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CLIMATE ACTION PLAN FOR AGRICULTURE FOR THE MUNICIPALITY OF TRAVNIK

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SOFI Smart Organic Food Initiative

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Climate Action Plan for Agriculture for the Municipality of Travnik

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1. INTRODUCTION

Across the entire world, the consequences of climate change are strongly felt: the melting of polar ice caps, rising sea levels, extreme weather conditions ranging from severe floods to intense heat waves and droughts. Climate change is becoming a very serious threat that affects all segments of human life. Generally, their impact could be categorised into several groups:

- Impact on nature (extremely high temperatures, floods, droughts, rising sea levels, forest fires, reduction in available drinking water quantities, changes in soil, air, and water)
- Impact on the economy (detrimental effects on existing infrastructure, agriculture, forestry, tourism, energy)
- Impact on society (there is an increased risk of heat-related illnesses, respiratory problems, and the spread of mosquito-borne diseases such as malaria and dengue fever; droughts, floods, and other extreme weather events destroy crops and affect food supply; for the same reasons, migration increases, creating new challenges regarding accommodation, integration, and resources for these people; social inequality rises as poorer communities are often the most vulnerable to the consequences of climate change, having fewer resources for adaptation and recovery).

Aware of the problems they face, countries around the world have adopted a series of international agreements and resolutions aimed at implementing measures to prevent further deterioration of the situation and to help reduce the resulting damage:

- The Paris Agreement on climate change, which outlines measures intended to reduce greenhouse gas emissions to ensure that the temperature rise is limited to an increase of 1.5–2°C. Additionally, the Paris Agreement defines measures to mitigate the damage caused by climate change.
- The UN 2030 Agenda for Sustainable Development, which established 17 global sustainable development goals onto which the entire world should focus its efforts. Goal 13 of this agenda pertains to climate change and states: *Take urgent action to combat climate change and its impacts*.

Bosnia and Herzegovina, as one of the countries of Southeast Europe, is also exposed to the impacts of climate change, which are reflected in extreme temperatures. These, combined with a reduction in summer precipitation, increase the risk of droughts and the demand for energy during the summer, as watercourses diminish, affecting the reduction of electricity production in the hydropower system. Farmers are facing greater variability in crop yields. Forest fires frequently occur, destroying large areas of woodland, which indirectly affects the depletion of groundwater[1].

Throughout the 20th century, there has been an accelerated increase in the global population, resulting in a heightened need to produce sufficient quantities of food. There arises a need for rapid progress in the food production industry, which involves the use and application of chemical mineral fertilisers, pesticides, fungicides, and intensive livestock farming to achieve high yields in

1 For example: Loss of vegetation: Forest fires destroy trees and plants which, with their roots, would otherwise assist in absorbing water from the soil and stabilising moisture levels. Without vegetation, rainwater runs off the soil surface more quickly instead of slowly infiltrating into the ground and contributing to the replenishment of groundwater.
Soil erosion: After fires, burnt soil becomes less stable and more prone to erosion. The topsoil layer, which would typically absorb water, can be destroyed, reducing the soil's capacity to retain water and decreasing the replenishment of underground reservoirs.
Changes to the hydrological cycle: Forests play a crucial role in regulating the hydrological cycle through evaporation and transpiration. When forest areas are lost due to fires, the ability of the area to maintain the water cycle is diminished, which can lead to a reduction in local and regional groundwater reserves.
Water runoff: Fires often leave hydrophobic layers in the soil, preventing the infiltration of rainwater. Instead of being absorbed into the ground, the water runs off more rapidly towards rivers or lower-lying areas, reducing the replenishment of groundwater.

a very short time. On one hand, the quantity of food produced increases, but on the other hand, this leads to significant pollution of ecosystems and climate change.

According to data from Our World in Data[2]:

- Food production accounts for more than a quarter (26%) of global greenhouse gas emissions.
- Half of the world's habitable land is used for agriculture. Habitable land refers to land free of ice and deserts.
- 70% of global freshwater withdrawals are used for agriculture.
- 78% of global eutrophication[3] of oceans and freshwater is caused by agriculture.

The impact of agriculture on climate change, particularly on global warming, stems primarily from emissions of methane (CH_4) and carbon dioxide (CO_2).

The agricultural sector in Bosnia and Herzegovina suffers from low overall productivity, weak and inefficient agricultural policies, limited budget allocations for agriculture, imperfect markets, and a general lack of information and knowledge. At the same time, the negative impacts of climate change are already being felt and are expected to increase according to currently available climate projections.

The impact of climate change on the agricultural sector can be viewed from two perspectives:

- Negative aspect, such as the occurrence of droughts, floods, erosion, landslides, storms, and hail, which is far more pronounced.
- Positive aspect, such as a longer growing season and more suitable conditions for certain crops, a positive effect on the yields and quality of winter crops due to an extended vegetation period.

To address these issues, a document was developed within the framework of the project "Enhancing the Process of Developing Bosnia and Herzegovina's (BiH) Climate Change Adaptation Plan (NAP) for Mid-Term Investment Planning in Climate-Sensitive Sectors in Bosnia and Herzegovina," which was funded by the Green Climate Fund (GCF) and implemented by UNDP in collaboration with the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, the Ministry of Spatial Planning, Civil Engineering and Ecology of Republika Srpska (as the UNFCCC focal point institution for Bosnia and Herzegovina), the Ministry of Agriculture, Forestry and Water Management of Republika Srpska, the Federal Ministry of Agriculture, Water Management and Forestry of the Federation of BiH, and the Federal Ministry of Environment and Tourism.

The Bosnia and Herzegovina Climate Change National Adaptation Plan – NAP[4] (2021) was presented with a proposal of measures intended to ensure vulnerability and risk assessments related to climate change and climate extremes, as well as possible adaptation options based on climate scenarios. *The Strategy for Climate Change Adaptation and Low-Emission Development of Bosnia and Herzegovina for the period 2020–2030* was adopted[5].

2 Our World in Data" is a scientific online publication that focuses on major global issues such as poverty, disease, hunger, climate change, war, and inequality.

3 Eutrophication is the process by which aquatic ecosystems become excessively enriched with nutrients, such as nitrates and phosphates, most often as a result of human activity.

4 The Bosnia and Herzegovina Climate Change Adaptation Plan – NAP (2021); https://www.undp.org/bs/bosnia-herzegovina/publications/plan-prilagodavanja-na-klimatske-promjene-bosne-i-hercegovine-nap
The NAP includes an analysis of the current regulatory framework and technical studies in BiH, climate change trends, future climate projections, an overview of impacts by sector, and proposals for mid-term measures to reduce the negative consequences of climate change on the most vulnerable sectors, including agriculture, water and forest resources, biodiversity, and tourism.

5 https://www.undp.org/sites/g/files/zskgke326/files/2023-08/BOS_Strategija%20prilagodjavanja%20i%20niskoemi-sionog%20razvoja%20BiH%202020-2030.pdf

Agriculture, as one of the strategic sectors of Bosnia and Herzegovina, is part of these documents, but there is no specific document proposing measures and recommendations for reducing CO_2 emissions in agriculture or measures to address the consequences of climate change. Based on the abovementioned, it is evident that agriculture is one of the economic activities where climate change has a significantly negative impact on operations. Therefore, this Climate Action Plan will focus on agriculture and attempt to define measures aimed at reducing CO_2 emissions, as well as measures to mitigate the consequences of climate change on agriculture in the Travnik Municipality.

Thus, this Climate Action Plan for agriculture in the Travnik Municipality holds significance for the further development of agriculture in this municipality. Specifically, the proposed measures for adapting to climate change in the agricultural sector of the Travnik Municipality are designed as a foundation for farmers, citizens, decision-makers, and all interested parties to implement them correctly, simply, and functionally. This ultimately leads to achieving a reduction in CO_2 and CH_4 emissions as a product of agricultural development and the attainment of sustainable development for society and the environment. Adapting to climate change requires the attention and involvement of all stakeholders, the economy, and decision-makers at national, regional, and local government levels. Measures should be tailored to assessed needs, implementation possibilities, and available capacities. Adapting to climate change entails significant costs, but ultimately, overall positive financial effects or a substantial reduction in negative impacts are expected, particularly if the implementation of adaptation measures begins early enough.

The Climate Action Plan is one of the activities of the SOFI (Smart Organic Food Initiative) project, co-financed by the European Climate Initiative (EUKI[6]), which funds climate protection projects across the European Union on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The SOFI project is an international initiative implemented by the Križevci College of Agriculture[7] as the lead partner, in collaboration with project partners: the Association for the Economy of Solidarity (Križevci, Croatia), the Centre for Lifelong Learning (Travnik, Bosnia and Herzegovina), and the Starkmacher Association (Mannheim, Germany). The ultimate goal of the SOFI project is to initiate, through its activities, results, and outcomes, the adoption of new, environmentally friendly decisions and solutions in the agricultural sector at the level of citizens, consumers, farmers, agricultural production, interested stakeholders, and municipalities.

By highlighting the potential of smart organic agriculture, the SOFI project has launched a green transition in the field of agriculture in the researched areas. In addition to developing climate action plans for the municipalities of Križevci and Travnik, a key activity of the project was the implementation of the Green Education Programme, which is focused on supporting business ideas in the field of organic agriculture.

In the development of the climate action plans for the municipalities of Križevci and Travnik, national associations for organic farming, agricultural advisory institutions, cooperatives, educational institutions, and other stakeholders participated, to whom we express our great gratitude for the assistance they provided during the preparation of these plans. Implementing this action plan will require full cooperation among all stakeholders: from citizens, farmers, the private and public sectors, to decision-makers at the local level, and possibly even at the regional or national level. This is essential because these measures will undoubtedly require financial resources for their implementation, but ultimately, positive effects on reducing CO_2 and CH_4 emissions are expected.

Finally, it should be noted that this is the first local climate action plan for agriculture in Bosnia and Herzegovina, a sector that, as previously mentioned, is highly exposed and vulnerable to climate change.

6 https://www.euki.de/en/

7 https://www.vguk.hr

1.1. Background and Legislative Framework

Bosnia and Herzegovina became a member of the United Nations Framework Convention on Climate Change (UNFCCC) on 6 December 2000 and operates in accordance with the convention's goals and objectives[8]. Although it is not a member of the EU, it strives to align with EU activities, directives, and recommendations related to climate change adaptation.

In developing strategic plans at all levels, efforts are made to incorporate measures and activities adopted as parts of international documents and events, such as:

1. *United Nations Framework Convention on Climate Change* (UNFCCC) [1], which aims to stabilise greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system.
2. *Kyoto Protocol* [2], an addition to the UNFCCC, is an international agreement on climate change signed with the aim of reducing carbon dioxide emissions and other greenhouse gases. Bosnia and Herzegovina ratified the Kyoto Protocol on 22 April 2007.
3. *Paris Agreement on Climate Change* [3], built upon the UNFCCC, unites all nations for the first time in a shared ambitious effort to combat climate change and adapt to its impacts, with enhanced support for developing countries to do so. It focuses on accelerating actions and investments needed for a sustainable low-carbon future. The goal is to keep the rise in global average temperature below 2°C by the end of the century, ideally limiting it to 1.5°C. The text includes, among other things, the following: "The Parties establish the global adaptation goal of enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change to contribute to sustainable development and ensure adequate adaptation measures in the context of the temperature goal." Bosnia and Herzegovina adopted the Paris Agreement on 12 December 2015.
4. *Goal 13 of the UN 2030 Agenda for Sustainable Development* [4], which pertains to taking urgent action to combat climate change and its impacts. In September 2015, Bosnia and Herzegovina, along with 192 other United Nations member states, committed to implementing the 2030 Agenda for Sustainable Development (Agenda 2030), consisting of 17 Sustainable Development Goals and 169 sub-goals.
5. *European Green Deal* [5], a strategy to achieve the sustainability of the EU economy by turning climate and environmental challenges into opportunities across all policy areas and ensuring a just and inclusive transition. Bosnia and Herzegovina adopted the European Green Deal in 2020.

In developing the Climate Action Plan, care was taken to ensure it aligns with national, regional, and local strategies and their respective action plans:

- Fourth National Communication on Climate Change of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change (UNFCCC) [6]
- Strategy for Climate Change Adaptation and Low-Emission Development of Bosnia and Herzegovina for the period 2020–2030.[9] [7]

8http://www.mvteo.gov.ba/data/Home/%D0%94%D0%BE%D0%BA%D1%83%D0%BC%D0%B5%D0%BD%D1%82%D0%B8/%D0%92%D0%BE%D0%B4%D0%BD%D0%B8%20%D1%80%D0%B5%D1%81%D1%83%D1%80%D1%81%D0%B8/Konvencije%20okoli%C5%A1/BOS_Okvirna_konvencija_Ujedinjenih_nacija_o_promjeni_klime.pdf

9 This document is part of the project "Preparation of the Fourth National Communication on Climate Change and the Third Biennial Report on Greenhouse Gas Emissions in Bosnia and Herzegovina," implemented by UNDP in partnership with the Ministry of Spatial Planning, Civil Engineering and Ecology of Republika Srpska, as the UNFCCC focal institution for Bosnia and Herzegovina. However, there are no strategies specific to entities, cantons, or municipalities, and consequently, there are no action plans addressing this issue, despite all interested parties in Bosnia and Herzegovina—including mayors and municipal heads—being aware of the need for involvement and taking steps related

- As part of the project "Launching Environmental Financing for Low-Carbon Urban Development," implemented by the United Nations Development Programme (UNDP) for 37 municipalities and cities, action plans are to be prepared in line with the Covenant of Mayors for Climate and Energy. The SECAP (Sustainable Energy and Climate Action Plan) is based on a baseline emissions inventory and risk and vulnerability assessments that include an analysis of the current situation. Unfortunately, these plans do not address the agricultural sector.
- Bosnia and Herzegovina Climate Change Adaptation Plan – NAP with proposed measures [8]
- Development Strategy of the Federation of Bosnia and Herzegovina 2021–2027 [9]
- Agriculture and Rural Development Strategy of the Federation of Bosnia and Herzegovina 2021–2027 [10]
- Development Strategy of Central Bosnia Canton 2021–2027 [11]
- Development Strategy of the Travnik Municipality 2022–2027 [12]

1.2. Methodology and Objective of Development

The methodology for developing this plan is based on the existing Integrated Local Development Planning Methodology (MiPRO)[10], which has been accepted and recommended by both entity-level bodies and the Association of Municipalities and Cities of both entities. The methodology is also in line with the Regulation on the Preparation of Strategic Documents of the Federation of Bosnia and Herzegovina (Official Gazette of FBiH, No. 32/17)[11].

The two fundamental principles of this methodology—sustainability and social inclusion—have been fully respected in the preparation of the Climate Action Plan for the Travnik Municipality. The principle of sustainability is grounded in the idea that natural and human systems must be regenerative (renewable) and balanced to endure. By adhering to the principle of social inclusion, the emphasis is placed on the requirement for social integration and cohesion, implying planning that demonstrates particular sensitivity to the needs and interests of socially vulnerable/marginalised groups.

Additionally, the following principles were respected:

- Partnerships: During the development process, the opinions of partner organisations (farmers' associations, the academic community, and representatives of local authorities) were included.
- Publicity and transparency: Information about the plan's development process was made available on the website of the entity responsible for its preparation, namely the Centre for Lifelong Learning (SCU), as well as on a joint web platform, which is one of the outcomes of this project.

In the preparation of the Plan, the principle of gender equality and equal rights for all residents of the municipality was upheld. Specifically, in the process of devising measures, the opinions of both men and women in agriculture were consulted, ensuring equal representation of their interests when defining goals and measures.

to climate change.

10 https://www.undp.org/bs/bosnia-herzegovina/publications/metodologija-za-integrirano-planiranje-lokalnog-razvoja-u-bih-mipro and http://www.dep.gov.ba/projekti/Latinica_MiPRO_teorijski%20dio_drugo%20izdanje.pdf

11 https://www.fbihvlada.gov.ba/bosanski/zakoni/2019/Uredbe/10h.htm

2. AGRICULTURE IN BOSNIA AND HERZEGOVINA

2.1. Geographical Characteristics of Bosnia and Herzegovina

Bosnia and Herzegovina is located in Southeast Europe, situated in the western part of the Balkan Peninsula. With a border length of 1,459 km, it shares boundaries with three countries and has access to the Adriatic Sea. Geographically, Bosnia and Herzegovina is situated between 41° and 45° north latitude and 15° and 20° east longitude, making its position highly significant for numerous regional transport routes as well as the ecological systems of the Balkan Peninsula.

The terrain of Bosnia and Herzegovina can be described as predominantly hilly and mountainous, and its entire territory can be divided into three main geographical units. The first unit is the mountainous region, as mountainous terrain dominates much of Bosnia and Herzegovina, particularly in the central, eastern, and western parts of the country. The second unit consists of valleys with river areas, which are the most suitable for settlement and agriculture. The third unit comprises the lowland and coastal areas, located in the north along the Sava River, where Posavina—a flat region ideal for agricultural production—is situated. Narrow coastal lowland with access to the sea is found in the southwest.

There are three main climatic zones in Bosnia and Herzegovina: a zone with a temperate continental climate, a zone with a mountain climate, and a zone with a Mediterranean climate. Bosnia and Herzegovina is frequently affected by extreme weather conditions, such as heavy and sudden rainfall that can lead to flooding, as well as droughts, particularly in the southern regions. The diversity of climatic zones contributes to a wealth of flora and fauna, as well as varied lifestyles, economic activities, and habits of the population.

This diversity is reflected in the large number of plant and animal species, habitats, and ecosystems that constitute the country's natural wealth. Bosnia and Herzegovina is home to over 5,000 plant species, and in terms of fauna, it hosts numerous species of mammals, birds, fish, amphibians, and insects. It should be noted that Bosnia and Herzegovina is one of the centres of endemism in the Balkans, with many species found nowhere else in the world. Maintaining and protecting this diversity is crucial for the future of ecosystems and biodiversity in the region.

The demographic profile of Bosnia and Herzegovina has been shaped by historical events, migrations, and political changes. According to the population census conducted in 2013, approximately 3.3 million people lived in Bosnia and Herzegovina; however, estimates suggest that by 2023, this number had decreased to 3.21 million inhabitants. The country is multi-ethnic, with three constituent peoples: Bosniaks, Serbs, and Croats. In addition to these groups, there are also minorities such as Roma, Jews, Albanians, and others. Bosnia and Herzegovina has a relatively low level of urbanisation compared to developed European countries. Around 40% of the population resides in urban areas, while the remainder lives in rural environments. According to available data, approximately 80% of Bosnia and Herzegovina's territory is considered rural.

Sarajevo is the capital city, while other significant cities include Banja Luka, Mostar, Tuzla, and Zenica. In recent years, the country has faced depopulation, particularly in rural areas. Many young people emigrate in search of better economic opportunities, leading to an ageing population. The birth rate is low, while the mortality rate is relatively high, contributing to the overall decline in population.

2.2 Political System and Economy of Bosnia and Herzegovina

Bosnia and Herzegovina, a country with a rich history, now nearly 30 years after the end of the war, has a complex state structure as it comprises two entities: the Federation of Bosnia and

Herzegovina and Republika Srpska, along with the Brčko District. The Federation of Bosnia and Herzegovina occupies 51% of the country's total area and consists of ten cantons with broad competencies, each having its own Government and Assembly. Republika Srpska covers 49% of Bosnia and Herzegovina's territory and has a National Assembly and Government of Republika Srpska, with levels of governance including municipalities or cities and the entity itself.

The currency of Bosnia and Herzegovina is the Convertible Mark (KM) with a fixed exchange rate, as the Currency Board has firmly pegged the BiH currency to the Euro at a rate of 1 EUR = 1.955830 KM.

