The Water Management Strategy 2017-2035 outlines long-term water management directions, as construction of irrigation systems that would cover 80% by 2025, or 100% by 2035 of the total available land suitable for irrigation and addressing flood risk assessments in the Danube and Adriatic basins. Other related strategic documents and laws include the Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood Risk Management Plan; National Plan for Protection and Rescue from Flooding; Preliminary Flood Risk Assessment for the Danube River Basin, etc. In the administrative realm, the Ministry of Agriculture, Forestry, and Water Management plays a pivotal role. It forefronts the establishment of water policy. The Ministry of Ecology, Spatial Planning and Urbanism reports on environmental quality, while the Environmental Protection Agency monitors overall environmental status. The Institute for Hydrometeorology and Seismology monitors water quantity and quality, forecasting floods, and adhering to the Water Framework Directive. The Ministry of Interior, specifically the Directorate for Emergency Situations, manages emergency responses, including flood protection and rescue measures.

The competencies in the water sector in **North Macedonia** are distributed among six institutions. The Ministry of Agriculture, Forestry and Water Economy (MAFWE) is in charge of water management in the agricultural sector. The Water Management Administration is a body operating within the MAFWE responsible for tasks related to the management of water for agricultural purposes and infrastructure facilities, such as dams, reservoirs, irrigation systems, drainage, etc. The state-owned Joint Stock Company for Water Management (AD Water Management) uses, maintains, and manages the irrigation and drainage systems as a whole. The water sector in North Macedonia is governed by several regulations: Law on Waters; Law on Determining the Prices of Water Services; Law on Water Management, etc. In 2021, the Government adopted the Long-Term Strategy on Climate Action (with an Action Plan). 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 the priority actions in climate change sector, 2021). In addition to the main sectoral strategic documents related to climate action, there is a National Strategy on Waters (2012-2042) and an Action Plan for Investments in the Water Sector (2014-2025). Almost all documents put emphasis on new challenges related to water, rehabilitation of existing and construction of new irrigation systems, policies for efficient water use, application of modern irrigation techniques, undertaking institutional reforms in the water management sector, etc. 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 and water sector in the economy have been supported by international and domestic funds.

In **Serbia**, the Water Directorate 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 (2018) controls the legal status of waters, integrated water management, management of infrastructure, sources and ways of financing water-related 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 Republic of Serbia until 2034, 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. Investment into and regular maintenance of drainage systems, construction of new drainage systems and construction of irrigation systems, transfer of knowledge, technological development, conservation of land resources (prevention of degradation), financing of agriculture (incentives), etc. are foreseen in these documents. Given that agriculture is extremely vulnerable to climate change, the Ministry of Agriculture, Forestry and Water Management of Serbia began developing the Irrigation and Drainage Development Strategy for the years 2023–2032 in 2022, in collaboration with the FAO, and it is in its final stages. Currently, 37 legal regulating provisions are in place to control matters relating more strictly to the protection of water, regulation of watercourses, protection from the adverse effects of water, use of water for various purposes, methods of financing, etc.

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Crops production analysis linked to climate change adaptation in agriculture in WBE

6. Crops production analysis linked to climate change adaptation in agriculture in WBE

The Western Balkans, like other regions of Southern Europe, are experiencing the impacts of climate change, including increased temperatures, changing precipitation patterns, and more frequent extreme weather events (Fayen et al., 2020). These changes pose challenges to agriculture, particularly crop production. Adapting to these changes is crucial for the sustainability of the region's agricultural practices and overall ecosystem health. The predominant climate types are the Mediterranean climate, continental climate, and mountainous climate and their mixtures and interactions (Knez et al., 2022; national reports). Moreover, the complex topography of the Western Balkans creates numerous microclimates, which are localized climatic conditions that differ from the surrounding areas. These microclimates can be found in valleys protected by mountains, coastal areas influenced by the sea, and high-altitude zones. The climate significantly influences agricultural practices, crop diversity, and the livelihoods of its inhabitants. The region's ability to adapt to the ongoing changes in climate will be critical for its future agricultural productivity and environmental stability. The region's coastal areas, characterized by a Mediterranean climate, are favourable for growing olives, grapes, and various fruits and vegetables. Moving inland, the climate becomes more continental, suitable for cereals (wheat, maize), fodder crops, tobacco, sunflower, and others. Traditional farming practices coexist with modern agriculture, reflecting a rich cultural heritage alongside contemporary development. Small family farms predominate, and they often focus on traditional crops and methods, while larger agricultural enterprises adopt modern technologies and practices, aiming for higher productivity and sustainability.

The prevailing climatic conditions in the region are already less than favourable for crop production and the changing climate is exacerbating the situation. Water scarcity is going to be more pronounced and will further limit crop growth, culminating in diminished yields and quality (Fayen et al., 2020). The vulnerability to climate change in the agricultural sector is high due to the sensitivity of crops to environmental stressors and their exposure to fluctuating climatic conditions. This vulnerability is magnified by the spectres of prolonged droughts, declining water supplies, and escalating temperatures. Nevertheless, the impact of the above-mentioned effects of climate change on crop production is reduced yield and quality of the crops. Moreover, the adaptive capacities of farmers are low and make them even more vulnerable.

Frequently, the present crop productivity gives an idea of the capacities of the agricultural sector to cope with existing challenges and the preparedness to adapt to the present and future changes in crop production. Figure 6.1 illustrates a multi-annual average yield of maize and winter wheat in European economies , showing that most of the analyzed economies in the Western Balkans are characterized by low crop yield.

Maize and winter wheat are representatives of crops with two different photosynthesis pathways. Winter wheat is representative of the C3 crops that follow the Calvin cycle, while maize is representative of the C4 crops (Hatch-Slack pathway). Although there is a big variation among the species, in general, C4 plants have evolved mechanisms that enhance their heat tolerance, reduce water requirements, and improve water use efficiency (Niklaus and Kelly, 2019), making them well-adapted to challenging environmental conditions. However, the hottest and the driest period of the growing season in Western Balkan economies is just a small part of the winter wheat growing period, while maize grows during the hottest and driest period of the year. Nevertheless, the average yield of both crops is among the lowest in Europe (Eurostat, 2024a; Eurostat, 2024b), with three out of four lowest yields in Europe recorded in WBE (Kosovo*, Montenegro, and North Macedonia). The situation in Bosnia and Herzegovina, Serbia, and Albania is slightly better, with yields at about 6 t/ha, which is still less than two-thirds of the highest average yields recorded in Spain and Greece. Figure 6.1 shows that Spain and Greece are among the economies with the lowest average yield of winter wheat, which is the result of a hot and dry climate that is not favourable for this crop, but have better performance with maize, a crop that is suitable for that region, particularly if irrigated.

Unlike these economies , the yields for both crops are very low in WBE, which is the result of the low capacities of the sector and cannot be associated with the climate preferences of these crops.

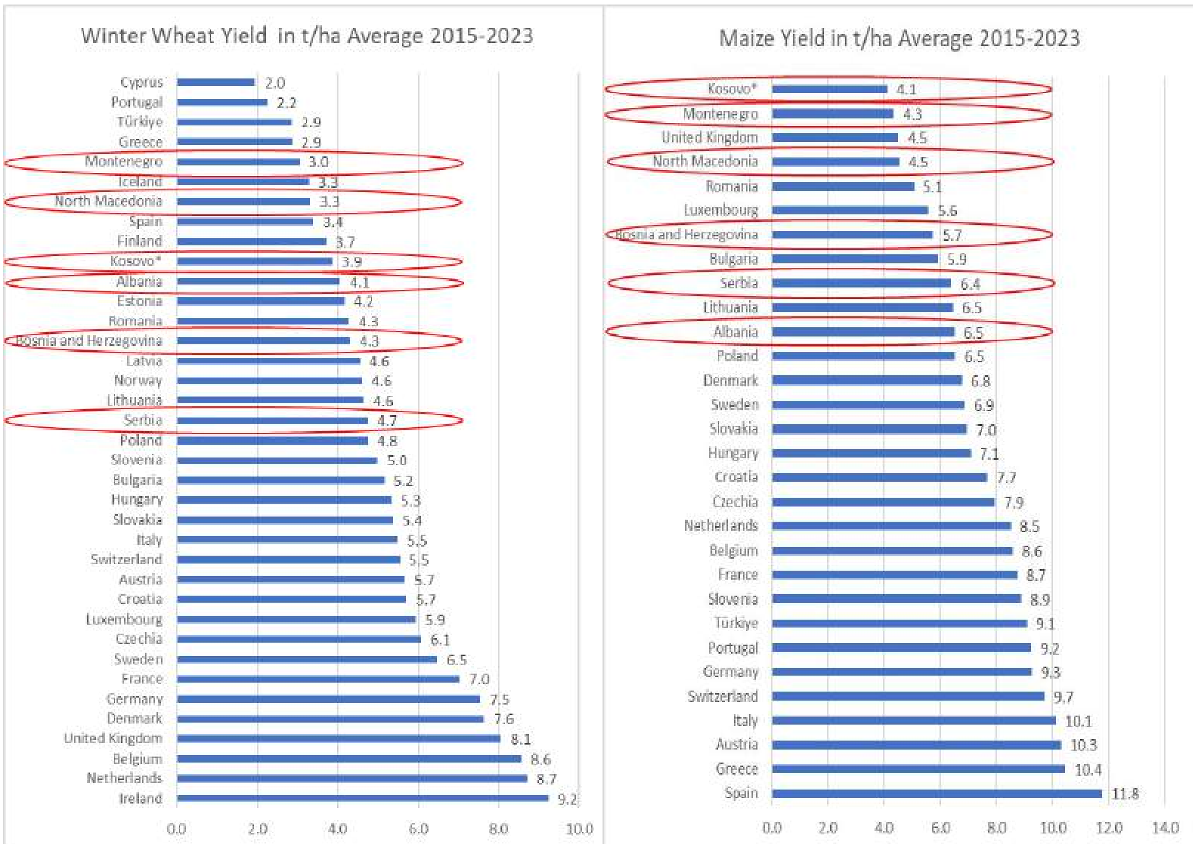


Figure 6.1. Average multi-annual yield of winter wheat and maize of European economies

Source: Eurostat (online data code: tag00027)

6.1. Meteorological data availability and accessibility

The importance of meteorological data for climate change analysis, research, understanding the vulnerability, and designing adaptation strategies and measures is very high. Historical meteorological records offer invaluable insights into long-term climatic trends, including variations in temperature, precipitation, and the frequency of extreme weather events. Moreover, real-time meteorological data and accurate short-term weather forecasts are used for early warning systems that support farmers to adjust their agricultural practices in response to imminent climatic threats and reduce potential losses. Together with phenological data, these datasets can be used for the development of adaptation strategies, testing potential adaptation measures using crop models, and enhancing the precision of early warning systems.

Nevertheless, meteorological data sets should cover the historical period for setting the baseline as well as future weather for assessment of crop response in the future. The important issues are the **spatial and temporal resolution** of the available meteorological datasets. Data from meteorological stations are point-oriented data and the number of existing meteorological stations cannot be representative for the entire agricultural land in the economy, therefore it is necessary do interpolate weather parameters in the space between the neighbouring stations. The process is complex and involves a number of steps such as:

- **Data collection** from the existing meteorological stations that continuously measure parameters such as air temperature, relative humidity, radiation, precipitation, wind speed, wind direction, and snow depth.
- **Spatial distribution** – Each station provides localized information, but to understand the broader patterns across the entire agricultural area spatially distributed datasets are required. The geographical distribution of meteorological stations is very important for creating spatially distributed weather data, particularly their location in horizontal and vertical dimensions. Better coverage results in better spatially distributed weather datasets.
- **Data integration and aggregation** is used to combine data from all meteorological stations to create a comprehensive dataset. Aggregation may involve averaging or weighting data based on station proximity, elevation, or other factors.
- **Spatial interpolation** – The methods of interpolation and spatial modelling are used to fill in the gaps and create a continuous representation of weather variables across the economy/region and to interpolate missing data points between stations to create a continuous grid. Common interpolation methods include inverse distance weighting, kriging, or spline interpolation.
- **Quality control and validation** are important to check for irregularity, inconsistencies, and errors in the data. Validation of the interpolated values is performed against observed data to ensure accuracy.
- **Creating spatial grids** – This process divides the study area into a grid (usually regular cells) and assigns the interpolated values to each grid cell based on its location.
- **Visualization and analysis** – Generating maps or visualizations to represent spatial patterns and analyze the data to understand climate variations, trends, and anomalies.
- **Modelling and prediction** are used for different interests, such as hydrological modelling, ecological studies, but for the crop sector for evaluating how climate variables affect crop growth and yield in different regions in present and future climates and for testing the effectiveness of the designed adaptation measures and strategies for climate change impact assessment.

Temporal resolution is very important for crop modelling because extreme weather events that happen in just a few hours can jeopardize crop production or even cause complete crop failure. Therefore, the coarsest dataset for crop modelling is daily data.

The analysis of the economies reports (Volume II) shows that meteorological services are very well developed in WBE. There is a legal and institutional setup that enables high-quality weather monitoring in all economies . Moreover, all economies implement WMO (World Meteorological Organization) standards in their operational activities. The meteorological observations started long before the World War II in all economies , but the systematic approach was implemented almost immediately after.

The number of main, climatological pluviometric and other type of meteorological stations by economy is presented in Table 6.1.

Table 6.1. Number of different types of meteorological stations operated by economies hydrometeorological services

Economy/ station	Main Meteorological	Climato-logical	Thermometric and Simple Meteorological	Pluviometric	Automated Weather Stations (AWS)
Albania	23	23	74	23	-
Bosnia and Herzegovina	31	-	-	-	-
Kosovo*	4	-	-	-	12
Montenegro	9	12	-	12	-
North Macedonia	19	7	-	103	43
Serbia	29	27	-	250	46
Total	**115**	**69**	**74**	**388**	**101**

Source: Economies reports (Volume II)

The number of main meteorological stations in the WB region is 115. However, most of the economies have reported a decline in the number of stations operated by professional observers in the recent period. Nevertheless, the number of automated weather stations (AWS) is increasing (Table 6.1). The meteorological network in the region is quite dense, but not as dense as in other parts of Europe. Therefore, the spatially distributed weather map produced using the datasets available in the region will be of much better quality than independent economy maps, particularly in the regions close to the borders between these economies .

The total number of temperature datasets (daily minimal and maximal temperature) is 224, combined with 282 datasets for daily rainfalls, and significantly lower number of datasets for daily air relative humidity, daily wind speed and daily sunshine duration.

Table 6.2. Number of datasets from different stations (spatial position) of daily meteorological data available in WBE

Economy	Period Covered	Tmax	Tmin	RH	P	V	SS
Albania	1949-present	74	74	29	29	29	29
Bosnia and Herzegovina	1961-present	31	31	31	31	31	31
Kosovo*	1950-present	4	4	4	4	4	4
Montenegro	1950-present	33	33	21	33	21	12
North Macedonia	1947-present	26	26	26	129	26	19
Serbia	Not specified	56	56	56	56	29	29
Total		**224**	**224**	**167**	**282**	**140**	**124**

Source: Economies reports (Volume II). Note: Tmax (daily maximal temperature in °C); Tmin (daily minimal temperature in °C); RH (daily relative air humidity in %); P (daily precipitation in mm); V (daily average wind speed); SS (daily sunshine duration in hours)

However, due to the transition and armed conflicts, some economies , such as BiH and Kosovo*, reported gaps in the datasets during the conflict period. Moreover, even though meteorological datasets with good-quality spatial and temporal resolution exist in all economies , there is a divergent level of data accessibility for researchers and a wider audience. Some economies provide monthly and annual reports of meteorological measurements, but this is not sufficient for research purposes. The analysis of economies reports provides some information about data access by research institutions, and if properly requested, it is possible to get some data for research purposes, free of charge or upon payment. However, meteorological data needed for climate change research are very intensive and almost all historical records from 1961-present are required. The economies hydromets are not willing to share such a large portion of their datasets even for research purposes. When data is associated with payment, the small charge based on the station/year principle is multiplied and becomes a significant cost, even reaching close to one million euros in some economies . Finally, even though high-quality datasets are available, they are not transparent, the researchers cannot access economies data and data policies of economies hydromets are considered the biggest weakness for the development of climate research in the region. Nevertheless, several researchers started using datasets from free international sources and gave up the idea of doing economy-oriented research with in-economy collected data. According to the economies reports, North Macedonia is using the Joint Research Centre of the European Commission gridded weather datasets with a resolution of 25x25 km (Agri4Cast Data, europa.eu). Also, Serbia reported using data from the EOBS database (https://www.ecad.eu/download/ensembles/download.php). Both datasets are regularly updated with new data and use station data sent to international exchange.

To resolve problems with economies meteorological data access and late conversion into grid weather, it is recommended to use free data sources mentioned above or other reliable sources. However, the regional analyses for the whole Western Balkan Area should be conducted using free international data sources.

In the Western Balkans region, **meteorological monitoring** plays a crucial role in understanding and responding to weather patterns and climatic trends. Each economy in the region maintains its meteorological infrastructure, tasked with collecting, processing, and disseminating meteorological data to support various sectors such as agriculture, disaster management, and public safety. However, despite efforts to establish robust monitoring systems, challenges persist in ensuring the accessibility and granularity of meteorological information to the public and stakeholders.

Albania, with the Institute of Geosciences, Energy, Water and Environment (IGEO), operates a network of 120 meteorological stations across the economy. While these stations diligently collect data on a range of meteorological parameters, including temperature, humidity, and precipitation, accessibility of this valuable information remains limited. IGEO, responsible for data management, does not openly share collected data, posing challenges for stakeholders seeking timely and accurate meteorological information.

Similarly, **Bosnia and Herzegovina** conducts meteorological monitoring through a network of 106 stations. Despite the extensive coverage of these stations, data accessibility is constrained, with bulletins primarily providing aggregated summaries rather than detailed parameters such as relative humidity. This limitation impedes stakeholders' ability to access comprehensive meteorological information necessary for informed decision-making processes.

In **Kosovo***, efforts to revitalize the meteorological network have led to the operation of 12 automatic stations since 2014. Despite advancements in data collection capabilities, public accessibility to meteorological data remains limited, with access restricted to annual averages and no provision for daily data access. This constraint hinders stakeholders' abilities to analyze short-term trends and respond effectively to meteorological events.

Montenegro's Institute for Hydrometeorology and Seismology (IHMS) manages meteorological data collected from nine main synoptic stations and 36 precipitation stations. While accessibility is facilitated through publicly available annual reports and yearbooks, challenges persist in ensuring timely data dissemination and promoting transparency in data management practices.

North Macedonia's National Hydrometeorological Service (UHMR) operates 19 main meteorological stations supplemented by automatic stations. Despite efforts to publicly report data, its usability is limited, with near-real-time hourly data available for only a subset of stations, hampering stakeholders' abilities to utilize meteorological information effectively.

In **Serbia**, the Republic Hydrometeorological Institute (RHMZ) oversees 25 meteorological stations. Despite the availability of publicly accessible reports, including annual yearbooks, challenges remain in data accessibility, particularly concerning precipitation data.

In summary, while each economy in the region maintains a network of meteorological stations and respective institutions responsible for data management, challenges persist regarding the accessibility and granularity of data provided to the public. Addressing these challenges is essential to ensure that stakeholders have access to timely and accurate meteorological information necessary for effective decision-making and response to weather-related events.

6.2. Most common agrometeorological indices available and used in economies contexts

Weather data, when transformed into agrometeorological indices, become more descriptive and more usable for the agricultural sector. However, there are no standardized indices that should be used in climate change research. This section summarizes the agrometeorological indices used in the Western Balkan region, focusing on their application in economies contexts and their significance in agriculture and climate analysis.

- **Albania** utilizes indices such as the Normalized Difference Vegetation Index (NDVI), Standardized Precipitation Index (SPI), sum of active temperature above 10°C, and evaporation data, mainly for illustrative purposes without detailed data presentation or relation to main crops.
- **Bosnia and Herzegovina** reports a range of indices including Referent Evapotranspiration (ET0), soil temperature, SPI1, 3, 6, and 12 months, Growing Degree Days (GDD) and others through the Federal Hydrometeorological Institute (FHMI) and the Hydrometeorological Institute of Republika Srpska (RHMZRS), with data available on their websites. These indices are used for drought, temperature, and soil water balance analyses.
- **Kosovo*** uses average climatic parameters over certain periods and their variability as indicators for agrometeorological conditions. The specific values for various indices across different locations are provided, but lacks detailed methodology or application insights.
- **Montenegro** highlights the use of climate parameters like temperature, precipitation, and a set of 27 climate indices including the SPI, emphasizing changes in climate patterns and their implications.
- **North Macedonia** focuses on drought and temperature indices, mentioning the need for a comprehensive analysis due to factors like late spring frosts and proposes adopting new methodologies for index calculation.
- **Serbia** uses indices like SPEI6a for drought analysis and various others for climate change analysis, crop vulnerability, and risk assessment, including phenophase occurrences and viticulture-specific indices.

From a regional perspective, this document indicates a varied approach to agrometeorological indices, emphasizing the importance of these indices in understanding and managing the effects of climate on agriculture. The indices range from drought and temperature indices to more specific ones like NDVI and GDD, each tailored to the economies context and agricultural needs.

A summary of the agrometeorological indices used by each economy in the Western Balkan region is presented in Table 6.3.

Table 6.3. Agrometeorological Indices used by Western Balkan economies

Economy	Agrometeorological Indices
Albania	NDVI, SPI, sum of active temperature >10°C, evaporation data
Bosnia and Herzegovina	ET0, soil temperature, SPI 1, 3, 6 and 12 months, GDD, soil water balance indices
Kosovo*	Daily Max/Min T, daily RH, daily precipitation, average daily wind speed, daily sunshine duration
Montenegro	Air temperature, precipitation amount, SPI, number of tropical days, number of frosty days and many others (set of 27 indices)
North Macedonia	Drought Factor by Lange, Drought Index by De Martonne, Aridity Index, meteorological water deficit, SPI
Serbia	SPEI6a, average annual temperature, growing season temperature, start and duration, frost-free period, frequency of hot days, OIV indices for viticulture

Source: Economies reports (Volume II)

SPI and its derivate SPEI is an index used by 5 out of 6 WBE and can be used as a common index for the region, the recommendation is to use SPEI because the SPI is purely a meteorological index that analyzes only rainfalls, while SPEI use and evapotranspiration that is always calculated by using temperature and some other parameters. Therefore, the SPEI is a much better index for the agricultural sector. Nevertheless, some other indices should be established as standards for the region and one of them should be the aridity index, recognized worldwide as an index for desertification.

6.3. Phenological monitoring in WBE

Phenological monitoring provides valuable information for the recorded changes in crop growth and crop growth stage appearance and duration. Increased temperature and faster temperature accumulation can make crops start growth earlier, earlier flowering, shortening of some growth stages, shorter biomass accumulation period, etc. Historical records can give a clear picture of the crop response in case of annual weather variability and of the expected behaviour in the future.

Phenological monitoring is crucial for understanding the timing of biological events in plants as they respond to environmental conditions, particularly climate. It is essential for using and calibrating crop models, as accurate phenological data helps predict plant development stages, optimize agricultural practices, and improve crop yield forecasts. However, climate change is affecting phenological stages, often leading to their shortening that can disrupt agricultural calendars and crop management strategies, necessitating adjustments to cope with earlier flowering, fruiting times, and potential mismatches between crops and their pollinators, which can affect food production and biodiversity.

The economies reports point out that weather monitoring conducted by economies meteorological services reports high-quality data, while phenological monitoring is organized differently and provides data with lower levels of systematization and lower quality. Usually the same institutions (economies hydromets) conducting weather monitoring, also conduct phenological monitoring. There are existing stations for phenological monitoring, but data is not systematically presented, and there is a general perception that there is a need for improvement. Only BiH and Montenegro have reported the existence of well-structured and classified long-term phenological data. Other economies have reported existing phenological monitoring but discussed data availability and transparency as well as issues with data systematization, integration, and availability. Finally, Kosovo* reported that there is no institutional setup for conducting phenological monitoring.

- **Albania** mentions limited systematic phenological information, even though there are 13 phenological monitoring stations. It is mentioned that frequently researchers depend on external sources like USDA for data on winter wheat and maize.
- **Bosnia and Herzegovina** conducts comprehensive phenological observations across wild and cultivated plant groups and tracks fieldwork activities, with long-term data available for certain locations.
- **Kosovo*** highlights a lack of dedicated institutions for phenological data, mentioning a short-term project for monitoring grapevine phases.
- **Montenegro** details systematic phenological observations since 1951, with data classified into several categories and observations reflecting the impact of global warming on growing seasons.
- **North Macedonia** describes its phenological network covering various crops and plant species, though facing challenges with data accessibility and consistency.
- **Serbia** notes phenological observations are performed but faces issues with data integration and availability, with efforts underway to revise and possibly integrate these observations.

The number of phenological monitoring stations that exist in WBE is provided in the following table:

Table 6.4. Number of phenological stations in Western Balkan economies

Economy	Albania	Bosnia and Herzegovina	Kosovo*	Montenegro	North Macedonia	Serbia	Total
Number of phenological stations	13	20	0	9	24	n/a	66

Source: Economies reports (Volume II)

The total number of phenological monitoring stations in WBE is 66 (without stations in Serbia). Monitoring is conducted for crops and wild species.

Finally, we can conclude that the WB region exhibits varied levels of sophistication and systematization in phenological monitoring, reflecting differing capacities and resources dedicated to understanding climate impacts on agriculture.

6.4. Crop models used for estimating crop response to climate change in WBE

Crop modelling is crucial for predicting future crop yields, assessing the potential impact of climate changes, and guiding adaptation strategies. These models are essential for integrating various data (climate, soil, crop characteristics) to simulate potential outcomes under different conditions, aiding in decision-making and policy development. The choice of crop models for climate change analysis poses challenges, including the need for comprehensive data, the complexity of model calibration, and the sustainability of technical expertise. Crop modelling allows for the estimation of agricultural outcomes based on inputs and environmental conditions, thereby playing a pivotal role in understanding and scientifically proving adapting to and mitigating the impacts of climate change on agriculture.

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 yields in the future and provide data for other models (farm models, economic models, and cost-benefit analyses) that can estimate expected damages and gains caused by climate change and adaptation measures.

The analysis of crop models used across the Western Balkans to estimate crop response to climate change is very diverse. It reveals varying levels of adoption and application of crop models by economy, with some nations employing models like AquaCrop, CropWat, and CropSyst primarily for research, while others have not systematically used crop models. The analysis indicates a regional trend towards understanding the impact of climate change on agriculture, though challenges such as data availability, model calibration, and maintaining expertise limit broader application.

The following table summarizes crop models already used in the respective economies.

Table 6.5. Crop models used in Western Balkan economies

Economy	Crop models used in the economy
Albania	Not systematically used; limited to research i.e. AquaCrop, CropWat, CropSyst.
Bosnia and Herzegovina	CROPWAT, SPAW, CROPFLEX, AquaCrop, SIMDualKc, SMARTWATER. Not used systematically but rather by individual researchers.
Kosovo*	Not systematically used; limited information available.
Montenegro	Crop modelling is still not used.
North Macedonia	Empirical model FAO-Crop Yield Response to Water deficit, CropSyst, BiOMA modelling platform, AquaCrop.
Serbia	AquaCrop, DSSAT used for specific conditions in research. Not used for economies level assessments.

Source: Economies reports (Volume II)

The analysis of the economies reports shows that four economies that report the use of models reported different crop models, but all of them have some experience with the FAO Aquacrop model. This suggests that the AquaCrop model could be the model of choice for WBE due to its relatively low data requirements, ease of use, and capability to assess the effects of water scarcity on crop production. AquaCrop was developed by the FAO and is designed to simulate yield response to water of several major crops, making it particularly useful for regions concerned with water management and the impacts of climate change on agriculture.

AquaCrop's applicability in the WB region is supported by its successful use in various research projects within the economies , its ability to operate with limited climatic and crop data, and its focus on water, which is a critical factor for crop production in the region. The model's simplicity and the provision of training by the FAO enhance its suitability for economies in the Western Balkans, aiming to integrate crop modelling into economies agricultural and climate change adaptation strategies.

6.5. Analysis of extreme weather events

There is high confidence that extreme weather events, such as drought, floods, late spring frost, hail, etc. will become more frequent and more severe in the future. Each WB economy experiences a variety of extreme weather events, such as droughts, floods, late spring frosts, hailstorms, and high-temperature events, which have been increasingly affecting crop production and productivity. A summary by economies is provided below.

- **Albania** reports an increase in extreme heat days and night heat events, with significant agriculture damages from floods, frosts, and hailstorms.
- **Bosnia and Herzegovina** faces droughts, floods, frosts, and hail, with notable droughts in 2000 and 2003 causing extensive agricultural damage.
- **Kosovo*** highlights hailstorms as frequent, especially in vineyard regions, affecting crops like apples, grapes, and peppers.
- **Montenegro** observes a decrease in cold days and an increase in hot days, heatwaves, and variable precipitation leading to floods and droughts.
- **North Macedonia** mentions a lack of systematic recording of weather extremes affecting agriculture, with media reports highlighting various events. However, drought is a regular event almost every year, and media are less interested in reporting on it, only in the most severe cases.
- **Serbia** identifies droughts and high temperatures as the most significant threats to agriculture, emphasizing the need for systematic data collection on damages.

The following table contains extreme events and their appearance based on datasets used by each economy for the preparation of economies reports.

Table 6.6. Extreme weather events reported by economies experts (the table does not represent all extreme events, nor their exact number, just a basic expert view of the problem)

Economy	Extreme weather events
Albania	Drought (2018), floods (various years including 2022, 2018, 2015, 2010, 2005, 2002, 1995-1996, 1962-1963)
Bosnia and Herzegovina	Floods (various years including 2014, 2010, 2004, 2001), drought (2000, 2003, 2007, 2011, 2012, 2013, 2015-2019), hail (2003-2010)
Kosovo*	Hail (2013, 2016-2017, 2023), floods (2021), drought (2009-2015), spring frosts (2016, 2017), high temperatures (2017-2021)
Montenegro	Floods (2010, 2012, 2022), low temperatures and wind (2017), stormy wind (2019), wet snow (2021), hail (2022), drought (2022), heatwaves (various years)
North Macedonia	Spring frosts (2017-2022), hail (2016-2023), drought (2015, 2020, 2021, 2023), varying impact on crops including fruits, vegetables, and tobacco
Serbia	(Data not reported)

Source: Economies reports (Volume II)

Based on the provided data, floods and droughts appear to be the most frequent extreme weather events across the Western Balkans. These events have been reported in multiple economies , indicating a regional vulnerability to water-related extremes, both in terms of excessive water and its scarcity. This pattern aligns with broader trends in climate change, where increasing temperatures and shifting precipitation patterns intensify the frequency and severity of both floods and droughts.

6.6. Most important crops sensitive to climate change in WBE

The economies reports provide an overview of the sensitivity of key agricultural crops to climate change across six Western Balkan economies : they highlight the importance of understanding which crops are the most vulnerable to changing climate conditions to design effective adaptation measures. Some economies emphasize the lack of specific studies due to challenges in accessing reliable data. Moreover, water limitation, shifts in growing seasons and increased risks from extreme weather events are considered the biggest drivers that will negatively impact crop production in WBE.

However, each economy has very specific approach to the determination of the most sensitive crops:

- **Albania** focuses on a variety of main crops without specific sensitivity analysis due to data access issues.
- **Bosnia and Herzegovina** mentions both benefits and threats from climate change, with small-scale agriculture being particularly vulnerable.
- **Kosovo*** lists specific crops highly sensitive to climate variations, with efforts underway to adapt, particularly in viticulture.
- **Montenegro** details the impact of climate change on dominant crops, noting significant yield reductions due to adverse weather.
- **North Macedonia** discusses the cultivation of a wide range of crops, highlighting water scarcity as a major limitation that will be exacerbated by climate change.
- **Serbia** provides a detailed analysis of vulnerable crops, with a focus on the sensitivity of fruit production and annual crops to climate extremes.

In total economy reports address a total of 20 crops as important crops and/or as crops sensitive to climate change (see Table 6.7).

Table 6.7. Crops sensitive to climate change listed in economies reports

Crop	Economies reported	Number of economies reported
Grapevine	Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, Serbia	6
Wheat	Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, Serbia	6
Apple	Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, Serbia	6
Maize	Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, Serbia	6
Pepper	Albania, Bosnia and Herzegovina, Kosovo*, North Macedonia, Serbia	5
Plum	Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia	4
Alfalfa	Albania, Bosnia and Herzegovina, Montenegro, North Macedonia	4
Raspberries	Bosnia and Herzegovina, Kosovo*, Serbia	3
Tomato	Albania, Bosnia and Herzegovina, North Macedonia	3
Potato	Bosnia and Herzegovina, Montenegro, North Macedonia	3
Clover and mixtures	Bosnia and Herzegovina, Montenegro	2
Onion	Albania, Bosnia and Herzegovina	2
Watermelon	Albania, Montenegro	2
Soya	Bosnia and Herzegovina, Serbia	2
Barley	Bosnia and Herzegovina, North Macedonia	2
Olive	Albania	1
Cabbage	Bosnia and Herzegovina	1
Strawberry	Bosnia and Herzegovina	1
Sugar beet	Serbia	1
Sour cherry	Serbia	1

Source: Economies reports (Volume II)

The crops identified as sensitive across all six economies include grapevine, wheat, apple, and maize. This commonality suggests that regional efforts should focus on these crops for developing shared research, technology transfer, and adaptation practices. Other crops, such as peppers, plums, alfalfa, raspberries, tomatoes, and potatoes show sensitivity in fewer economies but still represent significant agricultural interests. These require tailored approaches based on local climate risks and agricultural practices. Moreover, several crops are reported by one (five crops) or two (five crops) economies . These crops are maybe not of common interest, but are very important for economies reporting these crops, therefore economies should be supported in the development of adaptation measures for these crops as well.

Seven of the crops reported are perennial crops and crop models already used in WBE are hardly suitable for modelling such crops. Grape and apple are among the first four crops reported by all six economies . It is recommended to start capacity building for modelling purposes with maize and winter wheat, as annual crops reported by all six economies , and later capacities will increase searching for solutions and models that will be suitable for other crops.

Moreover, economy reports suggest the need for a regional approach to address shared vulnerabilities and build adaptive capacities. It is recommended to establish collaborative frameworks for research, water management, and the adoption of climate-smart agricultural practices. These measures aim to enhance resilience, reduce the adverse impacts of climate change on agriculture, and support sustainable development across the Western Balkans.

6.7. Information on vulnerable regions and crops and their combination

The overview of the vulnerability of regions and crops to climate change gives initial information on how climate change poses significant risks to agriculture based on the available information and expert judgment. The analysis focuses on specific regions within each economy, identifying key vulnerabilities and the crops most affected by climate change such as temperature increases, precipitation variations, and extreme weather events like frost, hail, and drought. However, the economies have presented different situations and levels of available information:

- **Albania** identifies lowland and coastal areas as the most vulnerable, with vegetables, grapevine, olives, and cereals being the most affected crops. Climate change is expected to cause shifts in marketing windows, damage product quality, and reduce precipitation, except in the Shkodra region prone to floods.
- **Bosnia and Herzegovina** divides the economy into four agroecological areas with different vulnerabilities. Issues include heavier precipitation leading to erosion, dry summer periods causing forest fires, and temperature rises affecting greenhouse vegetable production, vineyards, and various perennial crops.
- **Kosovo*** notes frequent hail and spring frosts in the Dukagjin District, affecting vegetables, apples, plums, grapes, raspberries, blackberries, peppers, walnuts, cherries, sour cherries, pears, beans, and corn.
- **Montenegro** discusses the specific vulnerabilities of different climate regions, including the impacts of spring frosts on lemons, cherries, apricots, peaches, and the challenges of excessive rainfall and late spring frosts on potatoes and other fruit species.
- **North Macedonia** identifies the most vulnerable areas and crops, with a focus on the Central Vardar Valley, southeast part, Southern Vardar Valley, Skopje-Kumanovo Region, and Ovche Pole Region. Sensitive crops include grapes, tomatoes, peppers, winter wheat, and alfalfa.
- **Serbia** details the vulnerability and risk assessment for plant production, highlighting the impacts and consequences of climate hazards like excess heat, water, storms, and the specific risks related to water deficits in fruit growing and irrigation needs.