The structure of the economy in Bosnia and Herzegovina is complex and characteristic of countries with transitional economies. The economy comprises three main sectors: the primary sector (agriculture, forestry, fisheries), the secondary sector (industry, mining, construction), and the tertiary sector (services).

The primary sector is mainly based on agriculture, which is vital for rural areas that make up nearly 80% of the territory and serves as the foundation for the livelihoods of a significant portion of the population. In recent years, there has been a noticeable decline in the share of agriculture in the country's total gross domestic product (GDP).

The secondary sector is divided into the industrial sector, which constitutes a significant portion of GDP. Traditionally, Bosnia and Herzegovina is known for metal production, particularly steel and aluminium. Key sectors also include the automotive and textile industries, as well as furniture manufacturing. Bosnia and Herzegovina possesses substantial natural resources, including coal, hydropower, and to a lesser extent oil and gas, making mining and energy critical sectors, especially in the Federation of Bosnia and Herzegovina entity. In recent years, construction has shown growth, particularly in residential and infrastructure development.

The tertiary sector, particularly the part related to services, is the largest sector in terms of its share of GDP, encompassing trade, transport, tourism, financial services, education, and healthcare.

Despite notably unfavourable conditions in both domestic and global markets during 2023, the GDP amounted to 25,026,590 EUR, with the added note that GDP has shown a consistent upward trend year on year. GDP per capita in Bosnia and Herzegovina in 2023 was approximately 35% of the European Union average.

Regarding the economy, its structure highlights industry, given the existing base that includes the energy sector, metals, chemicals, wood, and textile industries. However, many industrial facilities are outdated and require modernisation. Agriculture in Bosnia and Herzegovina constitutes a smaller portion of GDP, but it continues to have a significant impact on employment, particularly in rural areas. The service sector, including tourism, trade, and transport, is increasingly contributing to the economy, with tourism, in particular, showing substantial potential for growth.

2.3 Agriculture in BiH

The territory of Bosnia and Herzegovina can be divided into several geographical and climatic units, each with distinct natural and climatic conditions, which is significant from the perspective of agricultural development conditions that vary considerably across these units. Agriculture in Bosnia and Herzegovina is predominantly oriented towards livestock farming in mountainous areas and intensive agriculture in the more fertile lowland regions.

The first and largest unit, comprising approximately 70% of Bosnia and Herzegovina's territory, is the mountain-basin region, or the central Bosnia area, which includes the Dinaric Alps and the Sarajevo, Zenica, and Travnik basins. This is a hilly-mountainous area with peaks ranging from 500 to 2,000 metres. The climate in this region is continental-mountainous, characterised by harsh winters and mild summers, with abundant precipitation in higher elevations. In the lower basins

and valleys, it is possible to successfully cultivate various agricultural crops, while in the higher, mountainous parts, conditions for organising agricultural production are significantly more challenging. Livestock farming dominates this unit, particularly the rearing of cows and sheep, along with milk and meat production. The characteristics of this area include the abundance of clean water sources in lower regions, while the mountainous terrain hinders the significant use of mechanisation and other infrastructure.

The second largest unit, known as the Pannonian Lowland, constitutes 15% of Bosnia and Herzegovina's total territory and encompasses the northern part of the country. This region, known as Posavina and part of Semberija, stretches along the Sava River and includes cities such as Brčko, Bijeljina, and Orašje. Until recently, the climate here has been continental, with warm summers and cold winters, and evenly distributed precipitation. This area offers favourable conditions for agriculture due to its fertile soil and moderately continental climate, making its surface suitable for growing various types of cereals, vegetables, and livestock farming. Its advantages include flat terrain, rich alluvial soils, and a moderately humid climate that supports intensive agriculture and high yields.

The third unit, accounting for between 10 and 12% of Bosnia and Herzegovina's territory, is the Podrinje region, which covers the eastern part of the country along the Drina River. The area is predominantly hilly with valleys formed by the Drina River and its tributaries. The climate can be described as moderately continental, with characteristics of a mountain climate at higher elevations. Podrinje offers favourable conditions for agriculture, particularly in the lower areas along the Drina River, where the soils are fertile and sufficiently moist for various crops. In the hilly parts, conditions are more challenging and better suited to livestock farming. The soils are fertile and alluvial, with an abundance of water resources, though the hilly terrain in higher areas poses limitations to significant agricultural development.

Approximately 5 to 7% of Bosnia and Herzegovina's territory comprises the Herzegovinian hinterland, or High Herzegovina, characterised by mountainous terrain, including mountains such as Prenj, Čvrsnica, and Velež, and karst fields like the Mostar and Popovo fields. The climate is transitional between Mediterranean and continental, with hot summers and cold winters. This region features a karst landscape with dry and warm climatic conditions that are quite restrictive for agricultural development. This refers primarily to conditions such as drought, karst terrain, and a lack of arable land. Nevertheless, it is possible to cultivate certain drought-resistant crops, such as grapevines and olives.

The fifth unit is the Herzegovinian Coast, which constitutes about 0.5% of Bosnia and Herzegovina's total territory and is located in the southern part of the country, encompassing cities such as Mostar, Čapljina, and Neum. This area borders the Adriatic Sea. The climate is Mediterranean, with warm and dry summers and mild, rainy winters. This region has a Mediterranean climate conducive to growing olives, grapevines, citrus fruits, and vegetables. However, there is a paradox in the Herzegovinian Coast: while the climatic conditions provide excellent opportunities for agricultural crops typical of the Mediterranean region—such as olives, grapevines, and citrus—natural limitations (karst terrain and limited arable land) reduce its potential for larger-scale agricultural production.

Although nearly 80% of the country consists of rural areas with more than adequate conditions for development, according to data from the Agency for Statistics of Bosnia and Herzegovina, the agricultural sector accounted for approximately 6% of the total GDP in 2023 and 2022, which is relatively small compared to other economic sectors. Expressed in monetary terms, the value of agriculture's contribution to the country's total GDP in 2023 was approximately 1.9 billion euros.

Regarding the gross value added of primary activities in agriculture, forestry, and fishing, estimates from the Agency for Statistics of Bosnia and Herzegovina indicate that in 2023, at current prices, it amounted to 2.13 billion, representing 4.14% of the total gross value added of the Bosnia

and Herzegovina economy. Compared to 2022, the nominal decline in the gross value added of agriculture, forestry, hunting, and fishing was 3%.

The agricultural sector should be of key importance, especially for the rural population of Bosnia and Herzegovina, as it offers employment opportunities for a large number of residents. Although the contribution of agriculture to the total GDP can be considered decent, this sector has faced numerous challenges in recent years, including low yields and a lack of arable land. Generally, agriculture in Bosnia and Herzegovina contributes less than the average of EU countries, and issues such as fragmented agricultural holdings and unprocessed land further hinder the development of this sector.

2.4. Land Resources in BiH and Their Utilisation

According to data from the Agency for Statistics of Bosnia and Herzegovina, the total area of agricultural land in Bosnia and Herzegovina is approximately 2.2 million hectares, of which 1.6 million hectares is arable land and 600,000 hectares are pastures. Of these areas, only 48% of the land is used for active agricultural production, while the remainder is largely not utilised for any form of agricultural activity. "During 2022, approximately 535,000 hectares of agricultural land were used in Bosnia and Herzegovina. In the structure of the utilised areas, the most prevalent are arable fields, covering 248,000 hectares, and permanent grasslands (meadows and pastures). Orchards account for 28,000 hectares, gardens for 9,000 hectares, vineyards for 2,400 hectares, while nurseries occupy the smallest area, at 180 hectares.[12]" (Table 1).

Table 1. Structure of agricultural areas in BiH in 2022.

	Arable land	Gardens	Orchards	Vineyards	Permanent grasslands	Nurseries	Total
Area in ha	247.880	8.890	27.990	2.360	247.500	0,18	**534.750**

Source: Authors' calculation based on data from the Agency for Statistics of BiH

During 2023, approximately 411 thousand hectares of agricultural land in BiH were sown with various crops in the spring and autumn sowing seasons. Cereals dominated the sown crops, covering 233,055 hectares or 57% of the land. Forage crops were sown on 97,378 hectares (24%), while potatoes, legumes, and other root vegetables were cultivated on 40,821 hectares (10%). The remaining 9% of the land was primarily used for industrial crops, tobacco, herbs, and other vegetables.

2.5. Plant Production

Plant production includes various types of cultivation, such as crop farming, vegetable growing, fruit growing, and viticulture. Its importance lies in providing raw materials for the food industry, livestock farming, and other economic sectors.

2.5.1. Cereal production

In 2023, during the spring and autumn sowing seasons, a total of 1,440,264 tonnes of various cereal crops were produced on 310,429 hectares. In the production structure, corn for grain accounted for approximately 73% of the total output, followed by wheat with a 19% share, barley at 4%, triticale at 3%, and other cereals making up 2% (Table 2).

12 Ministry of Foreign Trade and Economic Relations of BiH "Annual Report on Agriculture, Food and Rural Development for BiH for 2023", Sarajevo, May 2024.

Table 2. Cereal production in BiH in 2023

Cereals	Harvested area (ha)	Total production (tonnes)
Corn for grain	183.950	1.045.683
Wheat	62.659	275.167
Oats	37.433	17.502
Barley	15.596	53.064
Triticale	7.770	38.850
Rye	3.021	9.997
Total	**310.429**	**1.440.264**

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of Bosnia and Herzegovina and the Republic Institute of Statistics of RS[13].

2.5.2. Production of industrial crops in BiH

In 2023, agricultural producers in BiH cultivated the most important industrial crops, such as sunflower, tobacco, and soybean, on a total area of 12,807 hectares (Table 3).

Table 3. Industrial crop production in BiH in 2023

Crop	Harvested area (ha)	Total production (tonnes)
Soybean	10.806	25.695
Sunflower	1.189	2.813
Tobacco	812	1.690
Total	12.807	30.198

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and the Republic Institute of Statistics of RS[14].

2.5.3. Forage crop production

Forage crops play a key role in agriculture by providing essential nutrients necessary for animal growth and health. Their use is crucial for sustainable agriculture, contributing to cost-effective and environmentally-friendly food production. In BiH, the total production of forage crops and grass-clover mixtures in 2023 amounted to 659,194 tonnes, with almost 92% produced in the Federation. The leading crops in this category include maize for green fodder, alfalfa, grass-clover mixtures, pure clover, fodder beet, and mixtures of grasses and cereals.

2.5.4. Vegetable production

Vegetable production in Bosnia and Herzegovina is one of the key sectors of crop production, which faced numerous challenges in 2023, affecting yields, economic sustainability, and the overall agricultural situation in the country. In 2023, 58,043 hectares of arable land were sown with various vegetable crops, resulting in a total production of 829,547 tonnes of diverse vegetables (Table 4).

13 Statistical Yearbook of the Federation of Bosnia and Herzegovina, 2024 Edition and http://www3.rzs.rs.ba:8080/rzs/faces/indicators.xhtml

14 Statistical Yearbook of the Federation of Bosnia and Herzegovina, 2024 Edition and http://www3.rzs.rs.ba:8080/rzs/faces/indicators.xhtml

Table 4. Vegetable production in BiH in 2023.

Crops	Sown area (ha)	Production (tonnes)
Potatoes	38.417	565.548
Beans	4.989	11.000
Common onion	4.303	60.152
Cabbage and kale	3.747	70.919
Tomato	2.763	49.944
Peppers	2.757	60.957
Carrot	1.067	11.028
Total	**58.043**	**829.547**

2.5.5. Fruit production

The main characteristics of fruit production are the diversity of crops. The production of plums and raspberries is particularly important, given the tradition and export potential. Despite numerous challenges, producers have made efforts to maintain high fruit quality, particularly for export, and orchardists continued to apply modern techniques and standards to meet the demands of foreign markets, especially the EU. The majority of fruit production in BiH comes from small family farms. This production structure allows for flexibility but is also vulnerable to economic and climate-related challenges. In recent years, interest in organic fruit production has been increasing. However, this sector faces challenges related to organic certification and access to markets.

In fruit production in BiH, plums (53%), apples (35%), and pears (8%) are the most represented, although a large number of other fruit species such as sweet cherries, sour cherries, peaches, and subtropical fruits are also grown. The total production of the most common fruits in BiH in 2023 amounted to 307,823 tonnes (Table 5).

Table 5. Fruit production in BiH in 2023

Crop	Plums	Apples	Pears	Peaches	Sweet cherries	Sour cherries	Total
Production (tonnes)	163.767	106.858	23.206	6.468	4.869	2.654	307.822

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[15].

Viticulture in BiH has a long tradition, especially in Herzegovina, where the climatic conditions are most suitable for grapevine cultivation. In addition to Herzegovina, grapevine cultivation has been intensifying in central BiH in recent years. Herzegovina is home to some indigenous varieties such as Žilavka (a white variety) and Blatina (a red variety), which are symbols of Herzegovinian viticulture. In addition to indigenous varieties, international varieties such as Merlot, Cabernet Sauvignon, Syrah, Chardonnay, and Sauvignon Blanc are also grown. The total area under intensive vineyard plantations in BiH in 2023 amounted to 4,535 hectares, producing 28,609 tonnes of grapes.

2.6. Livestock Production and Livestock Population in BiH

Livestock production is one of the significant sectors of agriculture in Bosnia and Herzegovina, with a long tradition, especially in rural areas. Although this sector faces numerous challenges, it

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remains an important source of income for many agricultural households and has great potential for development. In the area of cattle farming, which is particularly developed in the northern parts of the country, the most common breeds are beef cattle and dairy cows. Sheep farming, especially the indigenous breed such as the Pramenka, is most prominent in the mountainous and hilly regions of BiH, such as Herzegovina, Romanija, and Eastern Bosnia. Pig farming is less common compared to cattle and sheep farming, but it is present in lowland areas and smaller family farms. Poultry farming is relatively developed, especially for egg and meat production, with modern farms producing for both the domestic market and export. In recent years, there has been an increasing interest in goat farming, with a focus on production of milk and dairy products.

Most livestock production takes place on small and medium-sized family farms and is often combined with crop production. There are fewer commercial farms in BiH that engage in intensive meat, milk, and egg production, using modern technology. BiH is home to several indigenous breeds, such as Buša (cattle), the previously mentioned Pramenka (sheep), and the Balkan goat, and it can be said that these breeds are adapted to local conditions, although they are often less productive compared to modern breeds.

According to available data from state and entity agencies and statistical institutes, in 2023, the livestock population in BiH totaled 1,917,054 head of livestock (Table 6).

Table 6. State of the livestock population in Bosnia and Herzegovina in the 2022 and 2023 period

Species	Sheep	Pigs	Cattle	Goats	Total
Number of heads 2022	1.065.043	499.705	392.163	63.075	2.019.986
Number of heads 2023	1.029.138	441.714	383.486	62.716	1.917.054

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[16]

Based on these data, it is evident that the number of heads of livestock declined in 2023 compared to 2022.

2.6.1. Production of milk and dairy products

Milk production is one of the most important sectors of livestock farming in BiH, with a significant share in total agricultural production. Dairy farming is particularly developed in the northern parts of the country. Posavina, Krajina, and parts of Semberija are regions with the most developed dairy farming, thanks to fertile plains suitable for growing fodder plants and the proximity to major processing centres. Milk production is also present in central Bosnia, where there are a larger number of small farms with lower yields per head. Generally, most of the milk in BiH comes from small and medium-sized family farms, which have between 5 and 20 cows. A significant portion of producers and processors have adopted international quality standards, such as HACCP[17] and EU standards, which is crucial for the export of dairy products. However, on smaller farms, challenges still exist in maintaining high milk quality, which can affect purchase prices and the market (Table 7).

16 Statistical Yearbook of the Federation of Bosnia and Herzegovina, 2024 Edition and http://www3.rzs.rs.ba:8080/rzs/faces/indicators.xhtml

17 HACCP (Hazard Analysis and Critical Control Points) is a food safety management system used to identify, assess, and control potential risks in the production, processing, and distribution of food.

Table 7. The number of dairy animals in BiH in 2022 and 2023 period

Dairy animal	2022	2023
Cows	183.745	178.456
Sheep	213.385	216.572
Goats	30.555	33.042

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[18]

During 2023, the raw milk production amounted to 636 million litres of milk, which is 2% higher compared to production in 2022 (Table 8).

Table 8. Raw milk production in BiH in 2022 and 2023 period

Raw milk	2022	2023
Cow's milk	603	616
Sheep's milk	12	12
Goat's milk	7	8
Total	**622**	**636**

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[19]

"On average, 40-45% of raw cow's milk is purchased by dairies, while significant quantities of milk (up to 60%) are processed directly on the farms, such as in the production of cheese, cream, yoghurt, etc., or are used for personal consumption and sold at markets. The low percentage of milk that is purchased (below 50%) indicates the extensive nature and low market orientation of domestic raw milk production."[20]

2.6.2. Egg production

Egg production in BiH is also an important segment of livestock farming, meeting part of the domestic market's needs and holding potential for growth and export. Although facing challenges, the sector is continuously developing and modernising. Central and northern Bosnia are the areas with the highest concentration of producers, including large commercial farms that use modern technology for intensive production. A smaller number of farms are also located in Herzegovina. The majority of egg production comes from commercial farms that utilise modern technologies, such as battery cages, free-range systems, and organic production methods. Many small farms and family holdings also contribute to egg production, but on a much smaller scale compared to large farms. In recent years, many farms have aligned their production with local and international standards for food quality and safety. There is a growing number of farms implementing standards for organic products and free-range systems. There is also increasing interest in product certification, such as "free-range" or organic eggs, which enhances their competitiveness in the market.

In 2023, a total of 768.4 million eggs were produced, of which approximately 471 million were produced in Republika Srpska, 291.2 million in the Federation of BiH, and around 6.5 million in

18 Statistical Yearbook of the Federation of Bosnia and Herzegovina, 2024 Edition and http://www3.rzs.rs.ba:8080/rzs/faces/indicators.xhtml

19 Ibidem

20 Ministry of Foreign Trade and Economic Relations of BiH "Annual Report on Agriculture, Food and Rural Development for BiH for 2023", Sarajevo, May 2024.

the Brčko District of BiH. Compared to 2022, total hen egg production increased by 8% (Table 9).

Table 9.Egg production in BiH in 2022 and 2023 period

	2022	2023
Number of laying hens (in millions)	3,8 million	3,7 million
Total egg count (in millions)	714,4 million	768,4 million
Total egg count per laying hen	190	207

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[21]

2.6.3. Meat production

Meat production in Bosnia and Herzegovina encompasses different types of meat, including beef, pork, sheepmeat, and poultry. Cattle farming is particularly developed in the northern and central parts of the country, where large farms operate, and traditional breeding methods are applied. Pig farming is less prevalent compared to cattle farming and is mostly found in lowland areas and on smaller farms. Sheep farming is concentrated in mountainous regions, particularly in Herzegovina and central Bosnia, with indigenous sheep breeds such as the Pramenka contributing to this production. Poultry farming is well developed in BiH, with large farms engaged in meat and egg production.

The majority of meat production comes from small and medium-sized family farms, which often combine livestock farming with crop production. There are fewer commercial farms engaged in intensive meat production, using modern technology to enhance efficiency and productivity.

In slaughterhouses across BiH, a total of 217,466 animals were slaughtered in 2023, yielding a total of 18,309 tonnes of meat (Table 10).