Agriculture's sensitivity to climate change is a common theme across the Western Balkans, with specific regions and crops facing unique challenges. It is important to conduct serious research to understand these vulnerabilities and to design effective adaptation measures suitable to different climates, soils, and other crop growth factors prevailing in the region.

Table 6.8. Regions and crops sensitive to climate change listed in economies reports

Economy	Vulnerable regions	Vulnerable crops
Albania	Lowland and coastal areas, Shkodra region	Vegetables, grapevine, olive, cereals
Bosnia and Herzegovina	High karst areas, lower Herzegovina, central hilly-mountainous area, lowland hilly area	Vegetables (greenhouse), vineyards, various perennial crops, fruits like plums, apples, pears, raspberries, strawberries, and various cereals
Kosovo*	Dukagjin District	Vegetables, apples, plums, grapes, raspberries, blackberries, peppers, walnuts, cherries, sour cherries, pears, beans, corn
Montenegro	Mediterranean climate area, areas with a continental climate	Lemon, cherry, apricot, peach, early potatoes
North Macedonia	Central Vardar Valley, southeast part, Southern Vardar Valley, Skopje-Kumanovo Region, Ovche Pole Region	Grape, tomato, pepper, winter wheat, alfalfa
Serbia	Vojvodina, south of Sava and Danube, Braničevski, Zaječarski, *Šumadijski*, etc.	Fruit crops with high water demand, maize, potentially wheat

Source: Economies reports (Volume II)

The table clearly shows that there are regions within each economy that are particularly vulnerable to the impacts of climate change, along with the crops that are most at risk. This information is crucial for planning and implementing effective adaptation measures to mitigate the effects of climate change on agriculture in these areas. There is need for tailored adaptation strategies that consider the specific vulnerabilities of each region and crop to ensure the sustainability of agricultural practices and livelihoods in the face of climate change.

6.8. Practices used by farmers to protect crops from weather variability damages

Farmers in the region are very experienced and have gained very good insight in their specific field/crop combination. They have grown their crops in various meteorological conditions (wet and dry years, cold and hot years, etc.) and experienced various extreme weather events. Over the years they successfully developed and adapted their technologies according to the conditions in each season. Therefore, farmers can significantly contribute to the design of adaptation measures and practices suitable for the region and crops they are experienced in.

Table 6.9. Practices used by farmers to protect crops from weather variability damages

Economy	Main concerns	Practices
Albania	Temperature stress, water quality, drainage, extreme weather events	Covering watermelons with hay, substituting groundwater with reservoir or spring water
Bosnia and Herzegovina	Lack of awareness of climate change, reliance on 'good-bad year' approach	Modern orchards with irrigation and protective netting, subjective irrigation assessments
Kosovo*	Hotter weather and intense sunlight	Greenhouse slaked lime, shading nets for vineyards with state co-financing
Montenegro	Impact of climate change through water	Increased irrigation, water-soluble fertilizers, greenhouses, agrotextiles, later potato planting, anti-hail and shading nets
North Macedonia	Weather variability and climate change effects	Covering grapes, using nets/lime on tunnels, mulching, green cover, controlling water flow with bottles, hail nets, drip irrigation
Serbia	Weather variability and extremes beyond current experience	Selecting hybrids/varieties, agrotechnical measures, nets for protection, implementing irrigation, advisory services information

Source: Economies reports (Volume II)

The table underscores a wide range of adaptive practices undertaken by farmers to mitigate the impacts of climate variability and change, from traditional methods to modern technologies.

Moreover, economies reports highlight some challenges, including lack of systematic monitoring, the need for better awareness, and the importance of state support and education in adopting effective climate-adaptive agricultural practices.

6.9. Climate change adaptation measures and practices related to climate change adaptation in agriculture

This section highlights economies efforts and tested practices to address climate change impacts. Each of the WBE has developed specific strategies to combat the impacts of climate change on agriculture, ranging from promoting sustainable practices and renewable energy to investing in infrastructure and technology.

Albania focuses on increasing farmers' access to technology and information for climate adaptation, including capacity-building for research and extension services, targeted to promoting superior agronomic practices directly on farms and sustaining yields in the face of more frequent instances of extreme water stress. Moreover, adaptation measures mentioned in economies reports are oriented towards improving the capacities of IGEO to disseminate hydrometeorological information and of Agriculture Technology Transfer Centres (ATTC) to enhance soil data collection and disseminate soil data, drainage data, and crop suitability data. Encouraging private sector involvement for efficient climate adaptation is also emphasized.

Bosnia and Herzegovina details the government's commitment to adaptation measures, such as improved water management, investments in irrigation, and development of new farming systems suitable for the changing climate. An ambitious plan targets vulnerable areas for intensive agricultural production, particularly in the Mediterranean region and northern lowlands.

Kosovo* addresses the impact of climate change on crops and food security through the Climate Change Strategy and the Strategy for Agriculture and Rural Development. Notably, it discusses the lack of promotion of good practices for climate change adaptation, including the use of cover crops, no-till or minimum tillage, crop diversification and rotation, and others. Direct payments are not tied to any environmental conditions and absence of agri-environmental measures, despite large pastures and low-input cropping systems providing some effectiveness against climate change. Direct measures presented in the economies report are solar energy systems on farms, anti-hail systems, drip and sprinkler irrigation, and introduction of minimum tillage practices.

Montenegro outlines number of policy documents addressing the climate change already adopted, including the key National Strategy for Climate Change Management until 2030, and the preparation of the National Climate Change Adaptation Plan (NAP) that includes the agriculture sector as high priority. 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.

North Macedonia foresees measures related to water management, as rehabilitation of irrigation schemes and increasing water use efficiency at farm level in the National Strategy for Agriculture and Rural Development. However, the Strategy includes adaptation measures from a project supported by USAID, including anti-hail/UV protective nets, drought-tolerant rootstocks, increased depth of planting fruits rootstock and implementation of water absorbent materials, changes in pruning techniques, use of protective materials against sunburns, mulching with peat and sawdust, using plastic bags for vegetable production, efficient water management techniques, such as drip fertigation for fruit growing, vineyards, and vegetable cultivation.

Serbia outlines national adaptation measures for agriculture in the Programme for Adaptation to Climate Change for 2023-2030, along with its Action Plan for 2024-2026. This document extensively assesses vulnerabilities and risks across sectors, with a detailed focus on agriculture, offering national-level adaptation measure recommendations. Key priorities for crop production adaptation include increasing national budget investments for anti-hail, shading nets, and anti-frost systems to protect perennial crops from extreme weather. It also proposes optimizing irrigation based on needs and resources, including the potential use of atmospheric water and existing large ponds, and enhancing the capacity and knowledge for adapting agricultural production to climate change through the development of manuals, advisor education certification, and production zoning methodologies under climate change conditions. Furthermore, it emphasizes improving agrometeorological services to bolster agricultural resilience by increasing measurement stations and developing new forecast products for efficient dissemination.

The economies reports listed several measures and a summary is presented below in Table 6.10. Even though these measures are not listed as climate change-related measures, they can be highly beneficial for climate change, especially when such measures build adaptive capacities and increase agricultural system resilience to climate change.

Table 6.10. Examples of measures from economies agricultural policies related to climate change adaptation

Economy	Measures
Albania	• Emphasizes efficient, innovative agriculture and fisheries sector resilience to climate change. • Introduces measures to increase carbon content in soil, sustainable practices, and the use of agricultural waste. • Supports new agricultural technologies or seed variety adaptation and water basin management plans.
Bosnia and Herzegovina	• Aligns objectives with the EU Common Agricultural Policy (CAP). • Focuses on adaptation measures like organic production, irrigation, and hail protection systems. • Financial support allocated for the modernization of farms, technical assistance, soil amelioration, and farmer education.
Kosovo*	• Aims to facilitate climate adaptation in agriculture with protective nets and solar systems for renewable energy production. • Urges the integration of climate change mitigation and adaptation measures into the national development strategy.
Montenegro	• Supports producers for climate change adaptation with funds for irrigation systems, anti-hail nets, greenhouses, etc. • Includes support for the application of innovative technologies and practices, sustainable use of autochthonous species, and production insurance.
North Macedonia	• Provides support for crop insurance, Areas with Natural Constraints, and investments in irrigation and drainage infrastructure. • Encourages research, education, and the dissemination of knowledge essential for adaptive capacity building.
Serbia	• Focuses on systematic inclusion of climate change adaptation through national policy documents. • Subsidizes equipment and education to address current problems, emphasizing the need for measures tailored to climate change needs.

Source: Economies reports (Volume II)

These efforts reflect a commitment to adapting to climate change, enhancing agricultural resilience, and ensuring food security in the face of evolving environmental challenges. The common measures listed above reflect a regional recognition of the key challenges posed by climate change to agriculture and a collective effort towards implementing strategies that enhance resilience, sustainability, and adaptability within the sector.

Based on the above, we can conclude that there is a clear focus across WBE on enhancing agricultural resilience through technology, information dissemination, improved water management, and the development of climate-adapted farming practices. Each economy's approach reflects a commitment to mitigating the impacts of climate change and ensuring sustainable agricultural development. Moreover, the document showcases several common adaptation measures and practices across the economies discussed, aimed at addressing the impacts of climate change on agriculture. Here are several measures that are highlighted by multiple economies :

- **Improving water management and irrigation systems:** All six economies emphasize the need for enhanced water management and investment in rehabilitation of the old, and construction of new irrigation systems to combat water stress and ensure efficient water use for agriculture.
- **Capacity building and access to information:** Several economies focus on engaging in capacity-building initiatives to enhance research and extension services, ensuring that farmers have access to the latest technology and information for adapting to climate change.
- **Use of protective systems:** The introduction and support for protective measures such as anti-hail and shading nets to safeguard crops from extreme weather conditions is almost a common issue considered as good adaptation measure and is usually supported through national system support to agriculture.
- **Sustainable and efficient resource management:** Encouraging sustainable management of resources, including organic production, efficient management of natural resources, and reduction of chemical dependence. This also involves promoting eco-scheme programmes for the adaptation of agriculture to climate change.
- **Support for agri-environmental practices:** Supporting agri-environmental practices like crop diversification and rotation, cover crops, no-till or minimum tillage, and other sustainable farming systems. This includes the use of anti-hail/UV protective nets, drought-tolerant rootstocks, changes in pruning techniques, and mulching.
- **Private sector involvement:** Albania encourages private sector involvement in climate change adaptation efforts, a strategy that can be inferred as beneficial for other economies in promoting innovative and resilient agricultural practices.
- **Development and promotion of climate-resilient crop varieties:** The emphasis on plant breeding programmes to develop new cultivars adapted to climate change conditions, such as drought and temperature extremes, is a measure that could be commonly beneficial, as indicated by Albania's approach.
- **Improved forecasting and agrometeorological services:** There is high confidence in all economies that the dissemination of hydrometeorological data and information (historical, real time and weather forecasts) to farmers and other stakeholders (including researchers) will significantly improve agrometeorological services, boost scientific evidence for adaptation practices and ensure timely and necessary information for increasing agricultural resilience to climate change.
- **Regulatory and policy frameworks:** Developing and implementing national strategies and programmes that include climate change adaptation measures, with specific guidelines for producers and the agriculture sector. This involves establishing climate change monitoring systems, developing methodologies for tracking climate-related damages, and creating reporting systems for adaptation measures.

Other measures with co-benefits in crop production include establishing a climate change monitoring system with a high-resolution data portal, developing and implementing a methodology for tracking climate-related damages, creating a reporting system for adaptation measures, improving national disaster risk assessment methodology to include climate change information, developing methodology for drought monitoring, enhancing Hydrometeorological Services capacities for timely dissemination of information on weather extremes and climate change, increasing public readiness for weather and climate extremes by improving forecasts and information dissemination tools, and addressing regulatory issues in land use to manage unused and degraded agricultural land sustainably. These are not very different from the measures already present and/or promoted in each of the economies . Therefore, these measures should be further developed and introduced into national policy and become part of climate change adaptation practices for the agricultural sector.

6.10. Current infrastructure and systems for preventing and mitigating the negative effects of weather extremes on crop production

The WBE have invested in various infrastructure that can be considered beneficial for climate change resilience and adaptation. Investments in irrigation systems, drainage systems, flood protection systems, hydrometeorological and agrometeorological services, extension services and many others that should be effective tools for alleviating negative effects of climate change on crop production. However, during the transition period, the infrastructure for irrigation and drainage was seriously damaged and nearly devastated, erosion control was almost neglected, institutions established for supporting the agriculture reduced their activities and services provided to farmers were at a low level of satisfaction among their end users. After crises, conflicts and difficult periods, a number of projects for rehabilitating this infrastructure were conducted in almost all of the WBE. However, the need for rehabilitation, modernization and capacity building is still very prominent and urgent. The following points summarize the way these issues are addressed in economy reports.

- **Albania** has experienced increased flood and hail events, with past investments in drainage systems now compromized by lack of maintenance. Recent investments aim to mitigate flood effects, and fruit growers increasingly instal anti-hail nets. However, early-warning systems for frosts are lacking, and agricultural extension services offer limited climate risk adaptation advice.
- **Bosnia and Herzegovina** operates under a decentralized government, with entity meteorological institutes responsible for climate and crop parameter measurements. Plans include establishing an electronic platform for climate data and forming Climate Change Committees (CCCs) for monitoring and transparency in NAP implementation.
- **Kosovo*** has a network of meteorological stations covering almost its entire territory, but lacks a central data processing centre. The Environmental Protection Agency and Hydrometeorological Institute focus on protection, monitoring, and forecasting, with an imperative to enhance the agrometeorological station network for early warning.
- **Montenegro** reports no specific infrastructure for protecting against weather phenomena and weather extremes impacting crop production.
- **North Macedonia** highlights investments in irrigation systems to combat water limitations during summer, with a substantial portion of agricultural land covered by irrigation and drainage systems. Additionally, the National Hydrometeorological Service has developed an agrometeorological network providing valuable data and forecasts for agriculture.
- **Serbia** uses the Republic Hydrometeorological Institute (RHMZ) for short-term and seasonal forecasts, agricultural advisories, and monitoring, including drought bulletins. Plans include upgrading RHMZ's technical capacities for improved monitoring, forecasting, and information dissemination.

Across these analyses, a common theme emerges: the need for improved infrastructure and systems for data collection, forecasting, and dissemination, as well as enhanced capacity for climate change adaptation and risk mitigation in agriculture.

6.11. Existing data availability and quality

The data issue is quite important for further development of cooperation among Western Balkan economies in the field of climate change. The chapter on crops deals with meteorological and agro-meteorological data availability and quality, while the crop sector needs much more data for further activities, elaborated by other sub-sectors in this report, such as soil data, yield data, crop distribution, crop mask, land use, and many other datasets. All WBE are facing serious constraints and gaps in accessing meteorological data, and even more difficulties in assessing agrometeorological and phenological data. The following points address the key data constraints and gaps as reported in economies reports (Volume II):

- **Albania** struggles with low capacity to collect, generate, and provide meteorological data for agriculture. The official meteorological network covers the territory well, but data are not readily accessible for research or policymaking. IGEO is the primary institution managing climate data, yet there is need for improved data processing and maintenance capabilities.
- **Bosnia and Herzegovina** faces gaps in climate and plant production data from 1992 to 1999. The meteorological station network density is insufficient for the economy's diverse terrain. While climate data quality is good, agricultural data may not accurately reflect the actual situation due to poor record keeping.
- **Kosovo*** is in the early stages of collecting climate change and adaptation data. Data on climate parameters are limited and focused on three primary centres. Despite a comprehensive meteorological station network, there is a lack of a centralized data processing hub, making data access challenging.
- **Montenegro** reports very scarce official data on the impact of climate change on agriculture. No databases aggregate information on crop production damage or mitigation measures.
- **North Macedonia** has a well-covered meteorological network but faces challenges in data transparency for climate change analysis. High costs associated with accessing national hydrometeorological data hinder research development. Yield data is available but not in the spatial and temporal resolution required for detailed analysis.
- **Serbia** mentions that while meteorological data are monitored, phenological data are not publicly available. There is emphasis on the need to revize databases to improve the reliability and availability of data. Systematic monitoring of pests and diseases is recommended but not yet fully planned.

Across these economies , there are common issues regarding data accessibility, gaps in historical data, insufficient spatial and temporal resolution of available data, and high costs associated with data acquisition, which complicates climate change research and adaptation planning in agriculture. This will be further enhanced by access to other datasets required and the recommendation is to use international readily available datasets for immediate start with national/regional capacity building of researchers and research teams that should provide scientific-based evidence for adaptation of the crop sector to climate change.

7. Livestock farming analysis linked to climate change adaptation in agriculture in WBE

7. Livestock farming analysis linked to climate change adaptation in agriculture in WBE

7.1. Livestock farming and climate change adaptation in WBE

Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, Macedonia, and Serbia exhibit diverse agricultural landscapes, each with unique characteristics, challenges, and trends. In Albania, agriculture contributes significantly to the GDP, with a diverse range of products including dairy, meat, and poultry. However, economic disparities persist, particularly between rural and urban areas. Challenges such as land fragmentation hinder modernization efforts, while rural emigration exacerbates labour shortages. Livestock farming is significant in Bosnia and Herzegovina, with milk, dairy, and meat production being the key sectors. Fluctuations in livestock numbers are observed, with challenges including inadequate breeding practices and vulnerability to climate change. Economic disparities and rural emigration further compound these challenges. Kosovo*'s agricultural sector is characterized by small-scale livestock farming, with dairy cows comprising a significant portion of the cattle stock. Fragmented land ownership and declining agricultural importance are common challenges. Climate change, particularly heat stress, poses a threat to livestock farming, necessitating adaptation efforts. Livestock farming plays a crucial role in Montenegro's agricultural landscape, with dairy cattle predominant. However, there is a decline in cattle, sheep, and horse populations, while pig, goat, and poultry numbers are increasing. Land fragmentation and climate change impacts such as heat stress present challenges to the sector. In North Macedonia, small-scale farms dominate livestock farming, with a focus on dairy cattle, pigs, small ruminants and poultry. Economic disparities and rural emigration affect the sector, while climate change poses challenges such as heat stress. Efforts to adapt include investments in larger, more resilient farming operations. Serbia's agricultural sector is diverse, with cattle production dominant and both extensive and intensive production systems in place. Economic disparities and rural emigration impact the sector, while climate change exacerbates challenges such as heat stress. Policy support and investment opportunities are recognized as essential for addressing agricultural challenges and enhancing resilience.

Despite the differences, certain cross-cutting themes and harmonized patterns emerge across these economies ' agricultural sectors.

Economic indicators: While the contribution of agriculture to GDP varies, all economies rely on it as a significant economic sector. Agriculture plays a crucial role in sustaining livelihoods, particularly in rural areas where employment opportunities are limited. Economic disparities persist, with certain regions experiencing higher poverty rates and lower economic development.

Livestock farming: Livestock farming is significant across the region, with milk, dairy, meat, and poultry being major products. While there are fluctuations in livestock numbers, poultry production generally shows growth compared to other livestock categories. Both extensive and intensive production systems coexist, with small farms dominating the landscape but larger, more intensive operations emerging. Common challenges include inadequate structure of livestock breeds, inefficient breeding practices, and vulnerability to climate change impacts such as heat stress.

Agricultural challenges: Fragmentation of land ownership is a common challenge, hindering economies of scale and modernization efforts. The share of agriculture in GDP is declining in most economies , signalling a shift towards other sectors. Rural areas face challenges associated with emigration, leading to labour shortages and demographic shifts.

Climate change impact: Climate change, particularly heat stress, poses a significant challenge to livestock farming across the region. Efforts to adapt to climate change include investments in larger, more resilient farming operations and the adoption of innovative technologies.

Policy implications: There is a growing recognition of the need for supportive policies to address agricultural challenges, promote modernization, and enhance resilience. Despite challenges, agriculture presents investment opportunities, especially in improving infrastructure, technology adoption, and market access.

Data availability: While meteorological data is collected, challenges remain in terms of data accessibility and transparency, hindering effective decision making and planning. Greater cooperation and collaboration among institutions and stakeholders is necessary to improve data sharing and access.

By recognizing these commonalities and working together, policymakers and stakeholders can develop more coordinated and effective strategies to address shared challenges and capitalize on opportunities in the agricultural sector across the region.

7.2. Extreme weather events in WBE related to the livestock sector

The Balkan Peninsula faces a formidable challenge in contending with the escalating frequency and intensity of extreme weather events. Climate change has exacerbated these phenomena, placing immense strain on various sectors, including agriculture and livestock farming. This study endeavours to highlight the impact of extreme weather events on livestock within WBE, elucidating the challenges encountered and the imperative for enhanced monitoring and mitigation strategies.

The climatic conditions prevailing in **Albania** render the nation highly susceptible to a spectrum of extreme weather events, including floods, droughts, heat waves, and storms. Over recent years, these occurrences have heightened both in frequency and intensity, a phenomenon widely attributed to climate change. The consequential impact on livestock within Albania has been pronounced, although comprehensive data shedding light on the extent of these impacts may be lacking.

Similarly, **Bosnia and Herzegovina** has contended with a succession of extreme weather phenomena over the past decade, ranging from floods to droughts, heat waves, and hailstorms. The catastrophic floods of 2014, which inflicted significant damage across a vast area, serve as a poignant example of the severity of the prevailing conditions. Despite the substantial economic ramifications incurred by the agricultural sector, lack of systematic monitoring and data collection pertains to the specific impact on livestock farming.

Kosovo*, akin to its regional counterparts, has encountered a series of extreme weather disasters, including floods, wildfires, and droughts. These events have become an increasingly commonplace occurrence, with resultant material damage, particularly within the agricultural domain. Nonetheless, a conspicuous absence persists regarding a comprehensive monitoring framework for extreme weather events within the livestock sector, thereby impeding the capacity to gauge and mitigate their repercussions effectively.

Montenegro, too, has documented an array of extreme weather events that have exerted direct or indirect influence on livestock farming. Heat waves, droughts, and floods have each exacted their toll, resulting in diminished yields and quality of forage for grazing and winter feeding of ruminants. Despite governmental initiatives aimed at addressing these challenges, lack of systematic monitoring of the impact of extreme weather conditions on animal husbandry persists.

North Macedonia is faced with similar challenges, with extreme weather events posing significant risks to agriculture, including livestock farming. However, deficiencies in data transparency and monitoring mechanisms preclude endeavours aimed at accurately quantifying the impact on livestock farms.

Finally, in **Serbia**, the frequency of extreme weather events has escalated, leading to substantial economic repercussions. While the Republic Hydrometeorological Institute keeps records of extreme climatic events and anomalies, comprehensive data pertaining to the impact on livestock farms remain elusive.

Across the Western Balkan region, extreme weather events have become increasingly prevalent, exacting significant tolls on livestock farming. Floods, droughts, heat waves, and storms have ravaged agricultural landscapes, resulting in diminished yields, compromised animal welfare, and economic hardship for farmers. Despite sporadic governmental initiatives and efforts of meteorological agencies, systematic monitoring of these events remains deficient, hindering accurate assessment and effective mitigation strategies. Urgent action is warranted to bolster resilience within the livestock sector, necessitating comprehensive data collection, enhanced monitoring mechanisms, and targeted interventions to mitigate the impact of climate change on livestock farming in the Western Balkans.

7.3. Heat stress risk assessment for ruminants, pigs and poultry in WBE

The Western Balkans region faces significant challenges, particularly concerning the livestock sector, which is vulnerable to the impacts of climate change. Heat stress, changes in precipitation patterns, and emerging diseases pose threats to livestock health, productivity, and overall sustainability. In response to these challenges, efforts are underway to assess the extent of climate impacts on livestock and develop effective adaptation strategies. The current state of heat stress assessment in livestock explores initiatives, limitations, and recommendations associated with temperature-humidity index (THI) calculations.

In **Albania**, the Institute of Meteorology, Hydrology, and Seismology (IMHS) is engaged in calculating the temperature-humidity index (THI), a critical parameter for assessing heat stress in livestock. Systematic monitoring of extreme weather effects on livestock is lacking, but initiatives aim to improve data collection and analysis. Despite the lack of studies on climatic stress effects on livestock, there is growing recognition of the need for enhanced data collection and analysis to inform effective adaptation strategies. Nevertheless, efforts to improve data collection and analysis capabilities are ongoing, reflecting growing recognition of the need to address climate-related challenges in the livestock sector. Initiatives aimed at enhancing data availability and promoting collaboration among relevant stakeholders are essential for informed decision-making and the development of adaptive measures.

In **Bosnia and Herzegovina**, the agricultural sector faces significant challenges posed by climate change, particularly regarding its impact on livestock. Heat stress and the availability of fodder are major concerns, with changing temperature and precipitation patterns exacerbating these issues. Additionally, the emergence of new exotic animal diseases correlates with shifting climatic conditions, highlighting the interconnectedness between environmental factors and livestock health. Despite these challenges, current practices do not fully utilize THI modelling, and there is a notable absence of research in this area. To address these gaps, recommendations include the implementation of pilot projects, educational initiatives to raise awareness among farmers, and the establishment of an early warning system to mitigate climate-related risks.

In **Kosovo***, observations reveal thermal stress in animals, particularly in cattle, underscoring the need for effective mitigation strategies in animal husbandry practices. While efforts to construct ventilated barns and promote traditional practices such as seasonal sheep migration show promise in reducing heat stress, the utilization of THI remains limited. Establishing a regular system for monitoring microclimatic parameters is identified as a crucial step towards enhancing livestock welfare and resilience to climate variability.

Montenegro faces adverse effects of heat stress on farm animals, impacting their health, productivity, and product quality. Despite the recognized importance of THI monitoring, particularly in dairy and beef cattle farming, systematic data collection and monitoring efforts are lacking. To address this gap, there is a pressing need for regular monitoring of microclimatic parameters on farms to better understand and mitigate the consequences of heat stress on livestock.

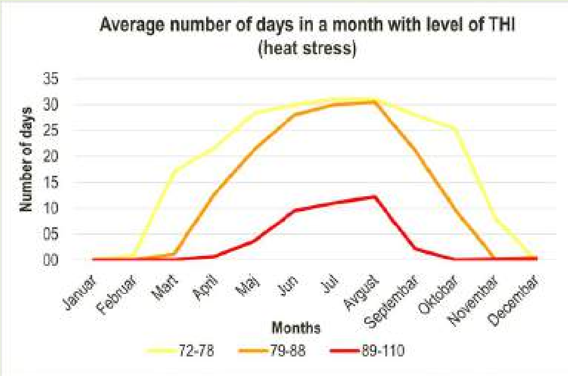
In **North Macedonia**, a comprehensive assessment of heat stress in livestock is underway, utilizing THI calculations under various climate scenarios. Projections indicate a significant increase in heat load, leading to economic losses in cattle and pig production. To improve the accuracy and relevance of these assessments, enhanced modelling and data resolution are recommended, enabling stakeholders to develop targeted adaptation strategies that effectively address climate-related challenges in the livestock sector.

In **Serbia**, despite THI usage in livestock assessment, systematic recording and monitoring are deficient. Research indicates substantial losses in milk production due to heat stress, highlighting the urgent need for improved monitoring and adaptation strategies. Moreover, climate change exacerbates heat stress and facilitates the spread of atypical animal diseases, underscoring the importance of enhancing monitoring efforts to safeguard livestock health and sustainability.

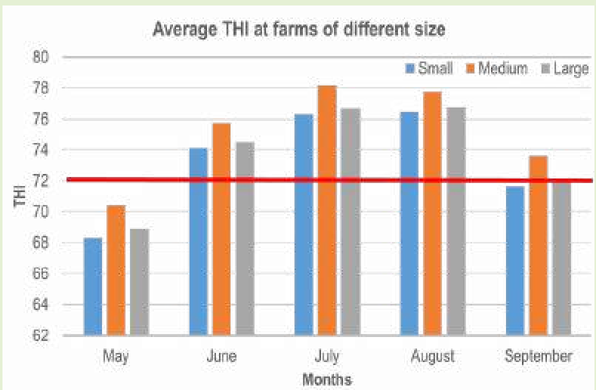
Box 3. Heat stress monitoring in dairy farms in Serbia

Dairy cattle are susceptible to heat stress, a condition often quantified through the temperature-humidity index (THI), which combines ambient temperature and relative humidity. The THI serves as the primary metric for assessing heat stress levels in dairy cattle, with a threshold value of 72 and above indicating significant heat stress, while the range of 68 to 72 represents a risk zone.

Data pertaining to temperature (t°C) and relative humidity (RV%) are recorded at 60-minute intervals utilizing data-loggers (AMTAST, AMT-116) installed within stall-barns. This data collection spans from March 2014 to April 2021 across twelve farms, evenly divided between two breeds, Holstein-Friesian (HF) and Simmental. These farms exhibit varying capacities categorized as small (<20 cows), medium (21-50 cows), and large (>50 cows), and utilize different cattle housing methods including free stall and tie stall arrangements.



Observations reveal an escalation in THI during the summer period, wherein severe heat stress lasting over 21 days is noted from May to October. Moreover, very severe to lethal heat stress, spanning between 10 and 12 days, is observed primarily in June through August, with peak occurrences in August. During periods of moderate and severe heat stress, lasting 31 days, very severe to lethal heat stress persists for 12 days.



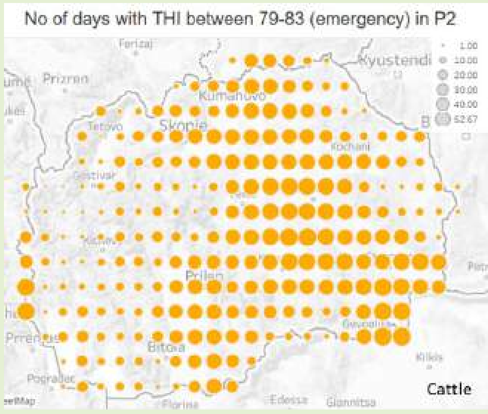
Research indicates that the impact of heat stress is particularly pronounced on medium-sized farms, which have not adjusted their animal population to the capacity of the stall-barn. This observation aligns with data from the 2012 Census of Agriculture in Serbia, which indicates that over 95% of livestock farming farms are classified as small or medium in size.

It is observed that farmers often seek to enhance milk production by increasing cattle numbers, yet expansion in production is frequently undertaken without commensurate adjustments to stall-barn capacity. This lack of synchronization between herd size and housing infrastructure exacerbates the harmful effects of heat stress on dairy cattle welfare and productivity.

Box 4. Assessment of Heat Stress Impacts on Dairy Cattle and Pigs under RCP 4.5 Scenario in Three Periods: A Case Study in the Republic of North Macedonia

The intensification of climate change poses significant challenges to livestock farming systems globally. Heat stress, exacerbated by rising temperatures and altered weather patterns, adversely affects animal welfare and productivity. A recent study focuses on evaluating the impacts of heat stress on dairy cattle and pigs under the RCP 4.5 scenario in the Republic of North Macedonia across three distinct time periods. Daily temperature-humidity index (THI) data were analyzed to compute annual THI loads for dairy cattle and pigs across three periods: 1986-2015 (P1), 2016-2045 (P2), and 2046-2075 (P3). THI threshold values were categorized into alert, emergency, and dangerous phases, with respective thresholds of 74-78, 78-83, and above 83. Spatial variations in THI loads were examined across different regions of the economy.

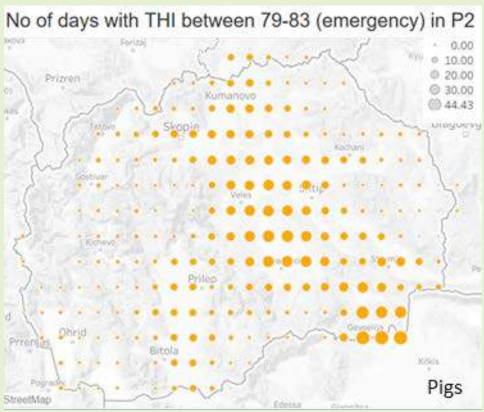
The study reveals that the intensity and duration of heat stress episodes vary across time periods and livestock categories. In dairy cattle, it is observed that specific cattle (THI) values exhibit variations across different time periods. During the period 2016-2045, the highest annual THI load surpassing the alert phase threshold (THI of 74-78) is estimated to extend for approximately 62 days. Furthermore, the emergency phase (THI of 78-83) persists for 30 days, representing an increase of 6 days compared to the average duration observed between 1986 and 2015. Additionally, the dangerous phase, characterized by THI values exceeding 83, is projected to last 7 days. An evident increase in the number of days surpassing the emergency phase threshold is anticipated over time. Regions experiencing prolonged emergency phases include those along the Vardar River, Pelagonia, and the areas surrounding Kumanovo and Strumica. Moreover, the emergency phases exceeding 50 days are also anticipated in regions such as Ovche Pole, Kochani, and Radovish.



In the case of pigs, THI loads for all categories are expected to be the lowest during Period 1 and increase progressively in Periods 2 and 3. During Period 2, the estimated average annual THI load for the alert phase (THI of 74-78) is projected to encompass approximately 34 days. Moreover, the emergency phase (THI of 78-83) is anticipated to persist for 11 days, which is 3 days longer than the average observed between 1986 and 2015.

Additionally, the dangerous phase, characterized by THI values exceeding 83, is forecasted to last for 3 days. Spatial analysis indicates an augmentation in the number of days surpassing the emergency phase threshold over time, with a more pronounced increase observed in low-lying regions. The emergency phases are anticipated to be more prevalent along the Vardar River and in regions such as Kumanovo, Ovche Pole, Radovish, and Strumica, while their occurrence in Pelagonia is expected to be comparatively less pronounced. Furthermore, emergency phases lasting over 30 days are projected to occur.

In conclusion, proactive adaptation measures are essential to mitigate the adverse impacts of climate change on livestock farming in North Macedonia. By implementing these recommendations, stakeholders can enhance resilience and sustainability in the face of escalating heat stress events.



(Source: Sectoral report on agriculture and forestry prepared for the development of the Fourth National Plan on Climate Change, North Macedonia, THI, Andonov et al., 2021)

The assessment of heat stress risk for ruminants, pigs, and poultry across several Balkan economies reveals common challenges and varying levels of preparedness. In Albania, limited accessibility to temperature-humidity index (THI) data hinders systematic monitoring of extreme weather effects on livestock, though efforts to enhance data collection and analysis are underway. Bosnia and Herzegovina faces threats to livestock from heat stress and emerging diseases due to climate change, yet lacks THI modelling and research. Similarly, Kosovo* observes thermal stress in animals but has yet to implement THI monitoring, emphasizing the need for microclimatic parameter monitoring on farms. Montenegro experiences heat stress impacts on livestock but lacks THI monitoring, necessitating regular microclimatic parameter monitoring. North Macedonia conducts comprehensive THI-based assessments, projecting economic losses in livestock farming due to increased heat load. In Serbia, despite THI usage, systematic recording and monitoring are lacking, highlighting the need for improved strategies to address heat stress and atypical diseases in domestic animals across the region.

In conclusion, effectively addressing heat stress and atypical diseases in domestic animals necessitates improved monitoring, data accessibility, and adaptation strategies to mitigate climate change impacts on livestock health and production throughout the region.

7.4. Existing farmers' adaptive practices in livestock farming in WBE

Livestock farming across the Western Balkans faces significant challenges due to extreme weather conditions, including periods of intense heat. In response, farmers in these regions have been implementing various strategies to mitigate the impacts of heat stress on their animals and ensure optimal conditions for their well-being and productivity.

Livestock farmers in **Albania** prioritize strategies aimed at ensuring adequate water intake and optimizing shelter conditions for their animals. Investments in stable construction focus on providing shade and ventilation, with some farmers even incorporating showers within stables to aid with cooling during periods of extreme heat. Shepherds adapt grazing practices to ensure small ruminants have access to water sources and natural shade, thus minimizing heat-related stress.

Similarly, in **Bosnia and Herzegovina**, despite the absence of official incentives, some farmers independently invest in ventilation and cooling systems to mitigate extreme temperature impacts on their livestock. Poultry farms prioritize temperature and humidity control to maintain optimal conditions for bird health and productivity. However, there is recognition of the need for education and government support to facilitate broader adoption of adaptation measures.