Table 10. Meat production in BiH in 2022 and 2023 period

	2022		2023	
Cattle	Number of heads	Weight (t)	Number of heads	Weight (t)
Goveda	43.424	10.720	40.044	10.125
Sheep	72.878	1.205	84.186	1.365
Pigs	104.424	7.953	93.236	6.819
Total	**220.726**	**19.878**	**217.466**	**18.309**

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[22]

"Poultry meat production is one of the leading meat production sectors in BiH. Poultry meat accounts for approximately 80% of the total net production of fresh meat in slaughterhouses. Additionally, the increase in production capacity and the number of poultry processed in slaughterhouses has contributed to the overall rise in net fresh poultry meat production. Furthermore, the expansion of production followed the approval for poultry meat exports to the European Union market."[23]

In 2023, a total of 72,180 tonnes of poultry meat was produced in BiH, compared to 69,871 tonnes

21 Ibidem

22 Ibidem

23 Ministry of Foreign Trade and Economic Relations of BiH "Annual Report on Agriculture, Food and Rural Development for BiH for 2023", Sarajevo, May 2024.

in 2022. In 2023, slaughterhouses processed 44.6 million poultry, whereas in 2022, this figure stood at 43.6 million.

2.6.4. Fish farming and production

Fish farming and production in BiH is a sector with significant potential, experiencing steady growth due to increasing demand for fish and fish products, as well as a rising interest in sustainable food production. The most commonly farmed species include trout (especially brown trout), carp, and grass carp.

In 2023, the total production of marketable freshwater fish in BiH amounted to 3,907 tonnes, representing a 2% increase compared to 2022. Of the total freshwater fish production, approximately 96% was trout, 3% was carp, and 1% consisted of other freshwater fish species (Table 11).

Table 11. Freshwater fish production in BiH in 2022 and 2023 period

	2022	2023
Trout (tonne)	3.387	3.767
Carp (tonne)	349	123
Other freshwater fish (tonne)	33	17

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[24]

2.6.5. Honey production

Honey production in BiH has a long tradition and significant potential for growth. The honey is known for its high quality and distinctive taste, attributed to the country's diverse flora and rich biodiversity. Beekeeping is most prevalent in central Bosnia and Herzegovina, where traditional techniques are still widely used, though modern beekeeping methods are becoming increasingly common.

Beekeepers are placing greater emphasis on maintaining honey quality, which includes testing for pesticides, antibiotics, and other contaminants. There is also growing interest in obtaining organic certification and producing specialized honey products to enhance market competitiveness.

Honey production in 2023 was affected by unstable weather conditions in the spring and a dry summer, leading to lower-than-expected yields. The average honey yield per hive was 8.5 kg (Table 12).

Table 12. Honey production in BiH in 2022 and 2023 period

	2022	2023
Number of hives	3.387	3.767
Honey production (in tonnes)	349	123
Honey yield per hive (in kg)	33	17

Source: Authors' calculation based on data from the Institute for Statistics of the Federation of BiH and Republic Institute for Statistics of RS[25]

24 Statistical Yearbook of the Federation of Bosnia and Herzegovina, 2024 Edition and http://www3.rzs.rs.ba:8080/rzs/faces/indicators.xhtml

25 Statistical Yearbook of the Federation of Bosnia and Herzegovina, 2024 Edition and http://www3.rzs.rs.ba:8080/rzs/faces/indicators.xhtml

2.7. Number of Agricultural Holdings and People Employed in Agriculture

Agricultural holdings in Bosnia and Herzegovina form the backbone of agricultural production and play a crucial role in the rural economy. These holdings are predominantly family-run and small in scale, which is a defining characteristic of most agricultural systems in the country.

The majority of agricultural holdings are small, with an average size of approximately 3–5 hectares. Land fragmentation is a significant challenge, making efficient and competitive production more difficult. Many family farms rely on household members for all stages of production, with more than 90% of farms falling into this category.

According to data from the Registers of Agricultural Holdings in the Federation of BiH, Republika Srpska, and Brčko District, a total of 133,752 agricultural holdings were registered in BiH in 2023. Of these, 128,153 were family farms, while 5,533 had the status of legal entities. Additionally, 91,000 individuals were officially recorded as employed in agriculture in 2023.

2.8. Other Characteristics of Agriculture in BiH

Among other key characteristics of agriculture in Bosnia and Herzegovina, the following three attributes should be highlighted:

1. Biodiversity in agriculture

Biodiversity in BiH plays a key role in preserving ecosystems and ensuring the sustainable development of agriculture. This biodiversity includes a large number of plant and animal species, including many endemic species found only in this region. BiH has exceptional natural resource wealth due to the various ecological zones that extend from the Mediterranean to the continental climate area.

The impact of biodiversity on agricultural production is reflected, among other things, in the preservation of traditional plant varieties and animal breeds. Many traditional plant varieties and animal breeds adapted to local conditions help sustain agricultural production. These varieties often have greater resistance to diseases, pests, and climate change compared to modern varieties. The diversity of plants and animals contributes to the greater resilience of ecosystems to stress factors such as climate change and soil degradation. This enables agriculture to be more stable and productive in the long term. Forests, wetlands, and other natural ecosystems in BiH provide essential ecosystem services, such as pollination, water resource regulation, and erosion control, which are crucial for agricultural production. The use of biodiversity can reduce the need for chemical inputs in agriculture, thereby minimizing environmental impact and enabling healthier food production.

2. The importance of agriculture in a healthy diet

Agriculture can play a key role in combating obesity in BiH by promoting healthy eating and ensuring access to nutritionally rich food. Data for 2023 indicate a concerning trend of increasing obesity in BiH, particularly among children and young people. Reports show that obesity is becoming more widespread, with younger generations being the most affected.

3. Organic production and certification in BiH agriculture

Organic production in BiH is growing in response to the increasing interest in healthy food and environmentally sustainable agriculture. This type of production involves growing plants and raising animals without the use of synthetic chemicals, pesticides, herbicides, or genetically modified organisms (GMOs).

A key characteristic of organic production is the increasing number of producers. In recent years, the number of certified organic producers has been rising, driven by both domestic and

international demand for organic products, as well as support through various programs and projects. Data shows significant interest among producers in obtaining certification in areas such as fruit growing, vegetable farming, beekeeping, and even cereal and livestock production.

Organic agriculture in BiH was launched in 2000 and has seen an annual growth rate of 10-20%. The share of organic products in the EU market in 2020 was 9.1%. Between 2013 and 2016, the area dedicated to organic crop cultivation increased significantly, from 292 hectares to 659 hectares, representing a 126% rise. The value of exported organic products from BiH to foreign markets in 2017 amounted to four million euros, which was 14% higher than the previous year and double the value compared to 2015. The main countries importing organic products from BiH include Germany, the Netherlands, Denmark, Italy, Sweden, and Switzerland[26].

The value of organic production in BiH continued to grow in 2023, although the sector remains relatively small. However, it is significant that consumer awareness of the benefits of consuming organic products has increased, further driving the sector's growth. Despite these positive trends, additional investments and strategic measures are needed for the further development of organic production.

2.9. Agricultural Funding in BiH

In 2023, national, entity, cantonal, and Brčko District authorities allocated a total of 434.2 million BAM (221.98 million EUR) in various forms of support for agriculture and rural development. The budget for agriculture and rural development has been continuously increasing year after year, with the amount allocated in 2023 being 62% higher than in 2022. In BiH, there are five categories of agricultural support: direct subsidies, rural development measures, market and price measures, general agricultural services, and other measures.

26 Report on the status of organic agriculture and industry in Bosnia and Herzegovina 2022.

3. AGRICULTURE IN TRAVNIK

3.1. Geographical Characteristics

The municipality of Travnik is located in the central region of Bosnia and is part of the Central Bosnia Canton, where it serves as the administrative centre. Travnik is situated at an altitude of 517 meters, covering an area of 529 km^2. According to estimates from 2023, the municipality had a population of 51,181. Travnik is the most populous municipality in the canton, consisting of 90 settlements grouped into 34 local communities.

Image 1. Position of the municipality of Travnik within the Central Bosnia Canton

Source: https://sbk-ksb.gov.ba/hr/o-kantonu.html

The municipality of Travnik is situated in the basin of the Lašva River, bordered to the north by Mount Vlašić (1,943 m above sea level), which belongs to the series of continental Dinaric Alps, while to the south are located the branches of Mount Vilenica (1,235 m above sea level). In addition to the Lašva River, which flows through this municipality for 52 km, the entire area is rich in both large and small watercourses, the most significant of which are the Ugar River, with a total length of 45 km, and the smaller Hendek and Šumeće rivers, which are tributaries of the Lašva.

The basin where the municipality is located is narrow and stretches from Turbe to Dolac na Lašvi, where it begins to expand into the Travnik valley. The entire Lašva Valley serves as a natural connection between the Vrbas River region to the west and the Bosna River to the east, giving it significant transport and strategic importance. Travnik is almost entirely positioned along a major road that runs through the Lašva Valley, linking central Bosnia with the northwestern regions as well as with the Adriatic coast. This area is characterised by a high volume of road traffic, primarily of a transit nature, which is crucial for the development of the municipality of Travnik. The average distance from Travnik to major regional centres such as Sarajevo, Mostar, Banja Luka, and Tuzla ranges from 100 to 170 km.

Due to the river flows, the terrain of the Travnik municipality is predominantly flat, making it suitable for intensive vegetable and crop production. Additionally, the area exhibits so-called soil zonation based on altitude and terrain inclination. There are distinct zones, including the lowland flat area in the Lašva River Valley, which is ideal for arable farming and vegetable production.

The second zone is slightly higher, consisting of gently sloping hills that are suitable for growing

fodder crops, fruit, and vegetables. This zone serves as a transition between the alluvial lowland soil and the mountain pastures.

The final third zone is located at higher altitudes and is suitable for growing cereals and seed potatoes. The municipality of Travnik is surrounded by mountains featuring extensive pastures on almost untouched mountain meadows, which serve as the foundation for livestock farming.

The Travnik area is known for its rich flora and fauna, as well as various endemic species. Notably, several plant species found here are endemic to the Dinaric Alps and the Balkan Peninsula.

Regarding fauna, Travnik is home to several species listed in the Red Book[27], including the brown bear (*Ursus arctos L.*), wolf (*Canis lupus L.*), griffon vulture (*Gyps fulvus Hablizl*), roe deer (*Capreolus capreolus*), beech marten (*Martes foina Erxleben*), and rock partridge (*Alectoris graeca Meisner*).

Based on these factors, it can be concluded that the municipality of Travnik has an exceptionally favourable geostrategic position, situated almost in the centre of Bosnia and Herzegovina. Thanks to its geographic location and climate, the municipality offers suitable conditions for agricultural development, particularly vegetable farming.

Image 2. Travnik

Source: https://travnik.ba/jesen-u-travniku-pogledajte-fotografije/

3.2. Socio-Demographic Characteristics

According to data from the Federal Institute of Statistics, the municipality of Travnik had a population of 51,181 in 2023, which is 2,301 fewer than recorded in the 2013 census. The municipality consists of 90 inhabited settlements, with an overall population density of 96.8 in 2023.[28]

In terms of age structure, in 2023, there were 35,741 people aged between 15 and 64 years, 8,555 residents aged 65 and older, and 6,885 people in the youngest age group (0–14 years). Over the past five years, Travnik has experienced negative natural population growth, with a rate of -2.4 in 2023 compared to -3.7 in 2022. The birth rate in 2023 remained at 6.8, the same as in 2022.

The negative natural population growth trend can be attributed to a declining number of live births, coupled with a simultaneous increase in the number of deaths. As a result of these demographic shifts, the municipality of Travnik is experiencing an imbalance in its age structure.

The municipality of Travnik has 24 elementary schools, with 4,031 students enrolled for

27 The Red Book is a document that records and systematises species of plants, animals, and fungi that are endangered or facing extinction.

28 Institute for Statistics of the Federation of Bosnia and Herzegovina, "Central Bosnia Canton in Figures 2024"

the 2023/2024 school year. According to data from the Federal Institute for Development Programming provided in the "Socioeconomic Indicators by Municipalities in the Federation of Bosnia and Herzegovina for 2023," there were 2,839 students enrolled in six secondary schools in the municipality for the 2023/2024 school year.

Travnik is also home to three universities: the University of "VITEZ," the International University of Travnik, and the University of Travnik. A total of 4,028 students were enrolled in these institutions for the 2023/2024 academic year.

Of the 51,181 residents in the municipality of Travnik in 2023, 35,741 were of working age[29]. The Federal Institute of Statistics classified 20,357 people as part of the workforce in 2023. According to data from 2023, the employment rate in the municipality was 69.8%. Compared to 2022 and 2021, the employment rate decreased by about 0.6%.

In 2023, there were 7,121 unemployed people in the municipality, a slight decrease compared to 7,551 unemployed in 2021. Among the unemployed, 166 had higher education (VSS), 370 had post-secondary education (VŠS), and 1,839 had secondary school qualifications (SSS). The remaining unemployed individuals (4,753) had lower education levels, including unqualified (2,535), skilled (2,135), highly skilled (12), and semi-skilled (64) qualifications.

The unemployment rate in 2023 was 30%, with 3,468 of the unemployed individuals being women.

According to data from the Federal Institute for Development Programming, there were 8,560 pensioners in the municipality of Travnik in 2023. Based on the aforementioned data, it can be concluded that for every pensioner in this municipality, there are 1.6 employed workers.

3.3. Economy in the Municipality of Travnik

The municipality of Travnik belongs to the third group of municipalities by development level and ranks 34th in the Federation in terms of development in 2023. Compared to 2022, the municipality dropped one position on the scale, with the most significant factors influencing this decline being employment rate, income from income tax, the proportion of the elderly population, and the level of educated workforce.

3.3.1. The number and structure of business entities

Over the past five years, the municipality of Travnik has seen an increase in the number of business entities, both legal and natural persons. A significant growth in the total number of business entities has been recorded in the establishment of businesses by individuals and craftsmen, among whom is a certain number of people engaged in various forms of agricultural production (Table 13).

29 The working-age population includes those aged 15-64, of which 13.236 were employed, earning an average salary of 1,060 BAM.

Table 13. Structure of business entities

	Population	Total	Legal persons	Business units within legal persons	Natural persons – craftsmen	Number of businesses per 1000 persons
2019	52.487	2.686	1.060	628	998	51,2
2020	52.308	2.757	1.082	636	1.039	52,7
2021	51.813	2.821	1.109	649	1.063	54,4
2022	51.469	2.851	1.127	646	1.078	55,4
2023	51.181	2.911	1.152	664	1.095	56,9

Source: Development Programming Institute of Federation of BiH, Socioeconomic indicators by municipalities in Federation BiH, in the period 2014-2023

In terms of activities in the area of Travnik municipality, the largest number of business entities are engaged in trade and hospitality (Table 14).

Table 14. Number of business entities by type of activity in the period 2019-2023

	2019	2020	2021	2022	2023
A Agriculture, forestry, and fishing	154	168	175	179	178
B Mining and quarrying	5	5	4	3	3
C Manufacturing industry	269	277	289	490	311
D Production and supply of electricity, gas, steam, and air conditioning	13	14	19	20	27
E Water supply; wastewater disposal, waste management, and environmental remediation activities	9	9	9	9	10
F Construction	65	69	73	81	83
G Wholesale and retail trade; repair of motor vehicles and motorcycles	593	597	602	582	577
H Transportation and warehousing	172	173	180	176	182
I Accommodation and food service activities (hospitality industry)	329	346	188	349	346
J Information and communication	26	28	19	37	41
K Financial and insurance activities	41	44	40	46	52
L Real estate	17	17	18	18	19
M Professional, scientific, and technical activities	83	85	72	95	100
N Administrative and auxiliary service activities	39	40	27	43	51
O Public administration an defense, mandatory social security	76	77	85	76	75
P Education	68	70	69	73	82
Q Healthcare and social protection	63	63	51	65	71
R Art, entertainment, and recreation	199	199	194	201	206
S Other service activities	465	477	442	487	497

Source: Institute for Statistics of the Federation of Bosnia and Herzegovina, "Central Bosnia Canton in Figures 2024

In the field of agriculture, the largest number of registered entities are individuals or craftsmen, with 143 in 2023. Additionally, 29 legal entities and six entities operating in the municipality of Travnik but part of larger companies were also involved in this activity in the same year.

3.3.2. Revenues from income taxes and average wages

Over the past five years, the municipality of Travnik has experienced a continuous increase in revenue collected from income tax payments. In 2023, a total of 11,961,626.00 KM (6,115,350.71 EUR) was collected from this source (Table 15).

Table 15. Trends in income tax revenue from 2019 to 2023

Year	Population	Revenue in BAM	Income per capita	Income per capita FBiH = 100
2019.	52.487	6.846.262	130	70
2020.	53.308	6.918.230	132	64
2021.	51.813	8.023.993	155	89,3
2022.	51.469	9.772.358	190	80,00
2023.	51.181	11.961.626	234	70

Source: Development Programming Institute of Federation of BiH, Socioeconomic indicators by municipalities in Federation BiH, in the period 2014-2023

The increase in revenue was due to the growth in average wages, which amounted to 1,060 BAM in 2023. In 2022, the average wage was 893 BAM, and in 2021, it was 812 BAM, which is 20 BAM higher than in 2020.

3.3.3. Foreign Trade Exchange

Most companies in the Travnik area have continuously achieved good business results in recent years, both in the domestic and international markets. Excluding 2023, when the trade balance was negative, companies in this area have managed to maintain a relatively good coverage of imports with exports (Table 16).

Table 16. The Municipality of Travnik's foreign trade exchange from 2019 to 2023

	Import in thousands BAM	Participation in import in %	Export in thousands BAM	Participation in export in %	Coverage of imports with exports	Trade balance
2019.	210.620	1,5	238.774	3,1	113,37	28.154
2020.	174.942	1,5	185.879	2.7	106,25	10.937
2021.	211.566	1,4	222.196	2,3	105,02	10.629
2022.	242.335	1,2	247.743	2,1	102,23	5.408
2023.	233.762	1,2	230.946	2,1	98,80	-2.816

Source: Development Programming Institute of Federation of BiH, Socioeconomic indicators by municipalities in Federation BiH, in the period 2014-2023

The negative trade balance in 2023 was significantly influenced by political and economic instability in global markets, the continued high dependence of the Bosnian-Herzegovinian economy on imports, and the lack of investment in production, which made domestic products

non-competitive on foreign markets. Furthermore, the previous period was marked by rising energy and raw material prices, which, coupled with the lack of institutional support for exports, affected business results negatively.

In 2023, the export value per capita in the Travnik area was 4,521 BAM, while the import value was 4,567 BAM.

3.4. Agriculture Sector in the Municipality of Travnik Area

Agriculture in the Travnik area has significant potential and should play a much larger role in the economy, but it faces numerous challenges that limit its development. This municipality, located in the central part of Bosnia and Herzegovina, has favorable climatic and relief conditions for various agricultural activities.

The main characteristic of agriculture in this municipality is the diversity of production in crop farming, horticulture, fruit growing, and livestock farming. Various types of cereals are grown in the Travnik area, including wheat, corn, and barley. Feed crop production, especially for livestock farming, is also significant. Travnik has favorable conditions for vegetable cultivation, including potatoes, cabbage, carrots, peppers, and tomatoes. In lower areas, horticulture is particularly developed, while the conditions for cultivation in mountainous regions are somewhat more demanding.

In terms of fruit growing, it is important to highlight that fruit such as apples, plums, pears, and sweet cherries are grown in the Travnik area. Fruit growing has potential for further development, especially considering the favorable climatic conditions and the possibility of organic production.

Livestock farming is traditionally an important sector in Travnik. The breeding of cattle, sheep, and pigs is widespread, and milk and meat production are key sources of income for many farmers. Mountain meadows and pastures provide good conditions for livestock grazing.

The agricultural sector in Travnik mainly relies on the work of small and medium-sized farms. These farms often combine different agricultural activities, such as animal husbandry and crop farming, to increase their resilience to market fluctuations.

One of the challenges faced by agriculture in the Travnik area is insufficient infrastructure, which is reflected in the lack of modern equipment, storage capacities, and access to markets, making it difficult to grow agricultural production. Additionally, the sector lacks adequate financial support due to insufficient state subsidies and incentives, as well as limited access to favorable loans, which also poses a challenge for many farmers in the region.