Efforts to enhance microclimatic conditions within livestock farms are underway in **Kosovo***, with support provided for model stable construction aimed at improving ventilation and thermal comfort. Dairy farms prioritize the installation of ventilation systems and the adoption of advanced feeding practices to support animal health and productivity. Small-scale breeders adapt their management practices by grazing animals near water sources and using natural shade to minimize heat stress.

Livestock farmers in **Montenegro** invest in modern barns equipped with ventilation systems to optimize airflow and reduce heat stress among animals. Some farms employ cooling mechanisms such as spraying water on livestock during periods of high temperatures. Seasonal migration of flocks to mountain pastures is also practiced to mitigate heat stress during the summer months. Commercial poultry farms employ advanced temperature regulation systems to maintain optimal conditions for bird welfare and performance.

Large dairy farms in **North Macedonia** prioritize the implementation of ventilation and cooling systems to mitigate heat stress among dairy cattle. Smaller farms emphasize natural shading and watering practices to provide relief to livestock during periods of extreme heat. Pig farms adopt various cooling measures, while poultry farms adjust population density and feeding practices to minimize heat stress and maintain productivity.

Livestock farmers in **Serbia** access knowledge and support for heat stress management through advisory services and training programmes. Various adaptation measures are implemented, including the installation of ventilation and cooling systems, selective breeding for heat tolerance, and adjustments to feeding practices. However, the adoption of advanced technologies such as artificial intelligence and IT solutions remains limited due to educational and structural barriers within the agricultural sector.

In summary, livestock farmers in the Western Balkan region are proactively adapting to the challenges posed by extreme weather events, such as floods, droughts, and heatwaves. By implementing strategies like ensuring adequate water intake, optimizing shelter conditions, and adopting advanced technologies, they strive to mitigate the negative impacts on their animals and maintain productivity. Despite these challenges, farmers remain committed to safeguarding animal welfare and ensuring the resilience of the livestock sector in the face of climate change. There is a recognized need for greater education, government support, and continued research to enhance the adaptive capacity of farmers and mitigate the adverse effects of heat stress on livestock farming. Through investing in these areas, policymakers and stakeholders can better support farmers in building resilience and sustaining livestock farming in the face of climate change.

7.5. National strategies and adaptation plans, reports, R&D, projects and communications to UNFCCC related to livestock adaptation to climate change

National strategies and plans for climate change adaptation play a crucial role in addressing these challenges, yet the extent to which they incorporate specific measures for livestock adaptation varies across economies . This study examines the approaches taken by each Western Balkan economy in integrating livestock adaptation into their climate change strategies and identifies gaps and opportunities for enhancing resilience within the livestock sector. By analysing the strategies and actions undertaken by these economies , valuable insights can be gained to inform future policy development and foster more effective adaptation measures for livestock farming in the region.

In **Albania**, the National Strategy on Climate Change (2016-2030) and its action plans acknowledge the importance of adaptation measures, including those relevant to livestock. However, while vulnerability assessments submitted to the UNFCCC highlight risks such as heat stress, water scarcity, and disease spread for livestock, specific interventions within the national strategy lack granularity. This implies that while the issue is recognized, there is a gap in translating this into actionable and targeted measures for livestock adaptation.

In **Bosnia and Herzegovina**, the Climate Change Adaptation and Low-Emission Development Strategy indirectly addresses livestock adaptation, but the focus remains limited. Proposed measures mainly concentrate on crop production, with insufficient involvement of livestock experts in strategy development. This suggests a missed opportunity to integrate expertise and insights from the livestock sector into adaptation planning, potentially resulting in less effective resilience measures for livestock.

Kosovo*'s approach to climate change adaptation involves mentioning adaptation in broader strategies and rural development programmes. However, specific actions for livestock adaptation are lacking, with proposed measures for agriculture being generalized and not specifically tailored to address the unique challenges faced by livestock farmers. This highlights the need for more targeted and livestock-specific strategies to enhance resilience in the sector.

Montenegro's National Strategy on Climate Change until 2030 outlines general goals for adaptation, including those relevant to agriculture and livestock. While acknowledging the significance of livestock as a source of greenhouse gases, the strategy lacks detailed analysis and specific measures for livestock adaptation. This suggests a gap in understanding the nuanced needs of the livestock sector in the face of climate change, potentially hindering effective adaptation planning and implementation.

In **North Macedonia**, although adaptation is recognized as a weakness in the national rural development programme, specific actions for livestock are lacking. While climate change mitigation and adaptation strategies include measures for agriculture, they do not appear tailored to address the specific challenges faced by livestock farmers. This indicates the need for more targeted and livestock-focused approaches to adaptation planning to ensure resilience of the sector.

Serbia stands out with its Climate Change Adaptation Programme and Strategy on Agriculture and Rural Development, which explicitly includes provisions for livestock adaptation. Furthermore, implemented projects provide thorough analyses of climate change impacts on livestock and propose specific adaptation measures. This indicates a more comprehensive and targeted approach to livestock adaptation, potentially strengthening the sector's resilience in the face of climate change.

Overall, while some economies in the Balkan region have taken steps to incorporate livestock adaptation into their climate change strategies and plans, there remains a need for more specific, comprehensive, and targeted measures tailored to address the unique challenges faced by livestock farming. Additionally, greater involvement of livestock experts in policy development and implementation is essential to ensure effective adaptation measures that enhance resilience of the sector.

In conclusion, the assessment of climate change adaptation strategies for livestock across the Balkan region reveals a diverse landscape of approaches and priorities. While some economies , such as Serbia, demonstrate commendable efforts with explicit provisions and targeted measures for livestock adaptation, others, like Albania and Kosovo*, exhibit the need for more specific and tailored interventions. Findings underscore the importance of integrating livestock expertise into policy development processes to ensure that adaptation measures are robust, contextually relevant, and effectively address the unique challenges faced by livestock farmers. Moving forward, enhancing collaboration between stakeholders, including policymakers, researchers, and livestock practitioners, is essential for developing comprehensive and targeted adaptation strategies. Additionally, greater emphasis should be placed on conducting detailed vulnerability assessments and impact analyses to inform evidence-based decision making and prioritize adaptation actions. By prioritizing livestock adaptation within climate change strategies, Balkan economies can enhance the resilience of their agricultural systems, safeguard livelihoods, and contribute to sustainable development in the face of ongoing climate challenges.

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

The political and institutional setup, along with the legislative framework for adaptation activities relevant to the agricultural sector varies across the Balkan economies .

In Albania, the Ministry of Tourism and Environment (MoTE) leads the climate change adaptation efforts, supported by various institutions such as the Inter-Ministerial Working Group on Climate Change (iMWGCC) and the Climate Change Unit (CCU). Additionally, the National Environmental Agency and other ministries, including Agriculture, Infrastructure, and Urban Development, play crucial roles in implementing adaptation policies. The legislative framework includes funding support from organizations like the Green Climate Fund and the European Union. Despite ongoing initiatives to enhance data collection and analysis regarding the impact of extreme weather events on livestock, systematic monitoring remains limited. Bosnia and Herzegovina operates as a decentralized state, with environmental management responsibilities divided between entities. While legislative competences primarily belong to the entities and Brčko District, coordination at the international level falls under the Ministry of Foreign Trade and Economic Relations. However, the existing legislative framework lacks specificity in addressing climate change impacts comprehensively, urging the need for amendments to integrate climate change adaptation into strategic plans. Kosovo*'s Ministry of Agriculture, Forestry and Rural Development (MAFRD) drives agricultural policies, supported by departments focused on various agricultural sectors. The legislative framework includes laws on agriculture, livestock, food safety, and animal welfare, emphasizing sustainable practices and animal care. Despite legislative measures, there is a need for greater emphasis on climate change adaptation including livestock in policy documents. Montenegro's Ministry of Agriculture, Forestry and Water Management (MAFWM) oversees agricultural policies and resources management. Laws on agriculture, organic farming, livestock, and veterinary activities outline measures for sustainable practices and animal welfare. However, despite the integration of climate change considerations into strategic plans and policies, adaptation to climate change, especially in livestock farming, requires more attention. North Macedonia's Ministry of Agriculture, Forestry and Water Economy (MAFWE) proposes agricultural policies and manages agricultural resources. While laws on agriculture, organic farming, livestock, and veterinary health exist, specific measures for climate change adaptation regarding livestock are lacking. Efforts are needed to integrate climate change considerations into national policies effectively. In Serbia, the Ministry of Agriculture, Forestry and Water Management oversees agricultural strategies and policies. Despite the existence of a climate change law, the legislative framework lacks specific provisions for livestock adaptation. Integration of climate change into strategic plans and documentation is emphasized, but implementation challenges remain. The Agricultural Extension Service is not fully equipped to support livestock adaptation to climate change, requiring further development and cooperation with academic institutions.

Overall, the Balkan economies , including Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, and Serbia, have established political and institutional frameworks to address climate change adaptation in the agricultural sector. Each economy has designated ministries and agencies responsible for coordinating adaptation efforts and implementing relevant policies. However, there are varying degrees of specificity and integration of livestock adaptation measures within the legislative frameworks across these economies . While some progress has been made, there is consensus that more concerted efforts and collaboration are needed to effectively address the challenges posed by climate change in livestock farming.

In conclusion, Western Balkan nations demonstrate a mixed level of readiness and action regarding climate change adaptation in the agricultural sector. While some economies have established governmental bodies and legislative frameworks to address climate change impacts, others lag behind in this aspect. There is a clear need for more comprehensive and integrated approaches that incorporate climate change adaptation into agricultural policies, spatial planning, and resource management strategies across all Balkan economies . Additionally, enhancing capacity building, research, and extension services will be crucial for effectively implementing climate adaptation measures in the agricultural sector. Collaboration with international organizations and funding mechanisms also plays a vital role in supporting these efforts. Overall, concerted action at the national and regional levels is essential to ensure agricultural resilience and sustainability in the face of climate change challenges in the Balkans.

7.7. Identification of data gaps and availability for livestock farming adaptation to climate change assessments in WBE

Albania demonstrates a comprehensive collection of materials, including national strategies, adaptation plans, reports, and projects concerning climate change. However, predominant focus on mitigation measures rather than adaptation is notable across these documents. While meteorological data exist, their accessibility to relevant stakeholders is limited, thereby impeding effective planning and decision-making processes. Moreover, significant gaps persist in data availability and quality concerning the specific impacts of climate change on livestock farming. These deficiencies relate to various crucial aspects, including lack of information on adaptive practices employed by farmers, associated costs and benefits of such practices, vulnerability of livestock farming systems, and prioritization of research on climate change impacts. Addressing these gaps is paramount for devising robust adaptation strategies aimed at bolstering the resilience of Albania's livestock sector in the face of evolving climate-related challenges.

In **Bosnia and Herzegovina** climate parameters recommended for monitoring by the National Adaptation Plan (NAP) are available, but there is a lack of official data on relative humidity and losses in the livestock sector due to extreme weather events. Insufficient interest and cooperation among government employees and ministries hamper the development of concrete instruments for monitoring sustainable measures adopted by farmers and losses in the livestock sector.

Kosovo* lacks specific data on livestock adaptation to climate change, and there is limited understanding of climate change impacts among extension services and Agricultural Technology Transfer Centres (ATTCs). Meteorological data are available but may not be suitable for direct analysis, posing challenges for effective decision making in the livestock sector.

North Macedonia reports regularly to UNFCCC, mostly focusing on mitigation of GHG emissions. Adaptation to climate change lacks organized and compatible meteorological data, which poses a significant challenge for the livestock sector, hindering effective decision making and planning in the face of climate change impacts. Despite the availability of meteorological data, its format often makes analysis difficult or impossible. Future programmes and policies need to be based on reliable data to address climate change impacts adequately. Establishing a systematic evaluation system within public institutions is proposed to address this gap, facilitating early warning systems and adaptive measures in the livestock sector. The lack of systematization and unified databases for existing weather and risk data poses a serious threat to effective decision-making. Meteorological data are publicly available but may not be in a format suitable for direct analysis, making additional analysis difficult. Reliable and relevant data are needed for decision making in the livestock sector, but gaps exist in accessing and using such data effectively.

In **Serbia**, databases and historical records of local weather disasters and climate-related risks lack organization and standardization. Meteorological data are publicly available but may not be suitable for direct analysis, hindering effective decision making and policy formulation. Access to reliable data regarding climate change impacts on the livestock sector is essential for informed decision-making but remains a challenge.

In summary, there is a notable profusion of documentation pertaining to climate change strategies across WBE, though there is a prevailing emphasis on mitigation measures over adaptation. This underscores the need for a shift in focus towards developing comprehensive and targeted adaptation measures for the livestock sector. While meteorological data exist, they often lack accessibility and compatibility for direct analysis, hindering decision-making processes in the livestock sector. Moreover, significant deficiencies are evident in the availability and quality of data regarding the specific impacts of climate change on livestock farming, adaptive practices employed by farmers, and the vulnerability of livestock farming systems. Additionally, there is a lack of comprehensive understanding of climate change impacts among extension services and agricultural technology transfer centres. Addressing these data-related challenges is imperative for the development of effective adaptation strategies aimed at bolstering the resilience of the agricultural sector in the face of climate change.

Data accessibility remains a significant challenge, with limited availability and quality hindering effective planning and decision-making processes. Specific gaps include lack of information on climate change impacts on livestock farming, adaptive practices employed by farmers, and vulnerability of livestock farming systems. Efforts to address these challenges vary across economies . While some, like North Macedonia and Serbia, propose systematic evaluation systems to enhance data utilization, others, such as Albania and Kosovo*, face obstacles due to insufficient understanding and coordination among governmental entities. To effectively address the complex challenges posed by climate change on livestock farming in the Balkan region, concerted efforts are needed. This includes prioritizing adaptation measures, enhancing data accessibility and quality, fostering collaboration among stakeholders, and integrating livestock expertise into policy development processes.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8. Conclusions, recommendations and priorities

8. Conclusions, recommendations and priorities

Based on the Regional synthesis analysis (Volume I) and the extensive findings of sectoral reports from the Western Balkan region (Volume II), encompassing Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, and Serbia, herewith are presented the synthesized conclusions and recommendations addressing the impact of climate change on agriculture and its adaptation. These cover sector-specific priorities linked to the economic and socio-economic aspects, soils, waters, crop production, and livestock farming, as well as cross-sectoral priorities and actions foreseen for more effective implementation of the recommendations.

8.1. Sector-specific conclusions and recommendations

Conclusions on economic and socio-economic issues

- Climate change significantly impacts rural areas across the Western Balkan region, affecting natural resources, human productivity, social and economic activity, and ecosystem services. This, in turn, poses risks to public safety, food security, and economic stability. The socio-economic component is at the core of the adaptive capacity to climate change.
- Large portion of the population in WBE lives in rural areas. Population is aging, farm managers as well. At the same time, migration is on the rise. Poverty is slowly alleviated, but still affects about one-fifth of the population in WBE.
- The contribution of agriculture, forestry and fisheries to the Gross Value Added (GVA) in the Western Balkans is still very significant, although slowly declining in its share in the total economy. In parallel, employment in the sector is also decreasing.
- Half of the area of North Macedonia is land used for agricultural activities, followed by Albania, Serbia, Kosovo* and Bosnia and Herzegovina (over one-third), and Montenegro with less than one-fifth. The type and level of agricultural production depends on climatic conditions, terrain and soil type, but also the level of economic development and population density.
- Sectoral and rural development in WBE continues to experience hindrances, reflecting farmers' adaptive capacity – still slow productivity growth, high unemployment rates with persisting out-migration trends, limited access to productive assets, dominance of small-scale farming, fragmentation of agricultural land, weak value chains, lack of modernization and applications of new technologies, not fully functional knowledge transfer system and lack of innovation, high vulnerability to external shocks caused by climate change or market distortions.
- The agricultural sector in WBE faces significant direct and indirect economic impacts due to changes in productivity, yields, and trade flows, emphasizing the need for climate-smart approaches and resilience enhancement. In general, pronounced vulnerability is noted at smallholder farms due to various socio-economic, demographic, and policy trends limiting their adaptation capacity. Small farms with limited resources are more susceptible to climate change impacts, among other things, also due to a lack of diversification and risk management options.

Recommendations:

→ Support value chain resilience and development (foster the creation of farmer cooperatives and producer organizations for better resource access and risk management, value chains of organic products, mark/brand standards, differentiation)

→ Recommend to state statistical offices to include climate change related questions in surveys (Agricultural Census, Farm Structure Surveys, other statistical surveys). Encourage the use of additional indicators such as participation rate or active workforce for the assessment of employment status in agriculture and rural areas.

→ Establish the Farm Accountancy Data Network (FADN) in WBE where it is not yet in place (e.g. Albania, Bosnia and Herzegovina) and upgrade data quality, consistency, transparency and accessibility in the economies where it is functional. Also facilitate its transition to the Farm Sustainability Data Network, which will provide an array of valuable sustainability related variables. Make data available and accessible for research purposes, especially disaggregated at micro-level.

→ Support national and regional research initiatives focused on developing various economic models for climate change impact assessments (for instance, simulation of agricultural GVA effects of climate change, different livelihood vulnerability assessments, cost-benefit effects of different adaptation practices, spatial economic impact analyses, etc.).

Soil related issues

- The soils in WBE are under serious impact from climate-driven processes.
- Climate change and unsustainable agricultural practices (outdated machinery, lack of nature-based solutions) are causing severe soil degradation in WBE. This reduces agricultural productivity and long-term soil health.
- Sustainable measures have become part of strategic documents and work programmes of almost all WBE. The main intention is to prevent soil degradation by implementing nature-based solutions, which do not imply high-tech expensive approaches.
- The agricultural sector has limited potential to adopt sustainable soil management practices, with limitations such as unfavourable age structure and level of education, outdated technical capacities, financial constraints to invest and adopt new technologies and sustainable practices, limited access to up-to-date information, and inadequate infrastructure.
- There are many examples and initiatives of applying best sustainable management practices for the adaptation of soil to climate change in all WBE, but the general impression is that these practices are still not massively implemented, unless subject to cross-compliance or conditionality.

Recommendations:

→ Strengthen and raise social awareness of soil, its importance, the need for its protection and the process of adaptation to climate change.

→ Promote use of cover crops, crop rotation, and reduced tillage to improve soil health and fertility.

→ Encourage the adoption of natural fertilizers and organic farming methods to minimize soil degradation.