One of the emerging challenges in recent years is climate change, which has led to increasingly frequent and more pronounced changes in weather patterns, including droughts and heavy rainfall, negatively affecting agricultural production.

Regarding development potential, Travnik has the potential for organic farming, especially in fruit and vegetable production. Another opportunity could be linking agriculture with tourism through the development of rural tourism and offering local agricultural products to tourists. Additionally, the establishment of agricultural cooperatives could help small farmers better market their products and acquire the necessary equipment.

3.4.1. Agricultural resources of Travnik Municipality

In the Travnik municipality, most of the agricultural land is primarily privately owned. When considering the total area of available arable land (fields and gardens, orchards, and meadows) and the number of inhabitants, Travnik has approximately 0.32 ha of arable land per capita, which,

according to standards, is above the minimum level that allows for the production necessary to feed the municipality's population. Land is the most important natural resource, which is why maximum efforts should be made to preserve and use agricultural land in the best possible way. Once permanently lost, it becomes a non-renewable resource.

The total area of the Travnik municipality is 52,855 ha, of which, in 2023, 22,946 ha was recorded as agricultural land, 28,364 ha as forest land, and 1,747 ha as barren land (Table 17).

Table 17. Agricultural area by categories of use

	Arable land					
	Total (1+5) ha	Arable	Arable land and gardens	Orchards	Meadows	Pastures
		1 (2+3+4)	2	3	4	5
2019.	23.135	17.655	8.625	1.007	8.023	5.471
2020.	23.177	17.697	8.662	1.007	8.028	5.471
2021.	23.246	17.780	8.745	1.007	8.028	5.456
2022.	22.920	17.524	8.494	1.007	8.023	5.396
2023.	22.946	17.550	8.520	1.007	8.023	5.396

Source: Development Programming Institute of Federation of BiH, Socioeconomic indicators by municipalities in Federation BiH, in the period 2014-2023

In the Travnik municipality, agricultural land can be divided into several zones:

- Lowland areas in the valley of the Lašva River, suitable for growing cereals and vegetables
- Gently sloping hilly land, suitable for growing fodder crops, vegetables, and fruit
- Land at higher altitudes, suitable for growing certain types of cereals, and mainly consisting of pastures and meadows, making it suitable for livestock farming

Generally speaking, the land is classified into seven types based on its overall morphological, chemical, physical, and biological soil properties. According to the Federal Institute for Agropedology, there is no first-category agricultural land in the Travnik municipality. The second and third categories of agricultural land each make up 0.6% of the total area of the Travnik municipality. The most common agricultural lands are of the IV category (8.4% of the total area of the Travnik municipality), V category (11.4% of the total area), VI category (14.3% of the total area), and VII category (7.1% of the total area).

The majority of agricultural production takes place on fields and in gardens (Table 18).

Table 18. Cultivated and uncultivated arable land and gardens

	Total arable land	Cultivated	Rest on the arable land	Uncultivated land	% uncultivated land
2019.	8.649	1.521	45	7.083	81,9
2020.	8.625	1.476	39	7.110	82,4
2021.	8.660	1.676	34	6.950	80,3
2022.	8.740	1.717	34	6.989	80,0
2023.	8.494	1.615	47	6.832	80,40

Source: Development Programming Institute of Federation of BiH, Socioeconomic indicators by municipalities in Federation BiH, in the period 2014-2023

Pastures, which make up 24% of the land in the municipality, are also a valuable resource that

supports the development of livestock farming in the Travnik area. This region is widely known for the production of Travnik cheese, which is made from sheep's milk. Travnik cheese is an indigenous variety that represents a brand of the area and holds one of the most important positions among local dairy products.

Of the total area of the Travnik municipality, 52.5% is classified as forest land, a significant portion of which is now treated as pasture land, although it is used very extensively, contributing to further land degradation (reduced organic matter production, increased compaction due to grazing, acidification, etc.). The forest land is predominantly covered with beech, fir, and spruce trees, which are of excellent quality and form the basis for the development of the economy in the Travnik municipality. Forests and forest land are privately and state-owned.

3.4.2. Crop production

Almost all agricultural production is characterised by traditional methods with low productivity and high costs. However, there is an exception: producers who supply the market and employ intensive production methods while adhering to agrotechnical cultivation rules. The majority of households engage in mixed agricultural production, while only a smaller number of farms opt for market-oriented production. Market-oriented production is pursued by just one-third of agricultural producers, with the remainder occasionally selling surpluses, primarily on the local market. Market-oriented producers intensively utilise resources and apply modern technologies.

Field crop production in the Travnik Municipality can be assessed as moderately developed, as the majority of producers grow crops for their own needs, with a smaller portion destined for the market. Within this, a distinct group of producers can be identified who grow feed for their own livestock, as well as producers with pre-contracted production agreements. Nevertheless, the sown areas are relatively small compared to the total usable land area, which can be partly explained by inconsistent agricultural policies and a lack of financial support from all levels of government.

In the Travnik Municipality, during the 2022/2023 sowing season, a total of 612 hectares of land were planted with wheat, rye, barley, oats, and maize for grain, yielding a harvest of 1,347 tonnes of cereals (Table 19). Compared to 2022, when nearly the same area was sown, the yield in 2023 was lower by 182 tonnes.

Table 19. Cereal production in the Travnik Municipality area in 2023

Wheat			
Type of crop	**Area in ha**	**Yield per ha in tonnes**	**Total in tonnes**
Wheat	365	2,1	769
Rye	19	2,6	50
Barley	120	2,5	300
Oats	33	1,9	63
Corn in grain	75	2,2	165
Total	**612**		**1.347**

Source: Institute for Statistics of the Federation of BiH, Crop production in 2023.

In vegetable production in the Travnik Municipality in 2023, the leading crops were potatoes, onions, beans, cabbage, and tomatoes. A total of 401 hectares of land were sown with these crops, resulting in a yield of 929 tonnes (Table 20). In 2022, production of these crops on almost identical acreage amounted to 1,309 tonnes, which is 380 tonnes more than in 2023.

Table 20. Vegetable production in 2023

Crop	Area in ha	Yield per ha in tonnes	Total in tonnes
Potato	220	3,0	670
Common onion	35	1,4	49
Beans	57	0,8	44
Cabbage	75	2,1	158
Tomato	14	0,6	8
Total	**401**		**929**

Source: Institute for Statistics of the Federation of BiH, Crop production in 2023.

Fruit production in the Travnik Municipality is characterised by existing old orchards that represent an extensive cultivation system with very low yields and mostly neglected properties. There are a few intensively managed orchards in the municipality, established in recent years, which are in relatively good condition. In recent years, there has been growing interest among producers in intensive, commercially oriented fruit production (Table 21).

Table 21. Fruit production in 2023

Fruit	
Crop	**Yield in tonnes**
Apples	246
Pears	136
Plums	440
Sweet cherries	5
Sour cherries	5
Walnuts in shells	42
Total	**874**

Source: Institute for Statistics of the Federation of BiH, Crop production in 2023.

Regarding crop production, it should be highlighted that in 2023, in the Travnik Municipality, an area of 447 hectares was sown with crops such as clover, lucerne, green maize, fodder beet, and grass-clover mixtures. Their total yield amounted to 3,810 tonnes.

3.4.3. Livestock production

A highly significant segment of agricultural production in the Travnik Municipality is livestock farming, particularly the production of meat and milk, which has been on the rise in recent years. The Travnik Municipality has substantial production areas for livestock rearing, including numerous pastures. According to data from the Travnik Municipality, there are 8,023 hectares classified as meadows and 5,396 hectares as pastures, providing a strong foundation for the development of livestock farming.

Cattle farming is the most important branch of livestock production in the Travnik Municipality, with dairy cattle rearing being predominant, although there has recently been growing interest in fattening cattle as well. In addition to cattle farming, sheep rearing is also significant in the municipality, having nearly reached pre-war levels. A large number of producers have opted for sheep farming, many of whom are market-oriented and maintain flocks of over 100 adult sheep. Sheep rearing remains nomadic, leading to frequent issues such as overgrazing, the use of others'

land, and flocks crossing over crops. Alongside cows and sheep, there has been an increasing number of pig breeders in recent years, focusing on breeding sows and fattening pigs (Table 22).

Table 22. Livestock count in 2022 and 2023

Type and category of livestock	Number of heads 2022	Number of heads 2023
Cattle	4.500	4.600
Sheep	42.000	44.000
Pigs	1.300	1.100

Source: The Travnik Municipality

The Travnik Municipality has a long-standing tradition of rearing laying hens and producing table eggs; however, the current level of production is quite low. This production has development potential but is limited by unfair competition and a disrupted balance between input costs and product prices. A similar situation exists with broiler production.

The presence of multiple climatic zones, along with numerous pastures and meadows with lush vegetation, ensures very favourable conditions for the development of beekeeping in the Travnik Municipality, which also has a long tradition. The importance of beekeeping lies not only in the production of honey and other bee products but also in plant pollination, which contributes to increased productivity of various crops. Stationary beekeeping predominates in this area, with the honey produced mainly sold on the local market. According to data from the relevant municipal services, 5,150 beehives were registered in the municipality in 2023, compared to 5,050 beehives in 2022.

In Travnik, a livestock fair, also known as the "dernek," is held in Turbe near Travnik. This traditional event brings together livestock farmers from across Bosnia and Herzegovina, as well as neighbouring countries. A variety of livestock is sold at the fair, including horses, cows, sheep, and donkeys, and visitors can enjoy local specialities such as roasted lamb. The fair is renowned for its diverse offerings and high attendance.

Image 3. Animal husbandry in the Travnik Municipality – livestock market

Source: https://bijeljina.com/poljoprivreda/tradicionalni-stocni-sajam-u-travniku/

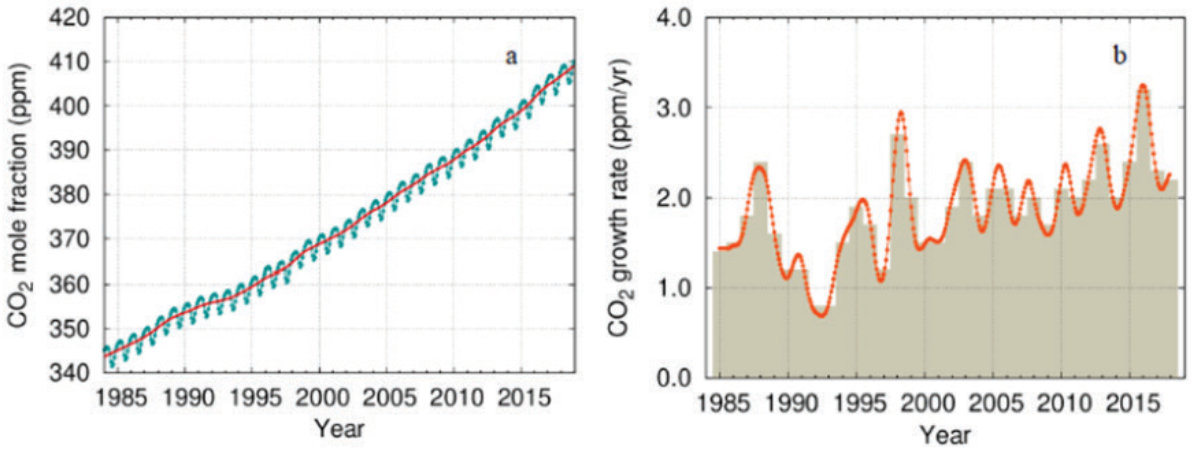
4. CARBON SEQUESTRATION[30]

4.1. Introduction

The presence of climate change is an undeniable factor that demands urgent and sustainable measures to effectively address its consequences. The increasing concentration of greenhouse gases in the atmosphere leads to global warming and extreme weather events such as droughts, floods, and heatwaves, placing pressure on the agro-food system and food security. To confront this threat, it is essential to take urgent and sustainable actions for both mitigating and adapting to climate change. In the search for necessary sustainable solutions, the focus must be on reducing greenhouse gas emissions, increasing the use of renewable energy sources, preserving natural ecosystems, and promoting innovations in technology and approaches to sustainable development. Human activities release varying concentrations of greenhouse gases, with CO_2 being one of the most significant gases causing the greenhouse effect and contributing to global atmospheric warming. Changes occurring in the atmosphere directly affect the hydrological cycle, soil fertility, and agricultural production. Soil can serve as a reservoir for atmospheric carbon dioxide, and increased carbon sequestration in agricultural soils could potentially mitigate the global rise in atmospheric greenhouse gases (Young, 2003) (Image 4). Agriculture plays a crucial role in this overall process; it is both impacted by climate change and contributes to it. Agriculture significantly influences these changes and aims to enhance carbon storage in soil, preserve existing carbon levels, and reduce CO_2 emissions. The process of transferring and securely storing atmospheric CO_2 into long-term carbon pools, which would otherwise be emitted or remain in the atmosphere, is known as carbon sequestration. Soil organic carbon and its sequestration have a substantial impact on the long-term ecological sustainability of agricultural production systems, soil fertility and its functions, and the quantity and cycling of greenhouse gases (Robertson G. P., 2008). For the sustainability and stability of the system, particular attention is given to intensive agrotechnical measures that influence carbon processes in soil and the atmosphere. Increasing carbon sequestration in agricultural soils and creating networked channels in the soil for atmospheric carbon can be achieved through proper management of agricultural land, such as conservation tillage, appropriate application of fertilisers, soil improvers, organic manures, crop rotation, and improved management of crop residues (Lal, 2003). Maintaining high levels of organic carbon in the soil is important for several reasons: it has a strong effect on soil quality, promotes aggregation, enhances water retention, improves nutrient supply and soil organism activity, and boosts soil fertility and productivity (Karlen et al., 1997). Carbon in soil exists in two forms: organic carbon and inorganic carbon. Agricultural activities primarily affect organic carbon, which represents a potential source of greenhouse gases. The content of organic matter in soil is largely influenced by human interventions in intensive agricultural production. Increasing the organic matter content in soil is a strategy that can positively impact climate change and sustainable agricultural production.

30 The author of this part of the Plan is Iva Rojnica, mag.ing.agr. from the University in Križevci (Croatia), which she did within the framework of Climate Action Plan for agriculture for the town of Križevci by a group of authors from the Križevci University of Applied Sciences, the Association for Community Economy, and RheinWalle University from Kleve (Germany).

Image 4. Global average mole fraction of CO_2 (a) and its growth rate (b) from 1984 to 2018



Source: WMOBilten

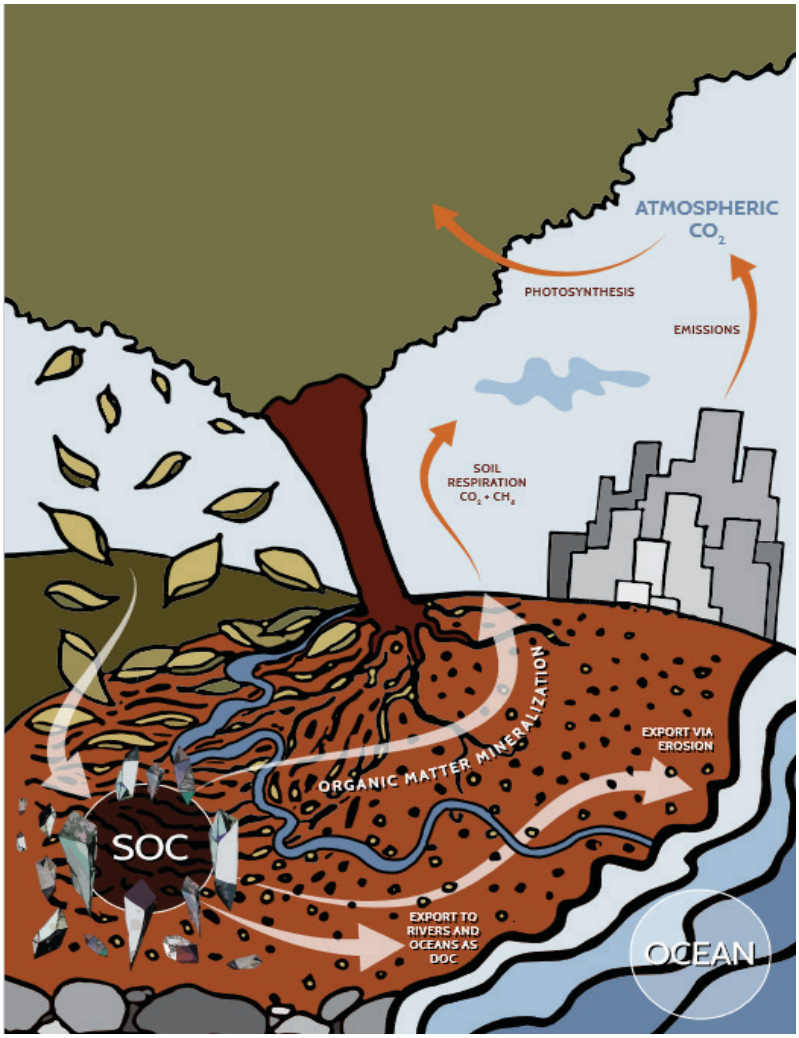
Reducing greenhouse gas emissions through carbon sequestration is of primary importance because that way, with proper agricultural techniques, it maintains and/or increases the carbon content in the soil and plant mass and thereby mitigate climate changes (Bilandžija et al., 2016).

4.2. Soil Organic Carbon: Key Component of the Global Carbon Cycle

Soil Organic Carbon (SOC) forms one part of the much larger global carbon cycle, which involves the circulation of carbon through soil, vegetation, oceans, and the atmosphere (Image 5). The SOC reservoir stores an estimated 1,500 PgC (1 Pg = 1 billion tonnes) in the top metre of soil, which is more carbon than is contained in the atmosphere (approximately 800 PgC) and terrestrial vegetation (500 PgC combined) (FAO and ITPS, 2015). This remarkable SOC reservoir is not static but continuously moves between various global carbon pools in different molecular forms (Kane D., 2015). While CO_2 (carbon dioxide) and CH_4 (methane) are the primary atmospheric carbon-based gases, autotrophic organisms (mainly plants), as well as photo- and chemo-autotrophic microbes, synthesise atmospheric CO_2 into organic material. Dead organic material (primarily in the form of plant residues and root exudates) is incorporated into the soil by microorganisms, leading to the input of carbon into the soil through the conversion of organic material by heterotrophic microorganisms.

This conversion process of organic material results in a complex biogeochemical mixture of plant waste compounds and microbial decomposition products at various stages of decay (Paul E., 2014), which can bind to rocky minerals and accumulate within aggregates, allowing SOC to persist in the soil for decades, centuries, or even millennia (Schmidt et al., 2011). CO_2 is re-emitted into the atmosphere when organic matter in the soil decomposes (or mineralises) due to microbial activity. Carbon loss can also be caused by root exudates, such as oxalic acid, which release organic compounds from protective mineral associations (Keiluweit et al., 2015). Ultimately, a portion of the soil carbon is exported to rivers and oceans as dissolved organic carbon (DOC) or as part of eroded material.

Image 5. Soil organic carbon: the hidden potential



Source: Lefèvre, C., Rekik, F., Alcantara, V., & Wiese, L. (2017). Soil organic carbon: the hidden potential. Food and Agriculture Or- ganization of the United Nations (FAO).