→ Invest in research and development of drought-tolerant crops and soil amendments to improve resilience.

→ Urgently develop and adopt appropriate legal documents and acts on soil in line with the European Soil Strategy and the objectives of the European Green Deal towards a climate-neutral Europe by 2050, and the forthcoming EU regulation on soil monitoring and protection.

→ Establish a system of sustainable and integrated land management and systematic monitoring of soil quality to enable transparency and availability of monitored data to enable better reporting and evidence-based decision making.

Water scarcity and irrigation

- Water resources in WBE generally meet the needs for all purposes. However, economies from the region continuously face huge damages caused by drought of varying intensity. It is a consequence of uneven spatial and temporal distribution of precipitation and watercourses. The impact has intensified in recent years, primarily due to the atypical and extreme impacts of climate change.
- The situation with hydro-meliorative systems and irrigation in most WBE is not satisfactory. There is a large irrigable area, inefficiently used for various reasons (obsolete irrigation systems, damaged equipment and infrastructure, reduced number of professional staff, land fragmentation, institutional and technical capacities, etc.). Also, many of the economies in the WB region have reported reduction of the drained area (in some economies over 50 percent not in operation).
- Data about irrigable and irrigated land differ both within and across WBE.
- Drought, as an adverse climate phenomenon, has often occurred in recent years in WBE. Due to climate change, the risk of intensification of dry periods will increase, while the water requirements for all purposes will grow. Irrigation is considered the best available adaptation option, achieving significant yield increases.
- Surface irrigation is still dominant in WBE, but drip and sprinkler irrigation in some of the economies are equally practiced. A common problem among producers is the tendency to over-irrigate, even with a drip irrigation system. Still, yield potential and quality of production are lower than they should be, primarily because a significant area irrigated by drip irrigation is not equipped with injectors (fertigators) and farmers still use traditional fertilizing practices. Irrigation scheduling is occasionally used in WBE.
- Many stakeholders are in charge of managing the water sector in WBE, which is a general problem for the proper implementation of planned reforms and investments in the sector.

Recommendations:

→ Enhance proper water management and sustainable irrigation practices as essential for stability and productivity of the agricultural sector.

→ Invest more substantially into hydro-meliorative systems (HMS) (irrigation and drainage systems), especially in building new small-scale irrigation systems, as well as in the rehabilitation of existing HMS and cleaning of the existing canal network.

→ Increase investment in modern irrigation systems (drip irrigation, precision irrigation) to improve water use efficiency, as well as to promote water-saving practices such as rainwater harvesting and improved irrigation scheduling.

→ Develop drought-tolerant crops and varieties to reduce reliance on irrigation water.

→ Apply standard methodology for estimating irrigable and irrigated areas, water extracted for irrigation purposes, as well as water use efficiency of each irrigation system separately.

→ Conduct institutional mapping, with overview of overlapping functions, possible opportunities for joint activities, and propose regulatory changes to improve inter-institutional cooperation.

→ Harmonize the water management sector with relevant EU strategic and programme documents, adopt all documents and strategies related to the water sector (irrigation and drainage) still not in place at economy level, as well as assess the compatibility of policies with other sectors.

→ Enhance managing water resources and adaptive practices at the regional level, given the many transboundary water resources in the Western Balkan region.

Crop production related issues

- The Western Balkan region is vulnerable to climate change, particularly in its crop production sector. Several factors contribute to this vulnerability: changing precipitation patterns, including increased droughts and floods; rising temperatures; more frequent extreme weather events (hail, frost, heatwaves); limited adaptive capacity of farmers. These factors threaten crop yields and overall agricultural productivity, which is anyhow among the lowest in Europe.
- The very low yield of crops is a clear sign of low adaptive capacities and WBE can hardly manage the present negative effects of the factors affecting crop production. Any further disturbance of these factors, together with expected climate change, will additionally jeopardize crop productivity and production.
- Across WBE, there are certain levels of availability of meteorological data (long-term data on temperatures and precipitation from 115 main meteorological stations, 69 climatological stations, 74 thermometric or simple meteorological stations, 388 pluviomatric stations and 101 automated weather stations). Moreover, there is a diverse range of already used agrometeorological indices. Also, there are existing phenological monitoring networks composed of 66 stations plus a number of stations in Serbia. Although improvement of observation networks is needed, described resources could be a solid basis for the use of crop models for research and evidence-based policy purposes. However, meteorological and phenological data is almost not accessible for the scientific community in WBE and, as such, it is the biggest obstacle for crop modelling development and lagging behind in climate change research and solid base policy. Therefore, there is a critical need for improved meteorological and agrometeorological data collection, analysis, and dissemination to support informed decision making and adaptation planning.
- There is a large range of crops grown in WBE. About 20 crops are considered as important crops that are vulnerable to climate change including citruses, olives, deciduous fruits, berries, grape, vegetable, fourages, and cereals. However, four of these crops are reported by all economies (grapevine, apple, wheat and maize), and are thus considered to be the most important vulnerable crops in the region. Moreover, about 20 regions are considered as the most vulnerable regions for crop production. Intensive research is required to understand these vulnerabilities and to design adaptation measures tailor-made to these specific conditions.
- Farmers already implement adaptation practices to protect their crops from adverse climate effects, starting from shifting of the planting date and selection of more tolerant varieties/hybrids, through inventive low cost solutions such as using mulch, covering fruits with straw or crop leaves, inventive solutions for increased irrigation water efficiency (including using alternate water sources

and drip irrigation/fertigation), and ending with intensive investment solutions as construction of protective nets and greenhouses. Moreover, in some economies there are adaptation practices that are already tested and proven as effective, but not yet implemented. There are quite a few measures from the economies agricultural policies related to climate change and crop production (capacity building, resilience building, efficient natural resource management, increased energy efficiency and green energy, improving the knowledge base, crop protection from extreme weather events, increasing crop productivity and production, etc.). These measures should be carefully analyzed to determine their mitigation and adaptation potential and be labelled as such and reported as economies contributions to climate change adaptation and mitigation. Some measures are implemented only in certain economies , but experiences from one economy can be transferred to others through the establishment of a regional task force on climate change in agriculture.

Recommendations:

→ Improve the coverage and quality of meteorological and agrometeorological data collection networks, ensuring open data sharing by economies hydrometeorological services for researchers, policymakers, and farmers to support climate-smart agriculture and evidence-based adaptation planning. Streamline the process for obtaining climate and crop data through web portal services, digitize historical data, and enhance economies services for data analysis. Promote the use of free international data sources for regional analyses.

→ Establish a working group of experts from WBE (within a regional task force) to agree on a core set of standardized agrometeorological indices, for regional comparisons and trend analyses.

→ Strengthen phenological monitoring, encouraging the establishment of additional phenological observation sites that track plant development stages. Integrate local knowledge and farmer observations. Develop a standardized data collection protocol to ensure consistency and quality across the region. Invest in training programmes on data collection methods, data quality control, and data analysis.

→ Expand crop modelling applications; for instance, promote wider use of the AquaCrop model due to its low data requirements and its suitability for water-scarce regions. Conduct regional workshops and training programmes aimed at capacity building for model use. Also, support research initiatives to develop local crop models specific to the main crops grown in the Western Balkans. This will allow for more accurate yield predictions under different climate change scenarios.

→ Develop early warning systems, utilizing meteorological data, agrometeorological indices, and phenological observations to create timely and location-specific alerts for farmers about potential threats like droughts, heatwaves, or floods. Utilize SMS, mobile apps, and local media channels for dissemination.

→ Establish strong collaboration between meteorological services, disaster management agencies, and agricultural extension services, to ensure effective communication and response during crises.

→ Invest in research and development – support research initiatives focused on developing and deploying new crop varieties that are more resilient to drought, heat stress, and pests. Fund research on adaptation strategies. Encourage research to inform policy development related to climate-smart agriculture and risk management for the agricultural sector.

→ Promote adaptation practices and climate smart agriculture in crop production, through developing incentives and sustainable support for designing, testing, promoting and implementing these measures.

Livestock farming related issues

- Climate change poses a significant threat to livestock farming in WBE through rising temperatures leading to heat stress in livestock, extreme weather events, changes in precipitation patterns affecting forage availability, and potential emergence of new diseases.
- The impacts on livestock farming are manifested through reduced animal welfare and productivity, economic losses for farmers, and ultimately compromised food security.
- Climate change might 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 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.
- Improved data collection and monitoring are crucial to understand the impacts of climate change on livestock and develop evidence-based adaptation strategies.
- Current national strategies lack specific measures for livestock adaptation, requiring a more comprehensive approach.

Recommendations:

→ Improve monitoring and data collection on extreme weather events, heat stress impacts, and livestock farming to develop effective adaptation strategies.

→ Develop and promote heat stress mitigation strategies for different farm sizes and production systems, like improved ventilation, cooling systems, shade provision, which are essential to protect animal welfare and productivity.

→ Support research and development of heat-tolerant livestock breeds.

→ Swiftly adopt practical actions and guidelines for applying technological optimization and biological adaptation measures in livestock farming to enhance resilience to climate change.

→ Reduce the risks and vulnerability of livestock to disease outbreaks, by adopting farm management and technologies to prevent outbreaks, but also to prevent further spread.

→ Adjust feeding practices in livestock, for better adaptation to climate change.

→ Improve water management on livestock farms and feed production and storage.

→ Support investments in modern infrastructure on livestock farms.

→ Identify and analyze livestock adaptive practices used by farmers to cope with changing climatic conditions. Foster knowledge sharing and promote the adoption of best practices across WBE.

→ Review and update national climate change strategies to explicitly address livestock adaptation.

→ Prioritize research on the impacts of climate change on livestock farming, focusing on animal health, productivity, and sustainability.

→ Involve livestock experts in policy development and enhance collaboration between policymakers, researchers, and farmers to develop effective adaptation solutions.

→ Develop and implement a legislative framework that incentivizes and facilitates adaptation activities in the livestock sector.

8.2. Cross-sectoral conclusions and recommendations

Knowledge and capacity in the sector

- Limited access to information, outdated knowledge, and a lack of financial resources hinder WBE farmers' abilities to adopt sustainable practices. This reduces the effectiveness of adaptation efforts.
- Research, policy and extension segments in WBE lack knowledge about climate change impacts and adaptation strategies. There is a need for all-around skilled personnel in climate-resilient agriculture.

Recommendations:

→ Strengthen the currently modest research capacities in climate change adaptation in WBE.

→ Strengthen agricultural extension services to provide farmers with timely and relevant information on climate change impacts and adaptation options.

→ Develop training programmes for farmers and agricultural advisors on general management, innovation and entrepreneurship, sustainable soil management, water conservation, and climate-smart crop and livestock farming.

→ Facilitate farmer-to-farmer learning exchanges and showcase successful adaptation models.

→ Establish demonstration fields for testing and transferring technologies and know-how to farmers.

→ Endorse functional agricultural knowledge and innovation systems, including a set of procedures for developing and disseminating knowledge in climate change adaptation in agriculture, to foster collaboration between research institutions, extension services, and farmer organizations. This will provide systemic support to farmers and other stakeholders in promoting and facilitating successful adaptive measures.

→ Improve stakeholders' digitalization uptake capacity. Use digital technologies (mobile apps, online platforms) to disseminate knowledge and best practices to a wider audience. Promote the use of digital tools for weather forecasting, market access, and on-farm operations.

→ Create a platform for knowledge sharing and best practices exchange in climate change adaptation among WBE to leverage synergies and address common challenges more effectively.

Data gaps and monitoring

- Lack of reliable and accessible data on farmers' capacities, soil health, water resources, crop and livestock farming and climate patterns hinders informed decision making on adaptation strategies.

Recommendations:

→ Invest in improved data collection networks on farmers' capacities, soil quality, water availability, agricultural production and climate variables.

→ Ensure open access to data for researchers, policymakers, farmers and other stakeholders to support evidence-based adaptation planning.

→ Develop a comprehensive monitoring, reporting and verification system for continuous sectoral analysis, tracking the effectiveness of adaptation measures and identifying areas for improvement.

Legal and policy framework

- The EU approximation process drives WBE to align with the EU acquis; most of the economies are so far moderately aligned, with many important legislative acts yet missing.
- All WBE have well-developed agricultural policies and strategic documents following the EU framework. There is a notable push towards more environmentally ambitious strategies and goals, emphasizing environment, climate, and biodiversity-related support measures, in line with the EU Common Agricultural Policy. Implementation, however, remains a challenge, with marginal payments related to climate change adaptation actually injected in the sector.
- In line with the EU ambition, WBE have also committed to align with the European Green Deal's key elements by endorsing the Green Agenda for the Western Balkans (GAWB). The economies must work towards ensuring green and digital transformation of the agricultural sector, including supporting adaptation to climate change in agriculture.
- WBE face financial constraints to invest in adaptation measures, infrastructure improvements, and research and development. Farmers in particular lack financial resources to invest in new technologies and sustainable practices. Climate-related risks can cause significant economic losses.

Recommendations:

→ Develop and implement laws and policies that promote sustainable natural resources management and climate change adaptation in agriculture. Align with the European Green Deal's key elements by implementing the Green Agenda for the Western Balkans (GAWB) Action Plan.

→ Make existing agricultural policies, measures and financial incentives more climate-sensitive and encourage farmers to adopt sustainable adaptation practices and new technologies. Develop tailor-made effective financial mechanisms and measures to support farmers in adopting climate-smart practices and technologies.

→ Explore options for accessible and affordable insurance schemes for crops and livestock tailored to the specific needs of farmers to protect them from climate-induced losses.

→ Encourage diversification of crops and animal breeds and income sources to reduce vulnerability to climate shocks.

→ Ensure that adaptation strategies address the needs of vulnerable groups, particularly women and youth, in rural communities.

→ Promote land consolidation programmes and measures.

→ Prioritize adaptation measures in areas with high agricultural activity and vulnerability. Enhance investments in water-saving irrigation technologies, rainwater harvesting, and the rehabilitation of existing irrigation and drainage infrastructure to improve water use efficiency and resilience to drought. Encourage the widespread adoption of sustainable agricultural practices, such as crop diversification, conservation tillage, and organic farming, to enhance soil health, reduce emissions, and increase crop resilience. Encourage livestock specific measures for better adaptation to climate change.

→ Encourage faster accreditation of the currently inactive IPARD measures such as: agri-environment, climate and organic farming (M4), but also investment in rural public infrastructure (M6), advisory services (M10), and introduce a measure on access to knowledge and innovation.

- → Attract more international funding for climate change adaptation projects in agriculture.
- → Earmark financial resources related to climate change adaptation, to allow for more substantial policy analysis (e.g. update the existing Agricultural Policy Measures Classification tool - APMC, continuously supported by SWG).
- → Raise public awareness about the importance of climate change adaptation in agriculture to encourage social support and behavioural changes.
- → In parallel, prepare for forthcoming regulations on greenhouse gas emissions and carbon footprint in the agri-food sector.

Institutional weaknesses and collaboration

- Fragmented institutional structures, overlapping mandates, and insufficient inter-sectoral collaboration limit effective implementation of adaptation measures.

Recommendations:

- → Improve coordination between relevant ministries (agriculture, environment, finance, social policy, education and science, etc.) and relevant stakeholders.
- → Establish clear roles, responsibilities and effort-sharing among different institutions involved in climate change adaptation in agriculture.
- → Interconnect systems and databases across different institutions.
- → Implement monitoring, reporting and verification systems for climate change in agriculture, with adequate institutional structures.
- → Invest in capacity building for government officials and policy makers on climate-smart agriculture.

These elaborated recommendations provide grounds for a more actionable roadmap for building a climate-resilient agricultural sector in WBE. By implementing these steps, economies can empower farmers to adapt to climate change, create a more equitable future for all stakeholders in the face of climate change and ensure long-term food security in the region.

8.3. Priority actions foreseen for better implementation of the recommendations

1. **Establish a regional task force:** Form a task force dedicated to implementing the recommendations and priority actions, including representatives from all Western Balkan economies, to ensure a joint agenda and coordinated efforts.
2. **Develop national and regional strategic roadmaps:** Create applicable roadmaps for climate change adaptation in agriculture, focusing both on specific national contexts, as well as shared regional goals, resource pooling, and joint initiatives in Western Balkan economies.
3. **Implement pilot projects:** Launch pilot applied research projects to test and demonstrate potential adaptation practices and technologies, and showcase their effectiveness, facilitating broader adoption.
4. **Enhance capacity building:** Conduct training programmes and workshops for stakeholders at all levels, focusing on climate resilience, sustainable practices, and technological innovations.
5. **Promote information sharing and technology transfer:** Establish a digital platform for knowledge exchange and support the dissemination of innovative solutions and best practices across the region.
6. **Secure funding:** Identify and access international funding sources, including EU programmes, in addition to national sources, to support the implementation of action plans and ensure sustainability.
7. **Foster public-private partnerships:** Encourage quadruple helix collaborations between governments, private sector, research institutions, and civil society organizations to mobilize resources and expertise.
8. **Boost research potential:** Build research capacities by establishing a Regional Innovation Hub for Agriculture and Climate Change that will significantly boost research and innovation activities and create an enabling environment for effective scientific-based adaptation of the agricultural sector to climate change in the region. This is of particular importance since all of the Western Balkan economies have not enough developed research and innovation capacities in the sector to be able to solve climate change challenges without cooperation with other international networks, experts and innovators.

This comprehensive approach, combining sector-specific and cross-sectoral strategies with overarching goals for resilience and cooperation, ultimately addresses the multifaceted impacts of climate change on agriculture in the Western Balkan region. Implementing these recommendations and priority actions will require a concerted agenda with collaborative efforts from regional governments, international organizations, the private sector, and local communities.

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9. References

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Annexes

Annex 1. Economic and agricultural data in the Western Balkan economies

Table A.1.1. Key macroeconomic indicators across the Western Balkan economies

Indicator	AL			BA			XS			ME			MK			RS		
	2012	2017	2022	2012	2017	2022	2012	2017	2021	2012	2017	2022	2012	2017	2022	2012	2017	2022
GDP (at current prices, mil. EUR)	9,590	11,559	17,963	13,117	16,121	23,266	5,059	6,414	7,817	3,181	4,299	5,924	7,585	10,038	12,898	33,679	39,235	60,371
Value added (at current prices, mil. EUR)	8,296	10,098	14,288	10,685	13,293	19,532	4,167	5,163	6,244	2,668	3,519	4,769	6,561	8,700	11,592	28,426	32,576	49,671
GDP per capita (EUR)	3,306	4,018	6,430	3,419	4,601	6,763	2,799	3,566	4,316	5,126	6,908	9,598	3,680	4,839	5,136	4,677	5,588	8,882
External trade balance (mil. EUR)	-2,266	-2,633	-3,899	-3,781	-3,611	-5,452	-2,232	-2,666	-3,935	-1,406	-1,833	-2,834	-1,947	-1,816	-3,826	-5,945	-4,345	-11,404
Unemployment rate (%)	14	14	11	28	21	15	31	31	21	20	16	15	31	22	14	26	15	9
Food, beverages and tobacco in total household's expenditures (%)	39	43	45	:	41	33	45	44	46	36	30	:	37	38	52	38	35	36

Source: WBE STAT Databases (http://app.seerural.org/agricultural-statistics/, unpublished data). Note: (:) data not available.

Table A.1.2. Key agricultural indicators across the Western Balkan economies

Indicator	AL			BA			XS			ME			MK			RS		
	2012	2017	2022	2012	2017	2022	2012	2017	2021	2012	2017	2022	2012	2017	2022	2012	2017	2022
GVA of agriculture (at current prices, mil. EUR)	1,797	2,199	2,658	820	939	1,125	618	586	545	237	295	358	691	790	1,048	2,167	2,360	4,076
Share in AgGVA in all activities (%)	22	22	18	8	7	6	15	11	9	9	7	6	11	9	9	8	7	8
Number of employed in agriculture ('000)	525	457	440	167	154	85	:	:	50	11	18	11	113	120	69	467	481	431
Share in total employment (%)	55	38	35	21	19	7	:	:	14	6	8	4	17	16	10	21	17	15
Export of agri-food products (mil. EUR)	92	224	435	317	540	566	21	61	93	57	48	61	470	530	710	2,131	2,823	4,735
Share in export of all products (%)	6	11	11	8	9	6	7	16	24	15	14	9	15	11	9	24	19	17
Import of agri-food products (mil. EUR)	669	796	1,255	1,426	1,611	2,267	573	694	966	443	507	756	673	753	1,130	1,221	1,617	3,220
Share in import of all products (%)	18	17	16	18	17	15	23	23	22	25	23	21	13	11	11	8	8	8
Trade balance in agri-food products (mil. EUR)	-577	-572	-820	-1,109	-1,070	-1,701	-552	-633	-873	-387	-459	-694	-203	-224	-420	910	1,206	1,515
Share of crops in total agricultural output (%)	49	:	:	39	41	:	55	57	52	:	:	:	75	73	79	66	67	77
Share of livestock in total agricultural output (%)	52	:	:	61	59	:	45	43	48	:	:	:	25	27	21	34	33	23

Source: WBE STAT Databases (http://app.seerural.org/agricultural-statistics/, unpublished data). Note: (:) data not available.

Table A.1.3. Agricultural land in the Western Balkan economies ('000 ha)

Indicator	AL			BA			XS			ME			MK			RS		
	2012	2017	2022	2012	2017	2022	2012	2017	2021	2012	2017	2022	2012	2017	2022	2012	2017	2022
Total agricultural land	1,201	1,169	1,165	2,163	2,165	535	:	416	420	223	255	254	1,267	1,266	1,257	3,462	3,438	3,488
- Arable land	696	696	686	1,006	1,061	248	:	188	188	6	7	9	414	417	416	2,561	2,595	2,600
of which fallow and uncultivated land	209	188	:	476	466	:	:	:	:	:	:	:	137	:	0	22	15	7
- Land under permanent crops	77	84	90	109	108	:	:	10	14	5	5	5	35	40	40	185	208	206
of which orchards	:	:	21	99	102	28	:	6	10	2	3	3	15	16	17	163	184	184
vineyards	10	11	11	6	4	2	:	3	3	3	3	3	21	24	23	22	22	20
olive trees	36	45	49	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
other permanent crops	:	:	9	4	2	:	:	:	:	:	:	:	:	:	:	1	1	2
- Permanent grassland	505	478	449	1,048	1,061	248	:	218	217	210	242	240	817	808	800	690	616	662
of which meadows	:	:	0	460	444	:	:	75	78	:	:	:	60	60	59	382	322	330
pastures	:	:	:	588	617	:	:	144	139	:	:	:	757	748	742	308	295	332

Source: WBE STAT Databases (http://app.seerural.org/agricultural-statistics/, unpublished data). Note: (:) data not available.

Table A.1.4. Area under agricultural crops in the Western Balkan economies ('000 ha)

Indicator	AL			BA			XS			ME			MK			RS		
	2012	2017	2022	2012	2017	2022	2012	2017	2021	2012	2017	2022	2012	2017	2022	2012	2017	2022
Total grain	:	:	133	304	299	207	137	121	124	2	2	2	161	159	156	1,714	1,710	1,724
of which: Wheat	:	:	54	61	69	51	103	81	80	1	1	1	80	73	70	603	556	631
of which: Maize	:	:	57	197	194	114	31	36	40	1	1	1	29	31	30	976	1 002	952
Oilseeds	:	:	1	6	10	16	3	4	:	-	-	-	4	4	6	357	441	516
Tobacco	:	:	1	2	1	:	:	:	:	:	:	:	20	16	15	5	5	5
Sugar beet	:	:	1	:	:	:	:	:	:	:	:	:	:	:	:	69	54	35
Fodder	:	:	218	98	100	31	94	106	109	:	:	:	27	32	36	256	240	223
Potatoes	:	:	10	37	35	19	-	-	4	2	2	2	13	13	12	52	39	25
Grapes (total)	:	:	11	14	16	2	3	4	3	3	3	3	20	23	23	21	21	20
Fruit (total)	:	:	21	23	25	24	3	6	10	3	3	3	15	16	17	168	183	184
Vegetables (total)	31	32	34	41	34	14	4	20	19	1	2	2	31	31	32	61	73	53

Source: WBE STAT Databases (http://app.seerural.org/agricultural-statistics/, unpublished data). Note: (:) data not available.

Table A.1.5. Crop production in the Western Balkan economies ('000 tons)

Indicator	AL			BA			XS			ME			MK			RS		
	2012	2017	2022	2012	2017	2022	2012	2017	2021	2012	2017	2022	2012	2017	2022	2012	2017	2022
Wheat	:	:	233	225	289	279	345	320	322	1	2	2	215	200	225	2,399	2,276	3,109
Maize	:	:	401	539	709	970	86	147	170	2	3	3	116	120	143	3,533	4,018	4,283
Oilseeds	:	:	1	7	18	48	7	11	:	:	:	:	5	6	10	667	1,052	1,131
Tobacco	:	:	2	1	2	:	:	:	:	1	1	0	29	23	26	7	7	6
Sugar beet	:	:	21	:	:	:	:	:	:	:	:	:	:	:	0	2,483	2,513	1,667
Fodder	:	:	:	555	643	360	260	487	482	:	:	:	179	257	425	1,496	1,224	1,175
Potatoes	:	:	263	300	335	312	:	:	74	22	37	32	169	178	195	578	589	523
Grapes (total)	:	:	211	26	28	20	30	15	27	25	22	21	277	180	266	128	166	162
Fruit (total)	248	263	211	204	163	165	30	34	68	20	22	24	204	94	255	930	1,205	1,513
Vegetables (total)	914	1,152	1,358	229	286	186	126	358	283	34	53	54	655	703	757	910	1,087	1,174

Source: WBE STAT Databases (http://app.seerural.org/agricultural-statistics/, unpublished data). Note: (:) data not available.

Table A.1.6. Livestock herd size in the Western Balkan economies (31 December, '000 heads)

Indicator	AL			BA			XS			ME			MK			RS		
	2012	2017	2022	2012	2017	2022	2012	2017	2022	2012	2017	2022	2012	2017	2022	2012	2017	2022
Cattle	498	475	298	445	445	339	329	260	260	85	87	71	251	255	165	921	899	800
of which dairy cows	358	349	261	251	206	149	183	133	132	59	60	48	123	123	97	455	429	374
Pigs	159	180	137	539	548	472	56	41	47	18	25	25	177	202	183	3,139	2,911	2,669
Sheep and goats	2,619	2,859	2,093	1,070	1,090	997	248	211	241	207	189	161	732	725	646	1,867	1,887	1,913
Poultry	9,494	7,835	6,848	19,401	21,583	12,777	2,318	2,811	2,788	732	788	855	1,776	1,840	1,562	18,234	16,338	14,817
Beehives	239	290	479	384	405	299	46	164	219	43	65	:	53	75	291	665	849	977

Source: WBE STAT Databases (http://app.seerural.org/agricultural-statistics/, unpublished data)

Table A.1.7. Average yields of major crops and milk in the Western Balkan economies (tons per hectare or dairy cow)

Indicator	AL			BA			XS			ME			MK			RS		
	2012	2017	2022	2012	2017	2022	2012	2017	2022	2012	2017	2022	2012	2017	2022	2012	2017	2022
Wheat (tons/ha)	4,,107	4,,037	4,296	3,708	4,157	5,460	3,352	3,976	4,030	2,800	3,213	2,707	2,696	2,743	3,204	4,000	4,092	5,000
Maize (tons/ha)	6,725	6,563	7,090	2,745	3,654	8,540	2,768	4,094	4,290	0,313	0,237	0,220	3,973	3,823	4,736	3,600	4,009	4,500
Potatoes (tons/ha)	25,043	25,111	26,506	8,153	9,641	16,500	10,446	27,562	19,200	11,800	17,006	15,501	12,795	13,475	15,992	11,100	15,316	21,100
Grapes (tons/ha)	19,475	19,146	20,002	1,898	1,732	7,890	9,221	4,803	7,600	0.108	0.128	0.135	13,871	7,708	11,522	6,101	7,905	8,100
Cow milk (tons/cow)	2,673	2,817	3,161	2,678	3,287	3,753	:	:	:	2,549	2,905	3,283	2,920	3,311	3,328	3,055	3,610	3,775

Source: WBE STAT Databases (http://app.seerural.org/agricultural-statistics/, unpublished data). Note: (:) data not available.

Table A.1.8. Data availability of different macroeconomic and agricultural data across the Western Balkan economies (expert assessment)

	Data at NUTS-1 level:						Data at NUTS-2 level:						Data at NUTS-3 level:						Data at LAU-1 level:						Quality of data satisfactory:					
Key macroeconomic indicators	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS
GDP (at current prices)	+	+	+	+	+	+	+	+/-	+	-	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	+	+	+
Value added (at current prices)	+	+	+	+	+	+	+	+/-	+	-	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	+	+	+
GDP per capita	+	+	+	+	+	+	+	+/-	+	-	+	+	+/-	-	+/-	-	+/-	-	-	-	-	-	-	-	-	+	-	+	+	+
External trade balance	+	+	+	+	+	+	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unemployment rate	+	+	+	+	+	+	+	+/-	+	-	+	+	+/-	+/-	+/-	-	+/-	-	-	+	-	-	-	-	-	+/-	-	+	+	+
Household expenditures	+	+	+	+	+	+	+	+/-	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+
Key indicators for ag. sector	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS
GVA of agriculture (at current prices)	+	+	+	+	+	+	+/-	+	+	-	+	+	-	+	+	-	+	-	-	-	-	-	-	-	+	+	-	+	+	+
Number of employed in agriculture	+	+	+	+	+	+	+	+	+	-	+	+	-	+/-	+/-	-	+/-	-	-	-	-	-	-	-	+	+	-	+	+	+
Export of agri-food products	+	+	+	+	+	+	-	+	+	-	+	+	-	+/-	+/-	-	+/-	-	-	-	-	-	-	-	+	+	-	+	+	+
Import of agri-food products	+	+	+	+	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+
Share of crops in total agricultural output	-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	-	-	-	-	-	-	-	+	+	-	+	+	+
Share of livestock in agricultural output	-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	-	-	-	-	-	-	-	+	+	-	+	+	+
Agricultural land use	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS
Total agricultural land	+	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	-	+/-	+	-	+	+	+
- Arable land	+	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	-	+/-	+	-	+	+	+
(of which fallow and uncultivated land)	+	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	-	+/-	+	-	+	+	+
- Land under permanent crops	+	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	-	+/-	+	-	+	+	+
(of which orchards)	+/-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+/-	+/-	-	+/-	-	+/-	+	-	+	+	+
(of which vineyards)	+	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	-	+/-	+	-	+	+	+
- Permanent grassland	+	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	-	+/-	+	-	+	+	+
Utilised agricultural area (UAA)	-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+/-	+/-	-	+/-	-	+/-	+	-	+	+	+
Number of agricultural holdings	+/-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+/-	+/-	-	+/-	+	+/-	+	-	+	+	+
UAA per holding	-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+/-	+/-	-	+/-	+	+/-	+	-	+	+	+
Number of livestock heads	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS
Cattle	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	-	-	-	-	-	+	+	-	+	+/-	+
Pigs	+	+	+	+	+	+	+	+	+	-	+	+	+	+/-	+/-	-	+/-	+	+	-	-	-	-	-	+/-	+	-	+	+/-	+
Sheep and goats	+	+	+	+	+	+	+	+	+	-	+	+	+	+/-	+/-	-	+/-	+	+	-	-	-	-	-	+/-	+	-	+	+/-	+
Poultry	+	+	+	+	+	+	+	+	+	-	+	+	+	-	-	-	-	+	+	-	-	-	-	-	+/-	+	-	+	+/-	+
Beehives	+	+	+	+	+	+	+	+	+	-	+	+	+	-	-	-	-	+	+	-	-	-	-	-	+/-	+	-	+	+/-	+
Yield of major crops and livestock	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS	AL	BA	XS	ME	MK	RS
Wheat	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	-	+/-	+	-	+	+/-	+
Maize	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	-	+/-	+	-	+	+/-	+
Potatoes	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	-	+/-	+	-	+	+/-	+
Grapes	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	-	+/-	+	-	+	+/-	+
Cow milk	+	+	+	+	+	+	+	+	+	-	+	+	+	+/-	+/-	-	+/-	+	+	-	-	-	-	-	+/-	+	-	+	+/-	+

Note: + (available); +/- (to some extent); - (not available); n/a (not applicable)

Annex 2. Soils in the Western Balkan economies

Table A.2.1. Exposure of soil to weather extremes – soil types affected

Processes	Floods	Heavy rainfall (storms)	Drought	Frosts	Land slides	Forest fires	Other extreme events
AL	Fluvisols, Cambisols, Gleysols, Vertisols, Luvisols, Stagnosols	All soil types	All soil types	Cambisols, Regosols	Cambisols, Regosols, Luvisols	All soil types	
BA	Fluvisols, Glaysols and Cambisols Eutric	Soils on limestone/ dolomite substrata with extensive vegetation	Luvisols, Podzol, Tera rossa, Fluvisols, Glaysols	No data	No data	No data	
XS	No data	No data	No data	No data	No data	No data	
ME	Alluvial soil, Gleysols and Cambisols Eutric	No data	Cambisols Eutric, Calcomelanosols	No data	No data	No data	**Soil erosion -** Calcomelanosols, Colluvial soils, and Terra Rossa
MK	Fluvisols (64.5% of flooded areas), Fluvisols Molic (10.41%), Gleysols (7.32%)	Cambisols Chromic, Litosols, Regosols, Vertisols	Regosols, Leptosol Calcaric, Vertisols, Cambisols Chromic	Cambisols Chromic, Vertisols, Fluvisols	Regosols, Vertisols, Cambisols Chromic	Cambisols, Leptosols Dystric, Regosols, Leptosols, Regosols, Colluvic	**Soil erosion -** Regosol, Leptosols, Leptosols Calcaric
RS	Fluvisol, Eugleys	Lithosols, Regosols, Arenosols	Vertisol, Cambisol, Fluvisol	Fluvisol, Leptosol	Leptosol, Cambisol	No data	

Table A.2.2. Land productivity potential affected – area affected

Processes	Floods	Heavy rainfall (storms)	Drought	Frosts	Land slides	Forest fires	Other extreme events
AL	approx. 16,000 ha at flood risk	several ha	hundreds of ha	several of ha	9% of the economy	several hundred ha	
BA	322,700 at flood risk	89.01% erosion, 25.4% torrential flows (12,970 km2)	total area 4,904 km^{2}, annually 258 km^2 (0.56%)	no data	1,800 active landslides	71,000 ha (2022), 100,000 ha (2020)	80%- prone to soil erosion
XS	12,300 ha. at flood risk	no data	several thousands of ha	several hundred ha*	no data	10,368 ha (2015-20)	
ME	30,000 ha. at flood risk	no data	2011 drought in the Zeta-Bjelopavlići region (hundreds of ha	no data	several hundred ha*	over 18,000 ha. (2005-15)	Soil erosion- over 460,000 ha
MK	54,380 ha prone to floods (Dottori et al., 2021)	no data	7,678 km^2 -within the two strongest categories	Several thousand ha. in valleys	no data (>400 locations)	4,384 in 2022 (EFFIS)	Severe soil erosion- 52,000 ha.
RS	15,000 ha flooded (2021)	42 flood events (2021); 409 flood events (2022)	59,192 km^2 (2017) 1,275 km^2 (2018) 34,681km^2 (2019)	no data	30% of the territory	3,635 ha (2020) 834 ha (2021) 332 ha (2022)	Soil erosion- 6,090 km^2 in 2019 (7.8%)