Fundamentally, the amount of SOC stored in a given soil depends on the balance between the quantity of carbon entering the soil and the quantity leaving it as carbon-based gases resulting from microbial mineralisation and, to a lesser extent, leaching from the soil in the form of DOC. Locally, carbon can also be lost or gained through soil erosion or deposition, leading to the redistribution of carbon-rich soil at local, landscape, and regional levels. Levels of SOC storage are therefore primarily controlled by managing the quantity and type of organic residues entering the soil (e.g., inputs of organic carbon into the soil system) and minimising carbon losses from the soil (FAO and ITPS, 2015). Factors controlling the decomposition of organic matter in soil include temperature and soil water content (largely determined by climatic conditions), which strongly influence carbon storage in soil through their impact on microbial activity. The composition of the microbial community (e.g., the ratio of bacteria to fungi) can also affect the preferential decomposition of specific compounds. The presumed chemical resistance of complex molecules that constitute SOC, such as lignin or lipids, does not significantly contribute to the stability or persistence of SOC (its longevity in soil) (Thévenot et al., 2010). The persistence of organic matter in soil is less related to chemical resistance and more to the stabilisation of SOC through interactions and associations with soil minerals (Schmidt et al., 2011). Quantifying global carbon fluxes is necessary to clarify, among other things, whether global terrestrial ecosystems are capable of sequestering more atmospheric CO_2 through photosynthesis than they release back into the atmosphere through respiration.

On one hand, the global carbon budget is determined by the concentration of atmospheric CO_2 and the uptake of CO_2 by oceans and land; on the other hand, it is influenced by emissions from fossil fuels, changes in land use, and land-use change. The latest carbon assessment indicates that between 2006 and 2015, carbon fluxes from land to the atmosphere were twice as large as the total fluxes absorbed by oceans and land, with 90% of these emissions originating from fossil fuels and industry (Le Quéré et al., 2016). Carbon fluxes from land-use change were more dominant in pre-industrial times, as between 1750 and 2011, one-third of all anthropogenic greenhouse gases (GHGs) stemmed from land-use change (IPCC, 2014). Over the long term, atmospheric CO_2 has risen from approximately 180 to 280 ppm since the last Ice Age, adding about 220 PgC to

the atmosphere over 10,000 years. This corresponds to an increase rate of about 4.4 PgC per year (Baldocchi et al., 2016). Recent research into soil carbon dynamics and its impact on the global carbon cycle has been driven, among other factors, by growing awareness of the importance of small-scale SOC approaches to microbial carbon decomposition extending beyond a depth of 20 cm (Vogel et al., 2014); the link between microbial communities and the dynamic and inherent properties of soil in relation to the carbon cycle and its interaction with other biogeochemical cycles (Gärdenäs et al., 2011); and the influence of plant diversity on enhancing soil microbial activity and carbon storage in soil (Lange et al., 2015).

4.3. Sequestration of Soil Organic Carbon

Soil organic carbon (SOC) sequestration is the process by which carbon is fixed from the atmosphere through plants or organic residues and stored in the soil. In the case of CO_2, SOC sequestration involves three phases:

1. Removal of CO_2 from the atmosphere through plant photosynthesis.
2. Transfer of carbon from CO_2 into plant biomass.
3. Transfer of carbon from plant biomass into the soil, where it is stored as SOC in the most labile reservoir.

This reservoir is characterised by the highest rate of turnover (days to several years), encompassing recently incorporated plant residues that are easily degradable by microorganisms, typically leading to CO_2 emissions back into the atmosphere. Therefore, planning effective SOC sequestration requires looking beyond the capture of atmospheric CO_2 and finding ways to retain carbon in the slow SOC pool. In contrast, research indicates that stable reservoirs have negligible potential for carbon sequestration due to their resistance to change and lack of response to management practices (Kane D., 2015). Newly added carbon can be stabilised in the soil through several mechanisms (Jastrow et al., 2007; Kane D., 2015). Physically, carbon can be stabilised by isolation within soil micro- and macro-aggregates, where it is inaccessible to microorganisms. Chemically, carbon can be strongly adsorbed onto clay through chemical bonds, preventing its consumption by organisms. Biochemically, carbon can be resynthesised into complex molecular structures that may hinder decomposition. These mechanisms depend on a range of biotic, abiotic, and management factors that determine their effectiveness in stabilising soil carbon (Kane D., 2015).

The concept of soil carbon saturation implies that the soil's carbon stock has reached its maximum capacity to store carbon inputs (Six et al., 2002; Stewart et al., 2007). This threshold, which depends on numerous factors including inherent and dynamic soil properties and their interactions with abiotic factors, is also referred to in the literature as the maximum carbon stabilisation capacity (Beare et al., 2014). This suggests that soil carbon stabilisation curves are not infinitely rising, and once carbon saturation is reached, SOC sequestration ceases, soils stop acting as net carbon sinks, and may become net carbon sources. As such, SOC sequestration has spatial and temporal limitations and is a reversible process (Paustian et al., 2016). Soils depleted of SOC have the greatest potential for carbon gain but the least propensity to achieve it. Since most soils worldwide are far from their saturation thresholds, there is significant potential to increase carbon inputs and implement management practices that protect existing stocks to maximise soil carbon sequestration (Kane D., 2015). Generally, the carbon cycle and carbon sequestration are most active in the surface horizons of soil, while stabilised carbon with longer turnover times constitutes a larger share of total SOC found in deeper soil horizons (Rumpel et al., 2012). Beare et al. (2014) estimated that deeper soils have a greater capacity to store additional carbon compared to surface soils due to the larger gap between existing SOC levels and SOC saturation values.

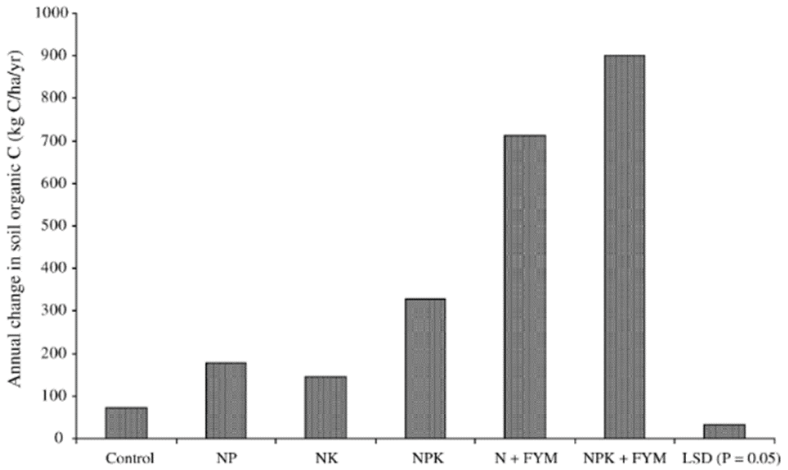
The accumulation of stabilised carbon with long retention times in deep soil horizons may result from continuous transport, temporary immobilisation, and microbial processing of dissolved organic carbon

(DOC) within the soil profile (Kaiser & Kalbitz, 2012) and/or the effective stabilisation of organic matter derived from roots within the soil matrix (Rasse et al., 2005). Lorenz and Lal (2005) highlighted that subsoils have the potential to store an additional 760–1520 Pg of carbon. At the same time, caution was advised when adding new carbon sources to subsoils due to the risk of enhanced mineralisation of existing SOC. Nevertheless, increasing SOC stocks in subsoils is still recognised as a promising approach to enable significant soil carbon sequestration (Rumpel et al., 2012).

4.4. Impact of Fertilisation on Carbon Sequestration

The application of organic fertilisers in agricultural production serves to maintain soil fertility and affects plant nutrition and crop yields, having been used in agricultural practice for thousands of years (Dormaar et al., 1988). Since the 1980s, the availability and use of chemical fertilisers have increased, leading to a drastic decline in the use of organic fertilisers (Zhu & Chen, 2002). Organic fertilisers are a diverse group, encompassing various residues of plant and animal origin in terms of composition and properties. The use of organic fertilisers is considered an effective way to increase soil carbon sequestration (Lal, 2004), and this is one reason why there is a growing shift towards organic fertilisers today, as they influence both agricultural production and the concentration of greenhouse gases in the atmosphere. Compost or manure, as organic fertilisers, can be applied to soil as a soil improver or in combination with mineral fertilisers to restore degraded soils or maintain elevated soil fertility levels. The application of compost enhances soil carbon sequestration, reducing production costs and the negative impact of agricultural activities by limiting the input of agrochemicals into the soil and reducing fuel consumption (Vázquez & Soto, 2017). Triberti et al. (2008) reported that applying manure can effectively increase soil organic carbon content, while other researchers found that the use of inorganic fertilisers damages soil structure and causes a loss of organic carbon (Wu et al., 2004). Numerous studies have shown that balanced fertilisation with nitrogen, phosphorus, and potassium, combined with manure (Image 6), increases soil organic carbon concentration and sustains high crop yields (Purakayastha et al., 2008). Soil organic matter content was significantly higher in treatments with NPK fertilisation combined with manure compared to those using only mineral fertilisers (NPK). This thirty-year study demonstrates that a combination of organic and mineral fertilisers results in satisfactory yields and has a positive effect on soil organic carbon (Kundu et al., 2007).

Image 6. Annual change of soil organic carbon, over 30 years under the influence of various treatments



Fertilisation treatment
Control, NP, NK, NPK, N + manure, NPK + manure LSD

Source: Kundu S. et al. (2007)

Many long-term fertilisation experiments worldwide have proven that balanced fertilisation with mineral and organic fertilisers can improve soil fertility, maintain high crop yields, and produce substantial crop residues that can be returned to the soil to increase soil carbon concentration (Holeplass et al., 2004). Crop residues are a biological byproduct not intended for cultivation, and their environmentally friendly management can influence soil organic matter, thereby affecting the emission of various gases. If crop residues are not returned to the soil but are instead burned in fields, organic matter is destroyed, causing atmospheric pollution (Yan et al., 2006). Numerous studies demonstrate a positive correlation between the amount of carbon incorporated into the soil—whether from crop residues, other organic fertilisers, or soil improvers—and soil carbon levels. Soil carbon levels are determined by the balance between the input of crop residues and organic matter additions and the losses of carbon through organic matter decomposition (Paustian et al., 1997). Jianling et al. (2014) note that different fertilisation treatments show negative carbon sequestration rates in the 20–40 cm soil layer and positive rates in the 40–60 cm layer (Table 23). This observation is largely attributed to the presence of a sandy soil layer at 20–40 cm, with significantly lower soil organic carbon content and reduced sequestration capacity in sandy soils (Bayer et al., 2006). Research results suggest that soil carbon sequestration could be underestimated if studies focus solely on the surface soil layer, indicating that different soil depths must be considered for greater carbon sequestration potential.

Table 23. Amount of carbon sequestration at different soil depths after 20 years of application of different fertilisers

Treatment	Carbon sequestration (Mg C ha-1 year-1)			
	0 – 20 cm	20 – 40 cm	40 – 60 cm	0 – 60 cm
Control – without fertilisation	–0.20	-0.06	0.07	-0.20
N and P	0.01	-0.02	0.12	0.10
N and K	–0.08	-0.06	0.06	-0.08
P and K	–0.05	-0.03	0.06	-0.03
NPK	0.05	-0.04	0.05	0.07
Compost and N	0.26	-0.02	0.11	0.35
Compost	0.51	-0.03	0.10	0.58

Source: Jianling F. et al., 2014

Contradictions among research findings are partly attributed to the specific processes governing carbon sequestration in practice, as these processes vary depending on soil type, soil depth, climate, and crop rotation (Liang et al., 2012). Long-term agricultural studies show that rates of change in soil organic carbon can be highest at the start of an experiment, but reaching a new steady state may take over 100 years (Johnston et al., 2009).

4.5. Influence of Crop Rotation and Soil Tillage on Carbon Sequestration

A key role in crop production is played by a well-designed system of agricultural land use, specifically crop rotation. Crop rotation, with all its components, offers multiple advantages over monoculture farming, which depletes soil, degrades it, and affects biodiversity. Cultivation in crop rotation results in stable yields, which is the goal of all agricultural production, while also influencing greenhouse gas emissions and contributing to the stability and sustainability of the entire ecosystem. Some studies indicate that transitioning from monoculture to crop rotation did not result in increased soil organic carbon sequestration (15±11 g C m^{-2} $year^{-1}$) on average, nor did switching to no-till farming; however, crop rotation is more effective at retaining carbon in the soil than monoculture farming (Gregorich et al., 2001). Cover crops, sown after the harvest of

the main crop, offer benefits such as increased soil carbon sequestration by enhancing the input of plant residues and providing vegetative cover during critical periods (Bowman et al., 1999). When green manure crops are included in the crop rotation system, they significantly influence soil organic matter content, respecting soil rest as one of the elements of crop rotation.

Soil tillage based on conventional techniques is a cause of anthropogenic soil compaction, disrupts soil structure, and affects fertility. Conservation tillage relies on practices that enhance the sustainability and stability of yields with multiple objectives, one of which is mitigating greenhouse gas emissions. Reduced tillage or no-till practices mitigate carbon losses through oxidation, while surface mulch protects the soil from sun and rain, increases soil organic matter, and serves as food for microorganisms. The result is higher soil organic carbon content, increased productivity, and reduced soil erosion (Kisić & Bašić, 2012). Constant use of agricultural practices based on conventional tillage, along with improper management of crop residues—such as burning them in the field—increases erosion losses and continuously degrades soil resources (Montgomery, 2007). Studies show that conventional tillage, compared to no-till, has a negative impact on soil carbon sequestration (Table 24).

Table 24. Carbon losses and gains from tillage and no-till

System	Crop rotation	Carbon gains and losses (t C/ha, year)
Tillage	Continuously corn or wheat	-0,105 do -0,460
	Mixed crop rotation and ground cover	-0,033 do -0,065
No tillage	Continuously corn or soy	+0,330 do 0,585
	Mixed crop rotation and ground cover	+0,660 do 1,310

Source: Pretty and Ball, 2001

Converting from conventional tillage to no-till can store atmospheric CO_2 at a rate of 0.1% ha ^{1} in the 0–5 cm soil depth each year, amounting to a total of 10 tonnes over 25–30 years (Paustian et al., 1997). Ghimire et al. (2012) note that the interaction between tillage and crop residues is significant at soil depths of 0–5, 5–10, and 10–15 cm (Table 25). No-till with crop residues stores more soil organic carbon than conventional tillage without residues. No-till with crop residue application sequesters 32%, 16%, and 21% more organic carbon than conventional tillage without residues at depths of 0–5, 5–10, and 10–15 cm, respectively.

Table 25. Influence of tillage and crop residues on soil carbon

Soil depth, cm	Organic soil carbon (Mg C ha-1)			
	$T_1 M_0$	$T_1 M_1$	$T_0 M_0$	$T_0 M_1$
0-5	9,50	9,90	10,9	12,7
5-10	10,0	9,87	10,8	11,6
10-15	10,1	10,8	11,3	12,2
15-30	21,3	21,9	23,0	24,3
30-50	23,9	22,3	21,9	25,3
0-50	76,1	73,4	77,9	86,4

Source: Ghimire et al. (2012)

T_1 – conventional tillage, T_0 – no tillage, M_0 – without crop residues, M_1 – with crop residues

However, results do not always point in the same direction. West and Post (2002) found in their research that switching to no-till in a wheat-fallow rotation did not significantly increase soil organic carbon, suggesting this may not be a recommended practice for carbon sequestration. In contrast, Alvarez (2005) reported in a compilation of studies that soils from wheat-fallow rotations under reduced and no-till had an average soil organic carbon content 2.6 t C ha ^{1} higher than with conventional tillage, a similar increase to that observed in other crop rotations. Doran et al. (1998) report a positive effect of no-till on soil organic carbon stocks, while Thomas et al. (2007) found no significant difference between no-till and conventional tillage, and Black and Tanaka (1997) even reported a negative effect from converting to no-till. In some other crop rotations, studies suggest that differences in carbon storage are either absent or reduced under no-till.

Differences in crop productivity between conventional and no-till are generally not significant (McConkey et al., 1996). It is believed that carbon sequestration in no-till results from reduced decomposition of organic carbon due to a less aerobic environment (Doran et al., 1998) and better physical protection of organic carbon within soil aggregates (Balesdent et al., 2000). Switching from conventional to no-till can favour greater carbon storage on sloping terrains and soils prone to erosion (VandenBygaart et al., 2003). Intensifying crop rotation will result in additional soil carbon storage when using no-till. Azevedo et al. (1972) found a 0.4% higher organic carbon content in the 0–7.5 cm layer of untilled soil compared to tilled soil. Below 10 cm, the organic carbon content was the same or slightly higher in tilled soil. Removing straw and tilling stubble reduce the organic carbon content in the surface soil layer. Accumulation of organic matter can occur not only in the surface layer but also in subsurface layers. Sisti et al. (2004) found that in a rotation of winter wheat and spring soybeans, soil organic carbon stocks up to a depth of 100 cm under no-till showed no significant difference from those under conventional tillage. However, in rotations with legumes sown as winter green manure crops, soil carbon stocks were approximately 17 Mg ha ^{1} higher under no-till than conventional tillage. Halvorson et al. (2002) determined that intensifying crop rotation and using no-till in agricultural production positively impacts carbon sequestration.

Therefore, the goal is to enhance agricultural production in a way that maintains stable yields while simultaneously reducing organic matter loss, which plays a key role in carbon sequestration. By sequestering carbon in the soil, we contribute to reducing the most significant greenhouse gas, carbon dioxide. Today, reduced or no-till practices are increasingly researched and applied in agricultural practice for several reasons: to improve system sustainability and stability, justify economic viability, and ensure environmental acceptability of cultivation. Intensive agrotechnical interventions, failure to adhere to crop rotation and its components, and the use of inorganic fertilisers lead to a reduction in soil organic matter, which, among other things, affects soil quality, greenhouse gases, and their emission into the atmosphere. Soil organic carbon is a critical factor in soil quality due to its connection to crop quality. Optimal soil carbon levels can be managed through crop rotation, maintaining fertility with the use of organic fertilisers and manure, various tillage practices, and other components of the production system (Janzen et al., 1998). Agrotechnical interventions and the proper type and use of fertilisers that increase soil organic matter content are desirable and beneficial, while those that degrade and impoverish the soil represent harmful practices.

Tillage itself introduces a significant amount of air into the soil compared to "normal" soil respiration, and negative agrotechnical interventions lead to substantial microbial development in the soil. These microorganisms cause a rapid increase in CO_2 concentration, resulting in its accelerated release into the atmosphere. Instead of destroying/burning or removing plant residues from the soil surface, retaining them in combination with minimal tillage increases soil organic matter content, playing a positive role by providing a nutrient substrate for soil organisms, a source of plant nutrients, and carbon storage. Intensive tillage interventions introduce large amounts of oxygen into the soil, leading to aeration that accelerates the decomposition of soil organic matter. This rapid decomposition produces less stable humus and increases CO_2 release (Jug et al., 2017). Contradictory results from various studies can be explained by differences in measurements related to soil type, soil depth, crop rotation, and climatic conditions under which the research was conducted.

5. CLIMATE IN BIH

The climate of Bosnia and Herzegovina is conditioned by several geographical and climatological factors, making it highly complex. The Adriatic Sea, altitude, terrain, and the presence of mountains belonging to the Dinaric system all influence the climate in BiH.

The Adriatic Sea has a significant impact, particularly in the colder part of the year, when it releases a large amount of thermal energy, partially mitigating extreme winter temperatures. The arrangement of mountain ranges, lowlands, basins, and karst fields also contributes to modifying the climate across the entire territory of BiH. The mountains of the Dinaric system act as a natural barrier, preventing the penetration of cold air masses from the north and warm air masses from the south into the interior of the country.

The climate in BiH is also influenced by Central European continental and Mediterranean climates, which penetrate the interior through karst basins and the valleys of major rivers. Other factors contributing to the climate of BiH include cyclonic activity over the country, numerous local influences, the type of surface, vegetation, and snow cover, all of which affect the characteristics of climatological elements.

5.1 Types of Climate in BiH

Due to the influence of the aforementioned factors, as well as many others, three basic types of climate can be distinguished in BiH:

1. Continental and temperate-continental climate
2. Mountain and mountain-basin climate
3. Mediterranean and modified Mediterranean climate

In the northern and central parts of the country, the continental climate prevails; the Mediterranean climate is characteristic of the south, while in the interior—where high mountains, plateaus, and gorges are present—the mountain climate is prominent, depending on altitude.

5.1.1. Continental and Temperate-Continental Climate

Northern Bosnia, along with the valleys of the middle courses of the Una, Sana, Vrbas, Bosna, and Drina rivers (an area bordered to the north by the Sava River and to the south by a line running from Bihać, southwards to Sanski Most and Banja Luka, through the valleys of the Usora and Spreča rivers to Zvornik), is dominated by continental and temperate-continental climates. This climate type is characterised by a sharp rise in temperatures from January to July, followed by a gradual decline towards December. In practice, January is the coldest month, and July is the warmest. This climate features pronounced temperature fluctuations in spring and autumn, so late spring and early autumn frosts can have negative consequences.

Summers are warm, winters are cold, and precipitation is relatively low. Regarding the annual average, the northwestern regions receive the most rainfall, while the areas around Bijeljina, Orašje, and Bosanski Šamac receive the least (below 800 mm). Although precipitation is scarce, it has so far been evenly distributed throughout the year, with the highest amounts occurring in May-June and the lowest in February-March, suggesting that the entire area still receives sufficient rainfall.

This part of BiH is an agricultural region, where snow during winter is crucial as the snow cover protects crops from severe frosts during the coldest part of the year and creates substantial water reserves in the soil. The number of days with snow cover increases from north to south and from

east to west, which is expected due to the corresponding rise in altitude. In this climate type in BiH, the annual distribution of cloudiness shows that winter is the cloudier part of the year, while in the summer half of the year, cloudiness is low, below 50%, which explains the long duration of sunshine in this area.

5.1.2 Mountain and Mountain-Basin Climate

The zone of this climate in BiH stretches from the boundary of the northern part of the country to the south, along a line extending from Posušje and the southern slopes of Čabulja, Velež, and Bjelašnica to Bileća. This area experiences the influence of the Central European continental climate from the north and the Mediterranean climate from the south, which, combined with diverse terrain, contribute to the development of a temperate mountain climate. Due to this climate, there are significant temperature differences, varying by up to 11°C depending on the location.

In areas with mountain and mountain-basin climates, January is the coldest month, while July and August are the warmest. Due to the strong influence of the Adriatic Sea, autumns here are somewhat warmer than springs. Annual temperature fluctuations in this region are smaller than in the northern parts, a result of various modifiers acting throughout the year.

Due to the complex terrain, the spatial distribution of annual precipitation is uneven. Windward sides of high mountains receive large annual precipitation amounts, ranging between 1,500 and 2,300 mm, while sheltered river valleys and basins receive significantly less, between 700 and 800 mm. The highest precipitation occurs in October, November, and December, with the lowest in the summer months of July and August. Snowfall accounts for 40–50% of the total precipitation in this area, while the average annual cloudiness ranges between 52 and 69%. The duration of sunshine varies greatly by month, with the longest periods in July and August and the shortest in December.

In conclusion, this area exhibits a pronounced influence of multiple mesoclimatic types, making it a transitional zone between continental and mountain climates.

5.1.3 Mediterranean and Modified Mediterranean Climate

This climate type is present in the southwest of the country, specifically in the Herzegovina region, between the southern boundary of the hilly-mountainous area and the southern border of the state. This area can be said to have characteristics of a maritime climate; however, the arrangement and orientation of relatively high mountain ranges limit maritime influences to a narrow zone and cause a very abrupt transition from maritime to continental conditions.

With January as the coldest month and July as the warmest, this region experiences relatively high average annual air temperatures. Due to maritime influences, autumns are warmer than springs. Annual temperature fluctuations here are the smallest compared to the rest of the country. Precipitation is unevenly distributed both spatially and throughout the year, primarily due to the pronounced influence of terrain on moist air masses coming from the south. Ascending movements on windward slopes result in abundant rainfall. The highest precipitation occurs in November and December, with snow being rare in this region.

Compared to other areas, this is the clearest region in the country in terms of cloudiness, with very long periods of sunshine, making it one of the sunniest areas not only in BiH but also in Europe.

5.2 Climate in Travnik

The municipality of Travnik is located in the central part of Bosnia and Herzegovina, within the Central Bosnia Canton, and has specific climatic characteristics significantly shaped by its geographical position, terrain, altitude, and the influence of various air masses. Travnik lies in the valley of the Lašva River and is surrounded by mountain ranges such as Vlašić to the north and Vilenica to the south. Altitude varies from 400 metres in the lower areas to over 1,900 metres on Mount Vlašić. This variable terrain significantly influences microclimatic characteristics.

The climate in the Travnik municipality can be described as temperate-continental, with a significant influence of the mountain climate regime at higher altitudes. Summers are moderately warm in the valley areas, while temperatures at higher elevations on Mount Vlašić are significantly lower. Average daily temperatures in July and August range between 18°C and 28°C in the lower areas, while at mountain peaks they can be 10–15°C lower. Winters, on the other hand, are cold, especially in mountainous areas where temperatures below zero are common. Vlašić, a popular winter destination, experiences abundant snowfall and very cold winters, with average temperatures below -5°C in the coldest months. In the lower parts of Travnik, average winter temperatures range from 0°C to -5°C, with occasional frosts.

Precipitation is fairly well-distributed throughout the year, which is particularly beneficial for vegetation and the cultivation of agricultural crops. Winters feature significant snowfall, especially at higher altitudes, particularly on Vlašić and Vilenica, where the climate can be described as distinctly mountainous. The total annual precipitation ranges between 900 mm and 1,200 mm, with the highest amounts in spring and autumn. Summer months are generally drier, though occasional showers are not uncommon. Autumn and spring are the periods with the most rainfall, which benefits agricultural crops and vegetation.

Mount Vlašić has a significant influence on the climate of the Travnik municipality, acting as a natural barrier to the penetration of cold northern winds while simultaneously creating specific microclimatic conditions. This includes significant cooling in the summer months and abundant snowfall in the winter period. Interestingly, Vlašić often generates local winds and clouds that contribute to precipitation and a stable winter season.

According to data from the Travnik Weather Station from the beginning of 2024 until August 2024, the following meteorological parameters were recorded in the municipality:

1. Air Temperature

- Lowest value: 13.1°C
- Highest value: 37.7°C
- Average temperature: 14°C

2. Relative Humidity

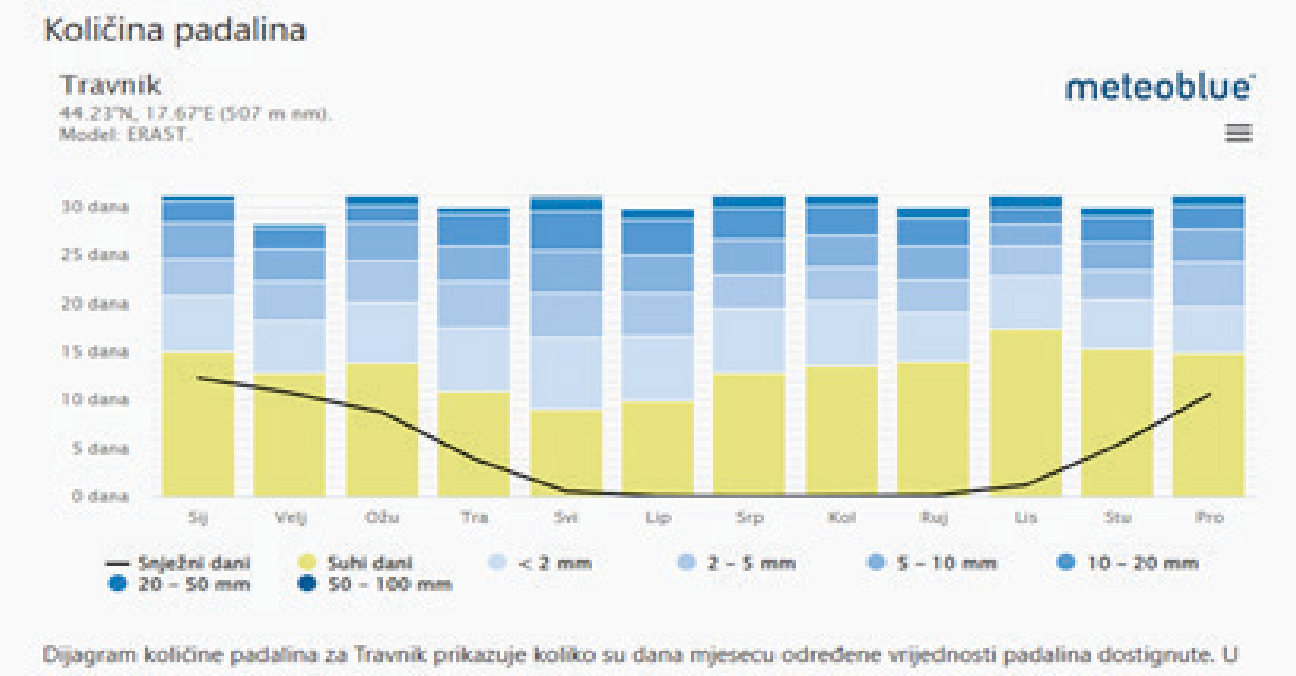
- Lowest: 18%
- Highest: 100%
- Average humidity: 78%

3. Air Pressure

- Lowest: 933.0 hPa
- Highest: 975.6 hPa
- Average value: 954.0 hPa

4. Precipitation: 355.6 mm

Image 7. Rainfall in Travnik



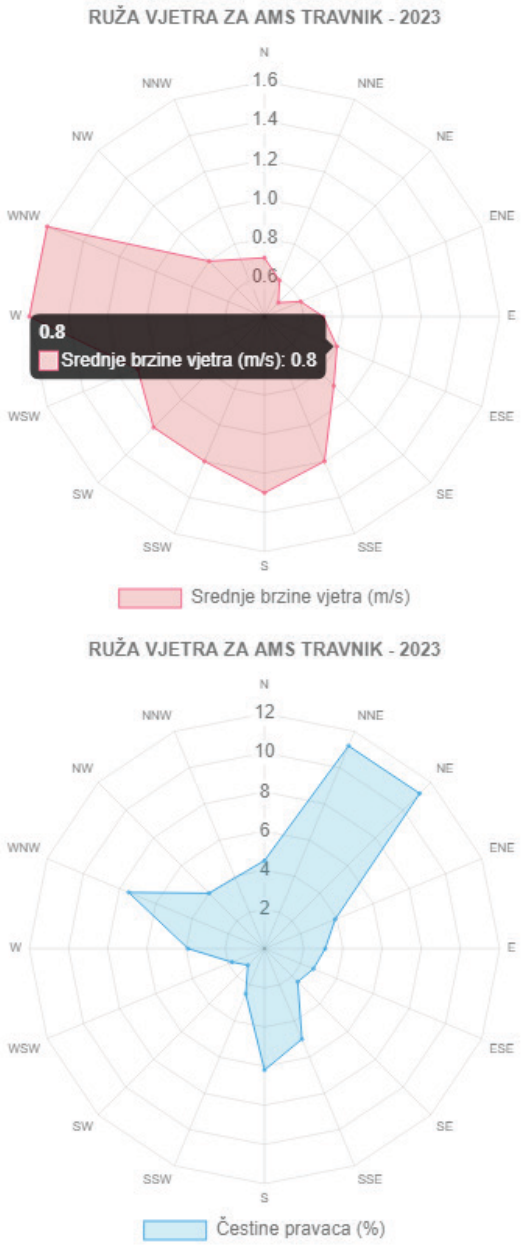
Source:https://www.meteoblue.com/hr/weather/historyclimate/climatemodelled/travnik_bosnia-and-herzegovina_3188924

5.2.1 Winds

Moderate winds are frequent in the Travnik area, particularly at higher altitudes, where mountains amplify wind intensity. Vlašić is particularly known for strong winter winds that contribute to the formation of snowdrifts.

A wind rose, one of the key tools for understanding climatic patterns in an area, is a graphical representation of wind direction and frequency over a specific period. It is a circular diagram where wind directions are shown relative to the cardinal directions (north, south, east, west), and the length of lines extending from the centre indicates how often winds blow from a given direction. Different colours or line thicknesses may represent wind speed. The basic characteristics depicted by a wind rose are wind direction, frequency, and speed.

Image 8. Wind rose in the Travnik Municipality area in 2023



Source: Federal Hydro-Meteorological Institute BiH[31]

A wind rose for the Travnik municipality in BiH is not widely documented as it is for larger cities, but general data on prevailing winds in this region are available. Travnik is situated in the central part of Bosnia and Herzegovina, in a mountainous area that influences wind patterns.

General Wind Characteristics in Travnik:

- Northern and northwestern winds are often dominant due to the proximity of mountain ranges (Vlašić). These winds are colder, especially during winter months.
- Southern and southwestern winds come from the Mediterranean and often bring warmer, moister air, particularly in spring and autumn.
- Local winds can vary due to specific topographic conditions, such as mountains and valleys, creating microclimatic effects.

31 https://www.fhmzbih.gov.ba/latinica/KLIMA/ruza-vjetra.php

Vlašić, as a significant mountain range near Travnik, can further influence the wind rose, generating specific local winds that may differ depending on altitude and terrain.

5.2.2 Air quality monitoring

Air quality monitoring is the process of continuously tracking and measuring the presence of pollutants in the atmosphere to assess their impact on human health and the environment. This process involves collecting data on concentrations of various pollutants, such as particulate matter (PM10 and PM2.5), gases (NO_2, CO, SO_2, O_3), and other harmful compounds.

In the Federation of Bosnia and Herzegovina, air quality monitoring is conducted by several operators within the Federal Network of Stations (managed by the Federal Hydro-Meteorological Institute) and local networks at the cantonal and municipal levels. One such station was established in the Travnik municipality in 2022. Monitoring air quality in Travnik is becoming increasingly important due to growing ecological challenges, such as air pollution caused by traffic, industry, fossil fuel combustion, and seasonal effects like increased heating use during winter. These factors are considered the primary air pollutants in the Travnik municipality.

According to data from the Federal Hydro-Meteorological Institute of BiH, monitoring stations measure sulphur dioxide (SO_2) levels, with an annual average concentration limit of 50 µg/m^3. During measurements conducted in 2023 in Travnik, the average annual sulphur dioxide concentration was 37 µg/m^3. The highest recorded hourly concentration was 900 µg/m^3, and the highest daily average was 242 µg/m^3. Data indicate that in 2023, there were 10 days in Travnik with daily sulphur dioxide concentrations exceeding the limit of 125 µg/m^3.

In 2023, the Travnik monitoring station also measured nitrogen dioxide (NO_2), with an allowable annual average concentration limit of 40 µg/m^3 and an hourly limit of less than 200 µg/m^3. The average annual NO_2 concentration in Travnik in 2023 was 13 µg/m^3, with the highest daily concentration at 47 µg/m^3 (below the limit of 85 µg/m^3). The highest hourly NO_2 concentration was 85 µg/m^3, which is below the limit of 200 µg/m^3.

The Travnik station also measured ozone (O_3) levels in 2023, which depend on both natural-geographical factors and human activities, with fewer possibilities for reduction compared to other air pollutants. The defined limit for ozone applies to days when the highest eight-hour averages exceeded 120 µg/m^3, with an allowable exceedance of 24 days per year. Measurement results in Travnik showed an average annual O_3 concentration of 45 µg/m^3, with the highest daily concentration at 134 µg/m^3. In 2023, there were 50 days with eight-hour concentrations exceeding 120 µg/m^3.

Measurements also included concentrations of particulate matter PM10 (particles larger than 10 micrometres) and PM2.5 (particles larger than 2.5 micrometres). The annual average concentration limit for PM10 is 40 µg/m^3, with an allowable exceedance of the daily limit of 50 µg/m^3 up to 35 times per year. The annual average limit for PM2.5 is 25 µg/m^3. In Travnik in 2023, the average annual PM10 concentration was 20 µg/m^3, and the average annual PM2.5 concentration was 17 µg/m^3. The highest recorded daily PM10 concentration was 141 µg/m^3, with the highest hourly value at 246 µg/m^3. For PM2.5, the highest daily concentration was 241 µg/m^3, and the highest hourly concentration was 242 µg/m^3.

According to the Federal Hydro-Meteorological Institute of BiH's data in the 2023 Annual Air Quality Report, CO_2 emission measurements at monitoring stations showed average annual values below prescribed limits, leading to the assertion that this pollutant rarely impairs air quality in our cities. The average annual carbon monoxide (CO) concentration in Travnik in 2023 was 0.5 mg/m^3, well below the allowable limit of 3 mg/m^3. The highest recorded daily CO concentration was 3.4 mg/m^3, below the limit of 5 mg/m^3.

5.2.3 Meteorological data

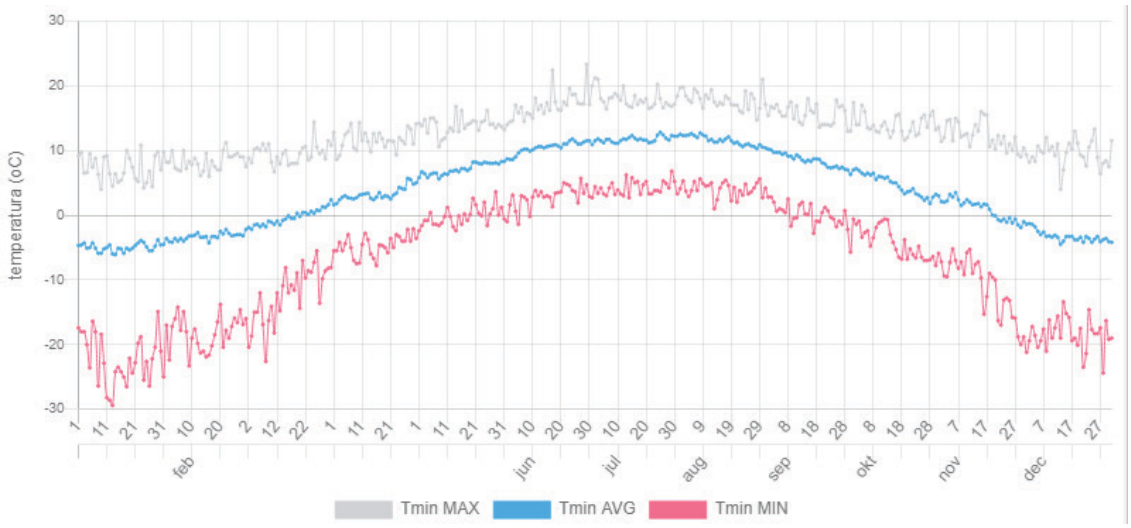
Across almost the entire territory of BiH, from 1961 to 2018, a continuous increase in average annual temperatures has been recorded, particularly pronounced over the last 40 years, especially in the continental part of the country. According to the Federal Hydrometeorological Institute, annual air temperature increases in BiH range from 0.4 to 1.2°C, while increases during the vegetation period (April–September) reach up to 1.4°C. Temperature increases over the last 18 years have been even more pronounced across all parts of the country.

Analysis of collected data shows that over the past 40 years, all warm temperature extreme indices exhibit positive trends, while cold temperature extreme indices show negative trends. The most evident changes are in the number of cold and warm days, with the number of cold days decreasing almost every year across all parts of the country.

"In central mountain areas, the number of cold days has decreased by 4 days per decade, while in the south of the country, the reduction is slightly lower, at 2 days per decade. The number of warm days shows a positive trend and is statistically significant."[32]

Measurements at all meteorological stations, including Travnik, confirm that January is the coldest month, with average temperatures ranging from -3.8°C in central areas to 5.3°C in southern areas. In the north, average January temperatures range from -0.2°C to 0.2°C.