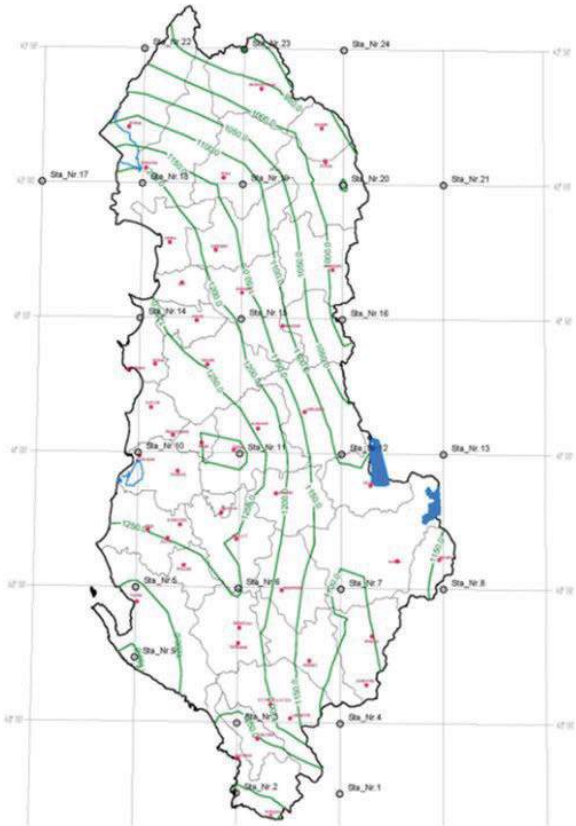
Table A.2.3. Exposure of soil to weather extremes – land productivity potential affected

Processes	Floods	Heavy rainfall (storms)	Drought	Frosts	Land slides	Forest fires
AL	HIGH (soil contamination and soil erosion)	HIGH (soil erosion)	HIGH (SOM depletion)	MINOR (Soil physical properties)	MEDIUM (soil loss)	HIGH (chemical, biological properties)
BA	HIGH (soil pollution and contamination, soil fertility loss)	HIGH (soil erosion and soil fertility)	MINOR (SOM depletion, soil structure loss, microbiological activity decline)	MEDIUM (soil physical properties)	HIGH (soil loss)	HIGH (physical, chemical, biological properties)
XS	HIGH (soil contamination and soil erosion)	no data	HIGH (SOM depletion, soil moisture disbalance)	no data	MEDIUM (soil loss)	HIGH (chemical, biological properties)
ME	HIGH (erosion, pH fluctuations)	no data	MEDIUM (pH changes, reduced moisture, and limited irrigation)	no data	HIGH (soil loss)	HIGH (physical, chemical, biological properties
MK	HIGH (burial of fertile soils with inert material, prolonged hydromorphic conditions, soil contamination etc.	MEDIUM (soil erosion, hydromorphic conditions in valleys)	HIGH (soil moisture, microbiological activity, Salinization and alkalization risk, SOC depletion, soil pH)	MINOR (soil physical properties)	MEDIUM (soil loss)	MEDIUM (physical, chemical, and biological properties of soils)
RS	HIGH (structural changes, soil fertility, decrease in soil microbial communities)	MEDIUM (structural changes, soil fertility)	MEDIUM (pH level, nutrient loss, soil fertility)	MEDIUM (soil physical properties)	HIGH (soil loss, sediment deposition, mixing of soil material)	MEDIUM (physical, chemical, and biological properties of soils)

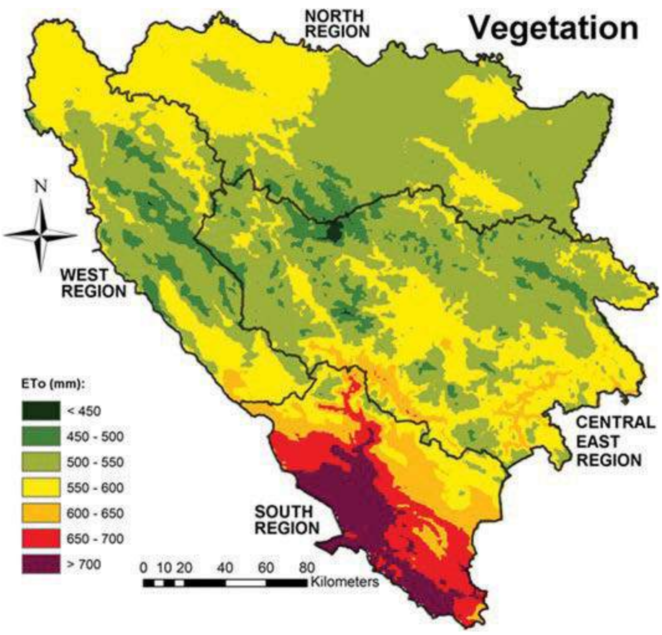
Table A.2.4. Producers capacities to adapt the soil to climate change, area affected (ha or %)

Indicator	Management practice	AL	BA	XS	ME	MK	RS
Cultivation	**Reduced tillage**	Area: 100,000 ha	Area: 95030 (4,5%)	Area: limited	Area: limited	Area: limited (approx. 13,000 ha)	Area: 10.06%
	No-tillage	not existing	Area: limited	not existing	not existing	not existing	Area: 20.909 ha
	Contour tillage	Area: limited	Area: limited	Area: limited areas	Area: limited	Area: limited	Area: <5%
	Strip cultivation	Area: 10,000 ha	Area: limited	not existing	not existing	not existing	Area: <5%
	Organic agriculture	Area: 897 ha	Area: 4,431 ha		Area: 4,752 ha	Area: 2,500 ha	Area: 21,265 ha
Fertilizers management	**Soil laboratory testing schemes**	Area: 100,000 ha	Farmers: all farmers using incentives	no data	Area: 350 ha	Area: >20,000 ha	Farms: 30% farms (70% farms in next 10 years)
	Organic fertilizers use	Area: 250,000 ha	Area: >100,000 ha	Area: limited	Area: 8690 ha	Area: 2,500 ha (organic farming)	Area: 373,871 ha
	Mineral fertilizers	Area: 450,000 ha	Area: >150,000 ha	Area: >100,000 ha	Area: 13,355 ha	Area: >100,000 ha	Farms: 30-40%
Precision agriculture	**Systems for agro-ecological zoning**	not existing	Area: limited areas	not existing	not existing	Area: whole agriculture land	Farms: <10%
	Thematic soil quality maps	Area: 450,000 ha	not existing	not existing	not existing	Area: whole economy (Soil texture maps, Soil pH map, Soil carbon map, etc.)	Farms: <10%
	On-line services	Area: 450,000 ha	Area: limited	not existing	Area: limited	Area: limited	Farmers: 11,000
Training programmes	**Lifelong learning programmes within universities**	Area: limited	Area: no data	not existing	not existing	not existing	Farmers: <5%
	Vocational training programmes related to soil	Area: limited	Area: no data	not existing	not existing	not existing	Farmers: <5%
	Targeted training courses for farmers	Area: limited	Area: no data	Area: limited (raspberry producers)	not existing	Area: limited	Farmers: 82,511
Land improvement practices	**Liming**	Area: none	Area: 5-8% of agricultural land	no data	Area: limited	Area: limited	Area: 10-20%
	Erosion control	Area: 50,000 ha	Area: no data Farmers: n/a	Area: limited	Area: limited	Area: limited	Area: 10-20%
	Saline soils management	Area: 500 ha	No problem with salinity	no data	not existing	not existing	Area: 150,000 ha

Annex 3.
Water resources in the Western Balkan economies

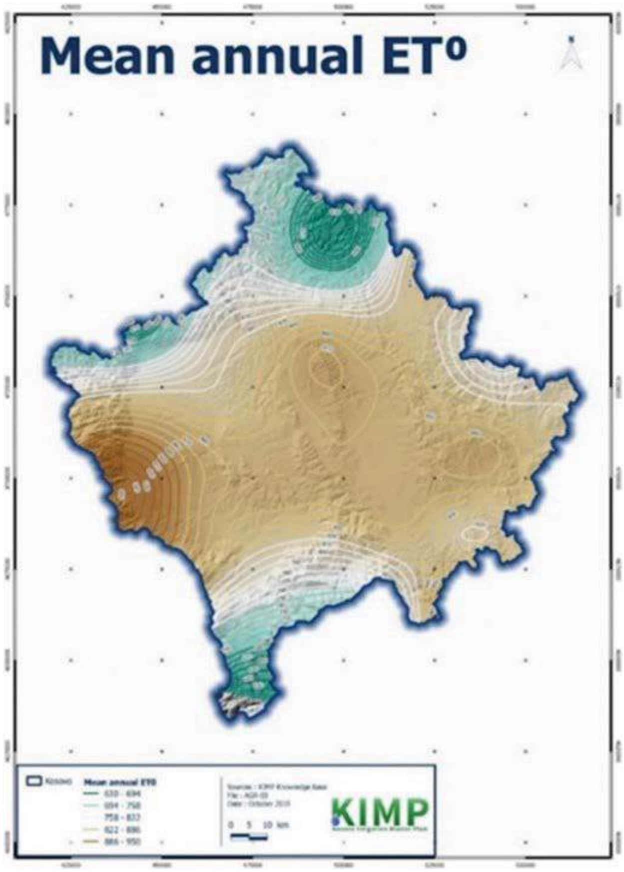


Map A.3.1. Annual Reference Evapotranspiration isolines (ETo) layers per station (mm/year) in Albania

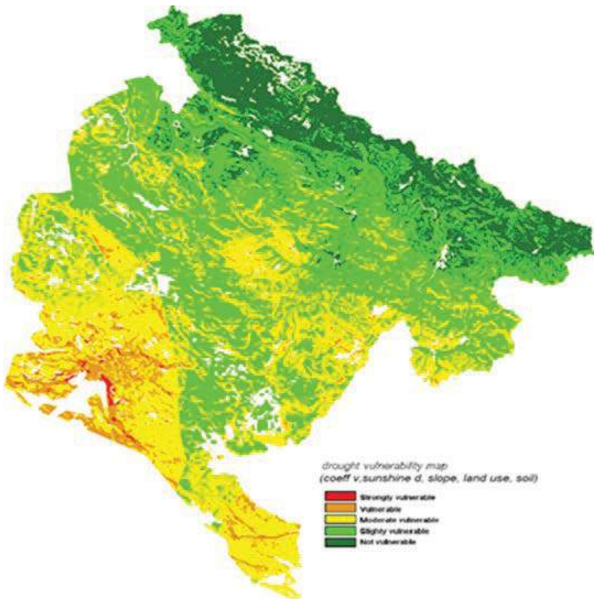


Map A.3.2. Spatial variation of long-term (1961–2016) mean vegetation period ET_0 in BiH

Source: *Čadro* et al. (2019)

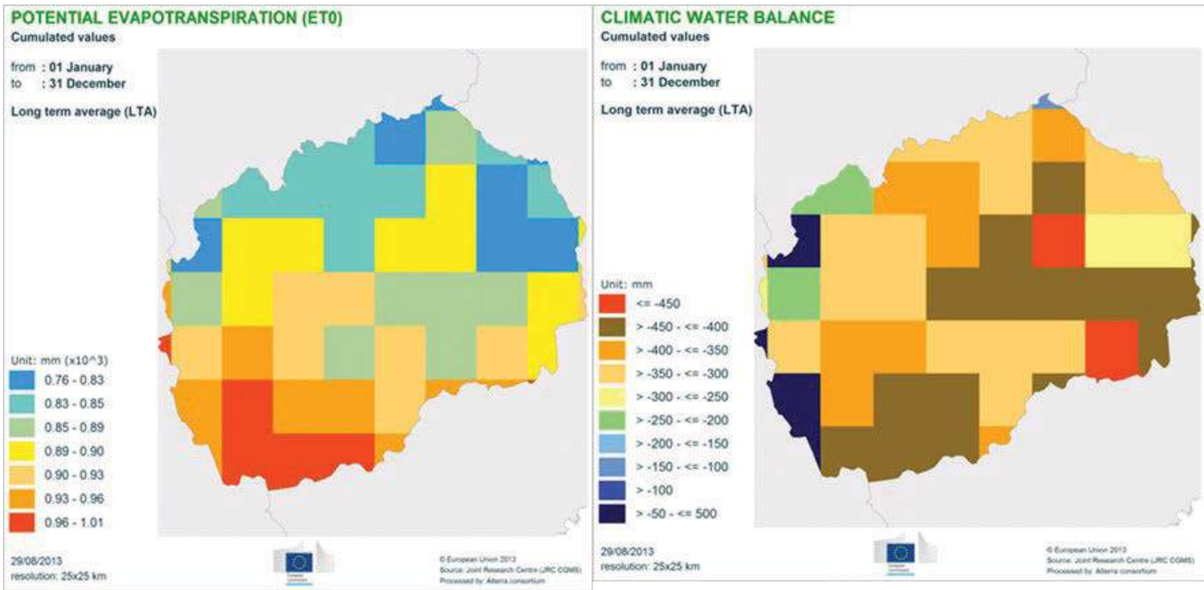


Map A.3.3. Average annual evapotranspiration in Kosovo*



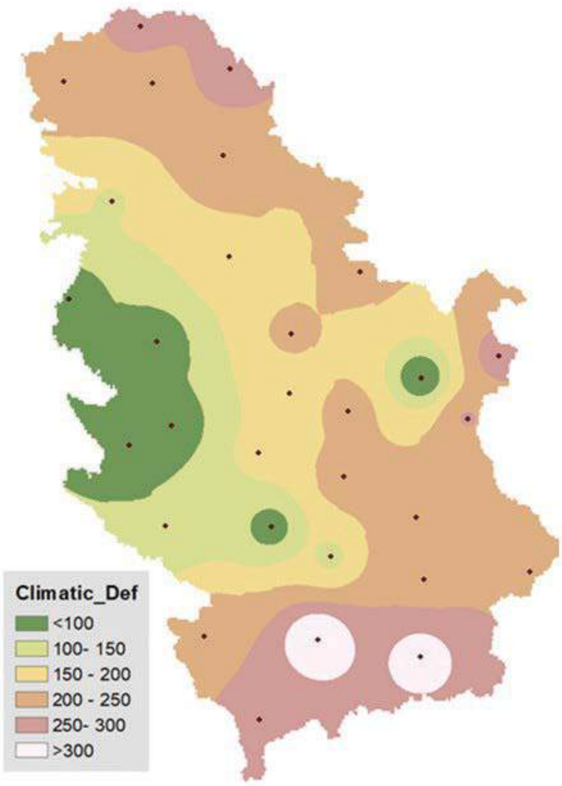
Map A.3.4. Vulnerability of agricultural areas to drought in Montenegro

Source: IHMS, http://meteo.co.me/page.php?id=48



Map A.3.5. Potential evapotranspiration (ETo, left) and Climatic water balance for the period 1975-2012 (right) in North Macedonia

Source: JRC MARS Weather database, Chukaliev (2014)



Map A.3.6. Climatic water deficit in Serbia (period 1991-2020)

11. List of acronyms

AL	Albania (Country code- ISO 3166-1 alpha-2)
APMC	Agricultural Policy Measures Classification tool
AquaCrop	AquaCrop FAO crop-water productivity model
ATTC	Agriculture Technology Transfer Centres
AVI	Average Livelihood Vulnerability Index
AWS	Automated Weather Stations
BA	Bosnia and Herzegovina (Country code- ISO 3166-1 alpha-2)
BD	Brčko District
BiH	Bosnia and Herzegovina (Country code- ISO 3166-1 alpha-3)
BiOMA	Biophysical Model Applications
CAP	Common Agricultural Policy
CC	Climate Change
CCCs	Climate Change Committees
CCU	Climate Change Unit
COP28	Conference of the Parties 28 (United Nations Climate Change Conference)
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)
DNA	Designated National Authority
DSSAT	Decision Support System for Agrotechnology Transfer
DTM	Digital Terrain Model
EEA	European Environment Agency
EIONET	European Information and Observation Network
EOBS	Daily gridded observational dataset for precipitation, temperature and sea level pressure in Europe
ESDAC	European Soil Data Centre
ET_0	Evapotranspiration
EU	European Union
EUROSTAT	European Statistical Office; DG ESTAT
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organisation of the United Nations
FBiH	Federation of Bosnia and Herzegovina
FHMI	Federal Hydrometeorological Institute
FSDN	Farm Sustainable Data Network
FSS	Farm Structure Survey

FUE	Fertilizer Use Efficiency
GAWB	Green Agenda for the Western Balkans
GDD	Growing Degree Days
GDP	Gross Domestic Product
GEO-Portal	National digital platform for geospatial data (Serbia)
GHG	Greenhouse gasses
GIS	Geographic Information System
GVA	Gross Value Added
HMS	Hydro-Meliorative Systems
IGEO	Institute of Geosciences, Energy, Water and Environment (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)
IPARD	Instrument for Pre-Accession in Agriculture and Rural Development
IPCC	Intergovernmental Panel on Climate Change of the United Nations
KIMP	Irrigation Master Plan (Kosovo*)
KIRP	Irrigation Rehabilitation Project (Kosovo*)
LAU	Local Administration Unit
LDN	Land Degradation Neutrality targets
LPIS	Land Parcel Identification System
LVI	Livelihood Vulnerability Index
MAFRD	Ministry of Agriculture, Forestry and Rural Development (Kosovo*)
MAFWE	Ministry of Agriculture, Forestry and Water Economy (North Macedonia)
MAFWM	Ministry of Agriculture, Forestry and Water Management (Montenegro, Serbia)
MARD	Ministry of Agriculture and Rural Development (Albania)
MASIS	Macedonian Soil Information System
MCM	Million Cubic Meters
ME	Montenegro (Country code- ISO 3166-1 alpha-2)
MESPI	Ministry of Environment, Spatial Planning and Infrastructure (Kosovo*)
MK	Macedonia (Country code- ISO 3166-1 alpha-2)
MOEPP	Ministry of Environment and Physical Planning (North Macedonia)
MONSTAT	Statistical Office of Montenegro
MoTE (MTE)	Ministry of Tourism and Environment (Albania)
NAP	National Adaptation Plan

NAPM	National Action Plan on Mitigation
NARDS	National Strategy on Agriculture and Rural Development
NDCs	Nationally Determined Contributions
NDVI	Normalized Difference Vegetation Index
NSCC	National Strategy on Climate Change
NSDEI	Strategy for Development and European Integration (Albania)
NUTS	Nomenclature of territorial units for statistics
NWC	National Water Council (Albania)
OIV	International Organisation of Vine and Wine
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)
SCADA	Supervisory Control and Data Acquisition
SDGs	Sustainable Development Goals
SORS	Statistical Office of the Republic of Serbia
SPEI	Standardized Precipitation Evapotranspiration Index
SPI	Standard 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
THI	Temperature Humidity Index
UAA	Utilised 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 Program
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNW-DPC	UN-Water Decade Programme on Capacity Development
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
WMO	World Meteorological Organization
WUA	Water Users Associations
XK	Kosovo* (Country code- ISO 3166-1 alpha-2)

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