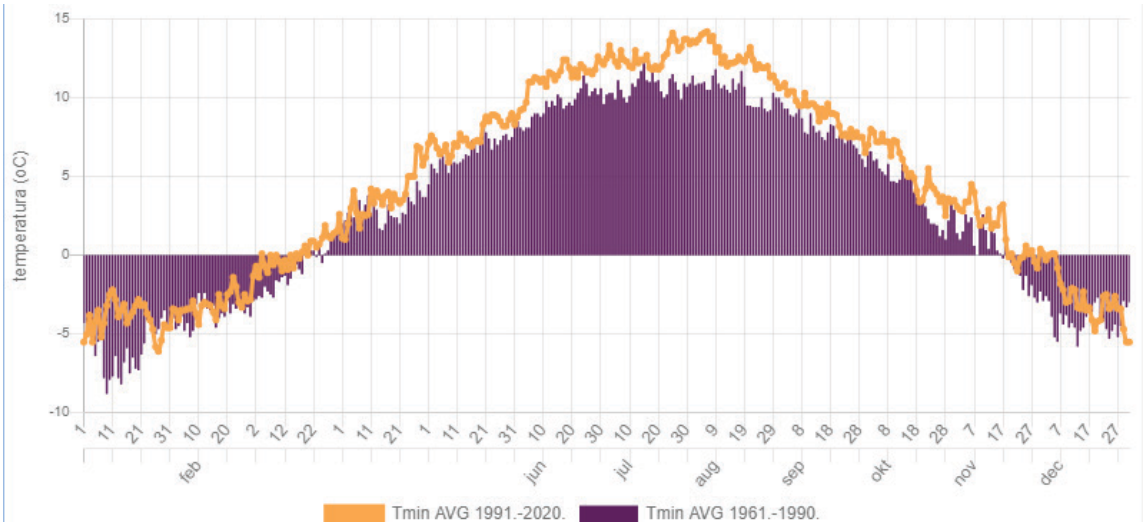
Image 9. Minimum temperatures in Central Bosnia region from 1961 to 2022



Source: Downloaded from Federal Hydro-Meteorological Institute BiH

32 BiH "Climate Change National Adaptation Plan of Bosnia and Herzegovina – NAP with proposed measures", September 2021

Image 10. Average and minimum air temperatures in Central Bosnia region from 1961 to 1991 and 1991 to 2022

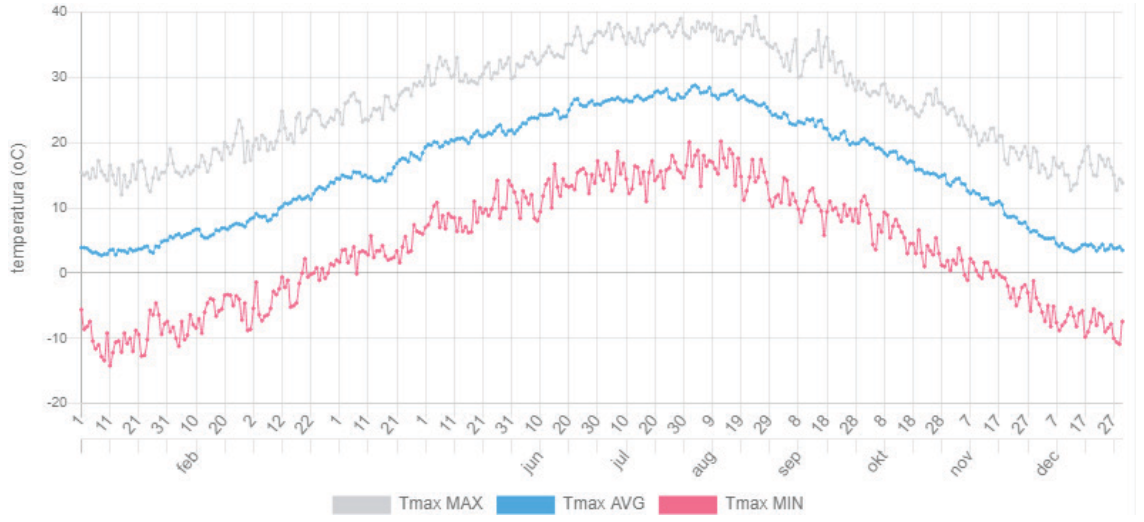


Source: Downloaded from Federal Hydro-Meteorological Institute BiH

Among the coldest years between 1961 and 2015 were 1962, 1964, 1976, 1978, and 1980 (all before 1990). In the northwest, the coldest years were recorded at the beginning of the analysed period. During this period, a statistically significant negative trend in the number of frost days was observed across almost all areas of BiH, with values ranging from 2.1 to 6.4 days per decade. In the last decade, the number of icy days was extremely low due to the pronounced effects of global warming. July is the warmest month, with the highest average air temperatures in the eastern and southern parts ranging from 21.8°C to 25.4°C. The average annual air temperature amplitude from 1961 to 2015 in the north ranges from 20.2°C to 21.7°C in the northeast. The greatest annual temperature amplitude across the research area is in Semberija, the most continental part of BiH. Temperature amplitudes are somewhat smaller in the south and central areas.

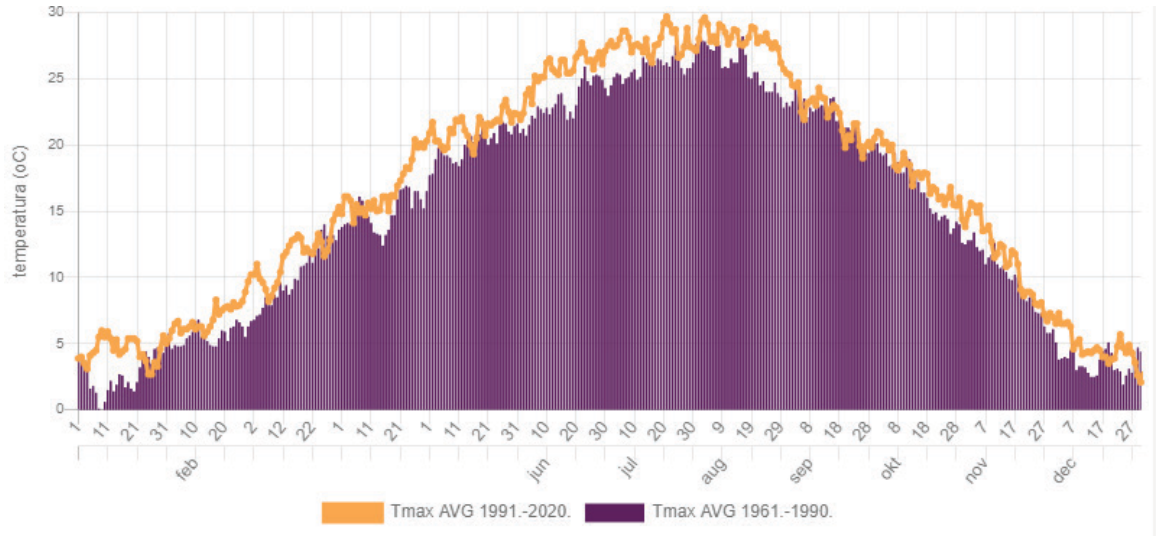
From 1961 to 2015, a continuous temperature increase was recorded, with nine of the ten warmest years occurring between 2000 and 2015. Among the warmest years in the analysed period were 2000, 2005, 2006, 2007, 2008, 2011, 2012, 2014, and 2015, with 1994 also recorded as one of the warmest.

Image 11. Maximum air temperature in Central Bosnia region from 1961 to 2022



Source: Downloaded from Federal Hydro-Meteorological Institute BiH

Image 12. Average and maximum air temperatures in Central Bosnia region from 1961 to 1991 and 1991 to 2022



Source: Downloaded from Federal Hydro-Meteorological Institute BiH

After 2015, 2021 was above average in warmth, though not as extreme as the most recent years, and was marked by numerous meteorological phenomena such as record-high temperatures, unprecedented February maximums, extreme wind gusts, exceptional heat in June, July, and December, extremely rainy November and January, and extremely dry June and September.

In BiH, from 1961 to 2018, a slight increase in annual precipitation was recorded, with changes more pronounced when viewed by season throughout the year. Summer season trends show a marked negative sign across the country. During winter, there is a trend of increasing precipitation in the northwest and southwest, while other areas show a negative trend, with a more pronounced reduction in the south (14.1 mm per decade). In autumn, an increase in precipitation was observed across all areas except the south. The pronounced change in the annual distribution of precipitation, combined with rising temperatures, is a key factor contributing to more frequent and intense droughts and floods in Bosnia and Herzegovina. Recent years have seen an increase in precipitation intensity, with heavy rains accounting for the largest share of total distribution, leading to frequent flooding, particularly in central and northern parts of the country. The most significant floods in this area were recorded in spring 2014.

"Based on research into climate and climate change to date, the greatest changes have been identified in the southern, northern, and northwestern parts of Bosnia and Herzegovina. These changes are most evident through increased intensity and frequency of extreme climatic events (floods, droughts, storms, hail days, prolonged heatwaves, extreme temperatures, etc.). Over the last two decades, at least one of these extremes has occurred each year, with some locations experiencing multiple different extreme events."[33]

5.3. Risks and Vulnerabilities to Climate Change

Climate change is felt worldwide, and its consequences are visible both across Bosnia and Herzegovina (BiH) and in the Travnik municipality. These changes manifest as frequent and abrupt—often extreme—shifts between cold and warm periods. As in much of BiH, the Travnik municipality is increasingly experiencing changes in the seasons: winters are warm, summers

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rainy, springs short, and autumns warm. These shifts already affect numerous aspects of life, but the greatest concern lies in their impact on agriculture.

Like the rest of Bosnia and Herzegovina, Travnik is not immune to the effects of global climate change. Over the past few decades, trends of milder winters, reduced snowfall at lower altitudes, and periods of intense drought during summer months have been recorded. These factors could have significant consequences for agriculture and the regional economy, particularly the winter tourism season on Mount Vlašić.

Sudden changes in climate patterns, including unexpected downpours or droughts, pose a challenge to the sustainable use of natural resources. Farmers in Travnik face the task of adapting to these changes to optimise production and reduce the risks of climate-related disruptions.

The climate in the Travnik municipality is diverse and heavily dependent on its terrain. Moderate continental climatic conditions, with pronounced seasonal variations and specific microclimates on Mount Vlašić, make this area suitable for various activities, from agriculture to winter tourism. However, climate change could trigger long-term shifts in precipitation and temperature patterns, necessitating adaptation from the local population and economy.

Climate change can exhibit a significant impact on agriculture in the Travnik municipality, with negative consequences manifesting in several ways:

1. Extreme weather conditions: Travnik is at risk of increasingly frequent droughts, heatwaves, and heavy rains. These extremes can destroy crops, reduce yields and quality, and complicate farmers' work.
2. Reduced water availability: Climate change may lead to decreased water availability for irrigation. Droughts and irregular precipitation distribution can stress plants, lowering yields.
3. Changes in seasonal patterns: Rising temperatures and shifts in the duration of seasons can affect plant growth cycles, flowering, and fruit ripening. Early spring frosts, for example, can damage blossoming fruit trees.
4. Spread of diseases and pests: Higher temperatures may accelerate the spread of pests and plant diseases previously less prevalent in the area, increasing protection costs and reducing yields.
5. Soil degradation: Climate change, such as frequent heavy rainfall, can cause soil erosion, reduce fertility, and lead to the loss of organic matter.
6. Reduced yields: Stressful conditions for plants, such as drought or excessive moisture, are expected to decrease yields of key agricultural crops, directly impacting farmers' economic situation.
7. Increased production costs: To adapt to changing conditions, farmers may need to invest in irrigation technologies or pest and disease protection, potentially raising production costs.

These negative consequences require adjustments in agricultural practices and the adoption of sustainable farming strategies to mitigate climate-related risks.

While climate change presents numerous challenges, there may also be some potentially positive impacts on agriculture in the Travnik municipality:

1. Longer growing season: Rising average temperatures could extend the growing season, allowing farmers to cultivate more crops annually or extend the season for specific crops. This could increase yields and potentially expand the range of cultivable plant species.
2. Possibility of new crops: Warmer weather might enable the cultivation of crops previously unfeasible in Travnik, such as certain fruit varieties (e.g., figs, olives) or vegetables, leading to production diversification and higher incomes.

3. Enhanced photosynthesis: Increased atmospheric carbon dioxide (CO_2) concentrations could improve photosynthesis in some plants, potentially resulting in faster growth and higher yields for certain crop types.
4. Reduced need for heated greenhouses: Milder winter temperatures could decrease the energy required to heat greenhouses or polytunnels, lowering production costs in protected environments.
5. Development of agriculture-related tourism: If climate change creates more favourable conditions for growing specific crops or extends the availability of certain products, it could support the development of agrotourism in Travnik. Tourists might be interested in visiting orchards, vineyards, or plantations thriving under new climatic conditions.
6. Opportunities for heat-loving crops: Crops like maize or sunflowers, which thrive in higher temperatures, could become more dominant in local agricultural production, yielding higher outputs and profits.
7. Reduced risk of late spring frosts: Consistently warmer temperatures could decrease the risk of late spring frosts that damage fruit tree blossoms, leading to better fruit yields.

While these potential benefits are significant, it's worth noting that the advantages of climate change often depend on farmers' ability to quickly adapt to new conditions and capitalise on the opportunities they present.

5.3.1 Extreme high and low temperatures

Extreme low and high air temperatures in the Travnik municipality follow seasonal patterns, but with climate change, these periods may become less predictable and more frequent. Extreme temperatures typically occur as follows:

1. Extreme low temperatures

Extreme low temperatures in Travnik usually occur during the winter months, peaking in:

- December, January, and February: These months record the lowest temperatures, often below zero, with possible periods of severe frosts. Nighttime temperatures can drop below -10°C, especially in higher parts of the municipality and mountainous areas like Vlašić.
- Early Spring (March and April): Late frosts can occur in spring, particularly in March and sometimes April, potentially damaging plants in the flowering or growth phase. Orchards and vineyards are especially affected by these frosts.

Extreme low temperatures, particularly in winter, can cause numerous issues such as agricultural damage. During periods of extremely low temperatures, especially with late spring or early autumn cold spells, crops and fruit trees—particularly blossoms—can be damaged. Frosts pose a danger to sensitive crops like fruit, potentially leading to significant yield reductions. Extremely low temperatures can affect livestock farming due to additional care for livestock, particularly in terms of providing shelter, extra feeding, and preventing water sources from freezing. Low temperatures can damage infrastructure, roads, and plumbing systems due to water freezing, increasing maintenance costs.

2. Extreme high temperatures

Extreme high temperatures typically occur during the summer months, with the highest values in:

- July and August: These are the warmest months of the year, with temperatures often exceeding 30°C and sometimes reaching over 35°C during heatwaves. These are critical periods for agriculture due to the heightened risk of drought and heat stress on crops and livestock.

- Late June and Early September: These periods can also see high temperatures, particularly in late June and early September, with potential heatwaves extending the hot summer period.

Over the past 20 years, the highest temperature recorded in Travnik was 40.3°C on 5 August 2017. This extreme high was part of a broader heatwave that affected much of Bosnia and Herzegovina and other parts of the Balkans that summer.

In recent years, Travnik, like other regions, has experienced increasingly frequent and intense heatwaves, particularly during summer months. Prolonged periods of high temperatures cause droughts, reducing water availability for irrigation and stressing plants. This can lead to reduced yields or even complete crop loss, especially for drought-sensitive crops like maize and vegetables. High temperatures can also cause heat stress in plants, reducing photosynthesis and affecting growth and yield. Similarly, livestock may suffer from heat stress, decreasing milk production in cows or slowing growth in meat production. Finally, higher temperatures can accelerate the reproduction of certain pests and pathogens that damage crops, necessitating more intensive pesticide use and potentially increasing production costs.

3. Climate change and seasonal irregularities

Climate change in the region has led to greater seasonal irregularities, meaning extreme temperatures can occur outside typical seasons:

- Heatwaves may appear earlier (May, June) or later (September, even October), extending summer conditions.
- Late winter frosts or early autumn frosts may also become more frequent, increasing risks for agricultural crops and other sectors.

These weather patterns demonstrate how extremes have become part of seasonal expectations, with potentially harmful effects on agriculture, nature, and infrastructure. However, so-called seasonal anomalies also occur, such as mild winters that can disrupt natural cycles in agriculture. A lack of cold days can affect the development of plants requiring a specific chilling period (known as "chilling hours"), such as fruit trees.

Conversely, sudden temperature drops can cause significant damage to crops, particularly fruit trees and vineyards. Rapid temperature changes can lead to bark splitting or the freezing of plant tissue.

Extreme low and high temperatures in the Travnik municipality are a growing problem, particularly in the context of climate change. Agriculture is especially vulnerable, but other sectors also face challenges. To mitigate negative impacts, farmers will need to adapt their practices, while improved infrastructure will be necessary to address these challenges.

5.3.2 Extreme precipitation

Extreme precipitation in the Travnik municipality, as in other parts of central Bosnia, can occur at various times of the year but is most often linked to specific seasonal patterns. Here's when it is typically recorded:

1. Spring (March, April, May)

- March, April, and May are often marked by more intense rainy periods. Spring is a season when Travnik experiences higher precipitation levels, occasionally leading to heavy showers and storms. During this period:
    - Rapid snowmelt from surrounding mountains (especially Vlašić) can raise river levels and cause flooding.
    - Frequent rains and storms: Intense showers, combined with already saturated soil, can

trigger flash floods, soil erosion, and flooding of arable land.

2. Summer (June, July, August)

Although summer is typically characterised by high temperatures and dry periods, occasional heatwaves can be interrupted by short but intense showers. These often take the form of thunderstorms, potentially causing sudden flash floods, especially in urban areas or on steep hill slopes. Short but heavy rainfall can overwhelm drainage systems, leading to temporary flooding.

3. Autumn (September, October, November)

- September, October, and November are also periods with an increased risk of extreme precipitation. During autumn, rains are frequent, with heavier precipitation particularly likely in October and November. This period often includes prolonged rainy spells that can cause river flooding, soil erosion, and an increased flood risk, especially in lower parts of the municipality and along rivers like the Lašva.

4. Winter (December, January, February)

- Winter months can bring significant snowfall but also occasional rain episodes, particularly in lower areas. During winter, extreme precipitation often occurs as snow, potentially disrupting traffic, interrupting electricity supplies, and triggering avalanches at higher altitudes. In warmer winter periods, rain is common and, combined with snowmelt, can heighten flood risks due to rapid melting.

Extreme precipitation in the Travnik municipality most commonly occurs in spring and autumn but can also appear in summer, particularly as short, intense storms. In winter, the risk is greater from heavy snowfall, while a combination of rain and snowmelt can cause flooding during transitional seasons.

5.3.3 Floods

Floods in the Travnik municipality are a relatively common occurrence, largely due to its specific geographical location, the presence of rivers such as the Lašva, and pronounced seasonal rainfall. They most frequently result from heavy rains and the rapid melting of snow from surrounding mountains, such as Vlašić.

History of floods in Travnik

1. Floods of 2014: One of the most significant events in recent history, the floods that struck much of Bosnia and Herzegovina in May 2014 also affected the Travnik municipality. That year, extreme rainfall triggered floods and landslides across the country. The Lašva River and its tributaries overflowed, causing damage to infrastructure, agricultural land, and buildings. Many families were evacuated, and a significant number of homes, bridges, and roads were damaged.
2. Minor Floods (2016, 2017, 2019): Following 2014, Travnik experienced several smaller floods. These events were typically caused by heavy spring and autumn rains, which led to rising river levels and flash floods. While they did not reach the level of devastation seen in 2014, damage to agricultural areas and local roads remained significant.
3. Floods of 2023: In May 2023, Bosnia and Herzegovina was again hit by floods, including parts of Travnik. These floods were a result of extreme rainfall, leading to river overflows and landslides. The Travnik municipality, particularly the lower areas along the Lašva River, once more suffered damage to residential buildings, agricultural land, and infrastructure.

Spring and autumn are the most common seasons for flooding. Spring brings a combination of snowmelt from Vlašić and heavy rainfall, while autumn typically features prolonged rains

that saturate the soil and cause rivers to overflow. Floods have become more frequent in recent decades, partly due to climate change, which brings more extreme weather conditions and uneven precipitation distribution. It appears that the intervals between major floods are shortening, with events occurring every two to four years.

Causes of floods in Travnik may include

- Heavy rainfall: The primary cause of floods is intense rain, often falling in a short period.
- Snowmelt: Rapid melting of snow from Mount Vlašić in spring frequently contributes to rising river levels, triggering floods.
- Geographical location: Travnik lies in a valley surrounded by hills and mountains, which accelerates water runoff towards rivers, especially after heavy rain.
- Poorly maintained watercourses: The accumulation of debris and inadequate regulation of river channels increase the risk of flooding.

5.3.4 Droughts

Droughts in the Travnik municipality are not uncommon, particularly in the context of global climate change, which leads to increasingly frequent weather extremes. Droughts are most pronounced during the summer months, though their severity and frequency vary depending on annual weather conditions.

The periods when droughts most commonly occur are summer months (June, July, August). Droughts most frequently occur in summer, when high temperatures and a lack of rainfall cause a significant water deficit in the soil. These months experience the most pronounced dry periods, which can lead to reduced agricultural production, especially for drought-sensitive crops such as maize, potatoes, and fruit. Dry periods can occasionally extend into early September, prolonging the summer precipitation deficit.

In the past two decades, the Travnik municipality, along with other parts of Bosnia and Herzegovina, has faced several significant droughts:

1. 2003: One of the most severe droughts in the region's recent history. This drought affected all of Bosnia and Herzegovina, causing serious agricultural losses.
2. 2012: Marked by an exceptionally dry summer, this year had a significant impact on agriculture across the country, including Travnik, with crop yields suffering a substantial decline.
3. 2015: Travnik experienced a prolonged dry period during the summer, further affecting agricultural activities.
4. 2017: Another drought year, which led to a significant drop in groundwater levels and reduced agricultural yields.
5. 2021: A dry summer period resulted in lower yields, particularly for vegetables and fruit.

Causes of droughts include:

- High summer temperatures: Prolonged periods without rainfall, combined with high temperatures, dry out the soil and reduce water reserves.
- Climate change: Droughts have become more frequent and intense due to shifts in climate patterns.
- Lack of adequate irrigation systems: The absence of modern irrigation systems in many parts of the municipality heightens vulnerability to drought.

5.3.5 Storms

Storms in the Travnik municipality are also a frequent occurrence, particularly during spring and summer, when unstable weather conditions arise from rapid changes in temperature and humidity. These storms can include strong winds, thunder, heavy rainfall, and even hail, potentially causing significant damage to infrastructure, agriculture, and forests.

Storms in the Travnik Municipality generally occur in Spring (April, May, June). This is the period when storms are most common, often accompanied by heavy showers and thunder. Storms result from seasonal shifts in air masses, leading to sudden rainfall.

Storms are also frequent during summer months (July and August), typically linked to heatwaves. Hot, dry weather can be interrupted by sudden, intense thunderstorms, sometimes with hail. Though less frequent than in spring and summer, storms can occur in early autumn, particularly in September.

Chronology of significant storms in the past 20 years in the Travnik Municipality

1. 2008: Spring and summer were marked by several severe storms. The greatest damage was caused by strong winds and hail, affecting crops, orchards, and house roofs.
2. 2010: In June 2010, a powerful storm caused floods and landslides. The combination of heavy rainfall and strong winds resulted in serious damage to infrastructure and agricultural land.
3. 2014: In addition to major floods, Travnik was hit by severe storms during spring and summer. These storms featured heavy thunder, hail, and strong winds, further worsening the flooding situation.
4. 2017: During July and August, Travnik experienced multiple storms with hail and strong winds, causing significant damage to crops, especially orchards.
5. 2020: In June 2020, a severe storm accompanied by hail struck the Travnik municipality. Hail damaged numerous crops, while strong winds felled trees and damaged homes and buildings.
6. 2023: Storms in June and July 2023 were particularly intense. Strong winds and heavy rain caused damage to local roads, and hail affected agricultural areas.

Storms in the Travnik Municipality area may cause agricultural damage because storms with hail and strong winds often damage crops, orchards, and vineyards. Strong winds and showers can topple trees, disrupt electricity supplies, and damage buildings. Intense rainfall during storms can trigger flash floods and, in hilly areas of the municipality, increase the risk of landslides.

5.3.6 Forest Fires

Forest fires in the Travnik municipality are not as common as in the drier, southern parts of Bosnia and Herzegovina but do occur, particularly during dry summers and periods of intense heat. Travnik is located in a region with dense forest cover, especially on Mount Vlašić, which increases the risk of forest fires during dry spells, although natural conditions (higher rainfall and humidity) somewhat limit their frequency.

Most forest fires in Bosnia and Herzegovina, including Travnik, are caused by human negligence. These causes include careless open fires, which are often sparked during agricultural work or recreational activities like camping. Carelessly thrown cigarettes can ignite fires in dry forests. Though rarer, forest fires caused by lightning during storms are possible in BiH. Prolonged droughts and high summer temperatures make forests more susceptible to fire outbreaks. While Vlašić and surrounding forested areas are generally moist, they become vulnerable during extended dry periods.

Forest fires in the Travnik municipality occur infrequently compared to drier parts of the country

but have become somewhat more common over the past 20 years due to climate change and more frequent summer droughts.

Chronology of significant forest fires in the past 20 years

1. 2003: During the dry summer of 2003, Travnik and the wider central Bosnia region were affected by several forest fires. Higher-altitude forested areas, including parts of Vlašić, suffered the most damage.
2. 2012: One of the worst years for fires across BiH, Travnik was not exempt. A series of forest fires broke out during the summer, particularly in hilly and mountainous areas. Vlašić was among the affected regions, with fires destroying significant forest cover.
3. 2015: In August 2015, several smaller fires occurred in the Travnik municipality, mainly in forested areas and meadows. The fires were quickly controlled by local fire brigades, but damage to the forest stock was recorded.
4. 2020: Another year marked by forest fires, which affected several mountainous areas of Travnik. Though less intense, the dry summer conditions posed a risk of fire spread.
5. 2023: During the summer months, Travnik recorded several fires in forested areas, particularly around Mount Vlašić. The fires broke out after weeks of high temperatures and no rainfall. Thanks to swift intervention by local firefighters and residents, the fires were brought under control, but significant forest land was damaged.

5.3.7. Summary overview of weather-related disaster risks

The analysis of natural disasters, their frequency, and characteristics provides a basis for identifying existing and anticipated events, trends, or consequences caused by both natural forces and human actions. The consequences of these events are becoming increasingly severe, resulting in significant material damage, a rising frequency of loss of human life, and, as a result of all disasters, more frequent injuries or other health issues among people.

Risk assessments are conducted for various timeframes to indicate when changes in frequency might be expected. These include the current timeframe with ongoing changes, short-term periods of up to five years, medium-term periods ranging from 5 to 15 years, and long-term periods exceeding 15 years.

Phenomena with the highest risk of frequency can be identified as extreme high temperatures, heavy precipitation, storms, and droughts. Based on past experiences and the lack of adequate preventive and mitigative actions, it is assumed that the risk of natural disasters will increase in the future (see Table 26).

Table 26. Risks from natural disasters in the Travnik Municipality

Type of natural disaster	Existing risks	Expected risks		
	Current risk level for natural disasters	Expected change in intensity	Expected change in frequency	Timeframe
Extremely high temperatures	High	Increase	Increase	Short-term
Extremely low temperatures	Moderate	No change	No change	Medium-term
Extreme precipitation	High	Increase	Increase	Short-term
Floods	Moderate	No change	No change	Short-term
Droughts	High	Increase	Increase	Short-term
Storms	Moderate	Increase	Increase	Medium-term
Forest fires	Low	No change	No change	Long-term

Source: authors' analysis

5.3.8 Vulnerability to climate change

Vulnerability to climate change in the Travnik municipality, as elsewhere, does not affect all population groups equally. Climate change impacts people differently depending on their social, economic, and demographic characteristics. The main groups most vulnerable to climate change in Travnik are:

1. Elderly people

Elderly persons are particularly vulnerable to extreme temperatures, such as heatwaves or low temperatures, due to a higher risk of dehydration, heatstroke, and worsening chronic conditions (e.g., heart and respiratory problems). Reduced mobility also makes them more vulnerable during natural disasters like floods or storms, as they face greater difficulty evacuating or adapting to sudden changes.

2. Children

Children are more sensitive to climate change effects, such as air pollution from forest fires or respiratory issues during heatwaves. Their immune systems are not fully developed to effectively cope with climate-induced stress. Children lack the capacity to independently manage dangers or recognise risks, making them reliant on adults for protection.

3. Farmers and rural communities

Farmers are directly affected by changes in precipitation levels, droughts, floods, and extreme temperatures. Crop losses due to adverse weather can lead to economic hardship, particularly for smaller farms lacking resources to adapt or protect crops. Rural communities may have limited access to adaptation resources, such as irrigation systems or technologies to mitigate the effects of weather disasters.

4. Poor and marginalised groups

People with lower incomes lack the resources to invest in risk-reduction measures, such as improving home infrastructure, installing flood protection systems, or safeguarding against extreme temperatures. Poor families struggle to secure food and water during droughts and

heatwaves. Impoverished communities often live in less resilient housing, which is vulnerable to storms, floods, and extreme temperatures.

5. Women and single mothers

In many cases, women and single mothers are economically more vulnerable and less able to protect themselves from climate-related disasters. If they rely on agriculture for income, this further increases their risk. Women often bear greater responsibility for family care, which can complicate evacuation and adaptation to climate risks, especially when caring for elderly relatives or children.

6. People with disabilities

Individuals with disabilities have specific needs during weather-related disasters. Reduced mobility hinders evacuation and access to shelters or assistance. They may also depend on medical equipment that isn't always available during crises (e.g., power outages). These individuals often rely on family or social networks for support during emergencies, increasing their risk if such support is unavailable.

7. Residents in urban areas of Travnik

Urbanisation can lead to the "heat island" effect (urban areas being warmer than surrounding rural areas due to dense buildings and lack of vegetation). Residents in central Travnik, especially those in poorer living conditions, face a higher risk from heatwaves. In urban settings, climate change can affect access to basic resources like water, energy, and healthcare, particularly during prolonged weather disasters.

8. Seasonal Workers and Migrants

Seasonal workers, particularly those in agriculture or construction, face an increased risk of heatstroke, drought, and other climate-related disasters. They often work outdoors with limited access to protective resources. Migrants or seasonal workers may have restricted access to social and healthcare services, making them more vulnerable during crises.

Physical and environmental vulnerabilities can be analysed through various aspects of natural and human systems directly impacted by climate change. These vulnerabilities encompass environmental features, ecosystems, infrastructure, and resources sensitive to changes in temperature, precipitation, extreme weather events, and environmental degradation.

Physical vulnerabilities relate to infrastructure characteristics, natural resources, and geographical features that make a community or region susceptible to climate change.

a) Geographical location and terrain

Travnik's location in a mountainous area contributes to soil instability and increases the risk of landslides, especially after heavy rain or during floods. Steep terrain can exacerbate soil erosion and reduce water retention capacity, heightening drought risk. Rivers like the Lašva flow through Travnik, and their proximity increases susceptibility to flooding. Rapid rises in water levels during heavy rain or snowmelt can lead to flash floods in lower areas

b) Infrastructure

Inadequate or outdated infrastructure, such as embankments and drainage systems, heightens flood vulnerability. Poorly maintained watercourses and channels can become clogged, increasing the risk of flash floods. Buildings, especially older ones not designed to withstand climate extremes, may be damaged during storms or extreme temperatures. Roads in mountainous areas can become impassable due to landslides, jeopardising access to emergency services.

c) Agricultural land

In areas with sloped agricultural land, soil erosion can be a major issue, particularly during intense rain or storms. This erosion reduces soil fertility and capacity for crop growth, posing a long-term threat to local agriculture. Prolonged droughts and improper farming practices can degrade soil, lowering fertility and productivity, which increases farmers' economic vulnerability.

d) Water resources

Climate change can cause prolonged droughts, reducing water availability for agriculture and households. Dependence on natural water sources, such as rivers and groundwater, increases vulnerability to shifts in precipitation patterns. Sudden snowmelt and intense rainfall can overload river systems, causing floods and flash floods that damage properties, farmland, and infrastructure.

Environmental vulnerabilities pertain to ecosystems, biodiversity, and natural resources affected by climate change, often with long-term consequences for the local economy and quality of life.

a) Forest ecosystems

Climate change, such as extended dry periods, increases the risk of forest fires. These fires can destroy forest resources, threaten biodiversity, and lead to habitat loss for many animal species. Extreme temperatures and changes in precipitation patterns can disrupt forest ecosystems, reducing the abundance of certain plant and animal species unable to quickly adapt to new conditions.

b) Agriculture and the environment

Changes in seasonal precipitation and temperature patterns can disrupt agricultural production. Droughts reduce crop productivity, while extreme rains can destroy crops or make them more susceptible to diseases. Farmers may need to switch to more resilient plant varieties capable of withstanding variable climate conditions, requiring additional investment and a shift from traditional farming methods.

c) Land degradation

Intense rainfall and snowmelt can cause landslides, leading to soil instability, particularly in mountainous areas. Landslides threaten agricultural land, infrastructure, and settlements. Soil erosion and land degradation reduce fertility, impacting the long-term sustainability of agriculture and natural resources.

d) Water ecosystems

Extreme rainfall can pollute surface waters by washing chemicals from agricultural land, leading to eutrophication (excessive algae growth) and reduced water quality.

Reduced Water Resources: Droughts and lower precipitation levels affect drinking water sources, increasing stress on water supplies needed for drinking, irrigation, and industry.

6. SURVEY OF FARMERS' ATTITUDES IN THE TRAVNIK MUNICIPALITY REGARDING ECOLOGICAL PRACTICES IN AGRICULTURAL PRODUCTION

During March 2024, a survey was conducted with the aim of determining the extent to which agricultural producers in the Travnik municipality are familiar with aspects of agricultural production and their attitudes towards environmentally friendly agricultural practices. The survey was carried out through interviews, with questions grouped into two thematic sections:

- Basic information about the respondents and basic data on agricultural production
- Implementation of climate and environmental measures on agricultural holdings

6.1. Basic Information about the Survey Respondents and Agricultural Production

A total of 34 agricultural producers participated in the survey, comprising 5.8% female producers and 94.2% male producers. Of the total number of respondents, four were young farmers (12%), while the rest were over 35 years old. In terms of educational attainment, 24 agricultural producers (71%) have completed secondary vocational education, three have only primary school education (8%), and seven respondents have completed vocational studies or university (21%). More than half of the agricultural producers lack education specifically in the field of agriculture.

A significant portion of the agricultural producers (14) have registered their holdings as agricultural holdings, accounting for 46%, while 13 are registered as businesses (43%) not subject to VAT. The reason for this is as follows: under the Law on Crafts and Related Activities, a business does not need to be part of the VAT system if it does not invoice more than 50,000.00 BAM (fifty thousand Bosnian Marks), and most agricultural businesses in the Travnik municipality do not exceed this revenue threshold. The remaining 7 respondents (11%) are not registered in any form. All respondents, who are agricultural producers, own their land and wish to live and work on it. The sizes of the land they manage vary: more than half of the respondents, 18 (52%), own land ranging from 3 to 10 hectares, while 6 (17%) have over 10 hectares. The number of agricultural producers with smaller amounts of agricultural land, up to 3 hectares, is 10 (31%).

The majority of respondents, 24 (71%), are engaged in livestock farming and arable farming, 6 respondents (17%) focus exclusively on fruit growing, while the remaining respondents have mixed production (fruit, vegetables, and grains).

During the interviews, respondents indicated that 6 of them (18%) have production equipment (machinery such as tractors, rototillers, seeders, etc.), an equal number are in the process of acquiring such equipment, while 16 (64%) plan to purchase the necessary equipment in the future.

Most respondents, 20 (59%), sell their products through markets or on their own properties, while 5 respondents (15%) sell their products through cooperatives. The remaining 9 respondents (26%) stated that they combine selling on their own farms with sales to smaller shops.

Five respondents (15%) are members of cooperatives, 6 are members of associations (17%), while the remaining respondents are not members of either cooperatives or associations.

6.2. Implementation of Climate-Environmental Measures on Agricultural Holdings

In the second part of the survey, the objective was to understand how farmers implement climate-environmental measures on their agricultural holdings and their general opinions about current climate change and adaptation measures.

Various climate-environmental measures can be implemented on agricultural holdings, such as

systems related to timing and space, which may include using only primary crops, crop rotation, employing cover crops alongside primary crops, using green manure crops, and integrating intercrops with primary crops. Irrigation is also one of the possible climate-environmental measures.

Unfortunately, none of the respondents apply these measures. All of them engage in conventional agriculture, although more than half of the respondents strive to reduce pesticide use and plant new fruit trees as a means of mitigating soil erosion.

While aware of the impacts of climate change, the respondents have not actively engaged in activities that would reduce harmful emissions of CO_2 and CH_4.

The general conclusion is that the farmers who participated in the survey lack sufficient knowledge about climate-environmental measures and the importance of introducing ecological production. The reasons for this are numerous: a lack of knowledge about the issue, insufficient financial resources to implement measures, a shortage of labour, inadequate information about the benefits of ecological production, and more.

These findings served as the basis for conducting the Green Educational Programme (Zeleni obrazovni program – ZOP) as part of the SOFI project activities, aimed at bringing this topic closer to farmers.

Between December and January, the Centre for Lifelong Learning (Sjedište za cjeloživotno učenje – SCU) delivered the Green Educational Programme, lasting 40 hours.

Image 13. Final certificate award ceremony for participants of the Green Educational Programme

Source: SCU

The programme covered the following topics:

- Soft skills
- The role of ecological agriculture in mitigating climate change and soil degradation
- Measures to combat climate change – conservation (and ecological) agriculture
- Climate change and livestock farming / fruit growing
- Climate change and preparing orchards for the season
- Business planning – CANVAS business model
- Developing a business plan
- European agricultural fund for rural development

During the programme, a field visit was also organised to a cherry plantation in Tarevac near Modriča, owned by Sakib Sarvan.

The programme was successfully completed by 14 participants, who received a certificate of completion for the 40-hour non-formal programme.

In addition to the knowledge gained, one of the outcomes of working with the ZOP participants was the registration of three new ecological producers:

- PO PIRNER, Travnik
- PO MAJDANAC, Travnik
- OPG SELMA, Vitez

At the end of the Green Educational Programme, a representative from the SCU discussed with the Mayor of Travnik the possibility of establishing a demonstration field for ecological agricultural production.

7. ACTION PLAN – MEASURES

The Travnik municipality is aware, on the one hand, of the importance of agriculture in its development, but it is also conscious of agriculture's impact on CH_4 and CO_2 emissions. This awareness is reflected in two key documents: the Sustainable Energy Action Plan (SEAP) and the Local Environmental Plan, through which it sought to reduce emissions of these gases by implementing planned measures. Unfortunately, the period covered by these measures ended in 2020. Therefore, the Climate Action Plan for the Travnik municipality will assist farmers in adopting principles and approaches to reduce greenhouse gas emissions, such as the use of new technologies and innovative tools.

The objectives of the Climate Action Plan are:

1. To strengthen the adaptability and resilience of agriculture to climate change
2. To reduce CO_2 and CH_4 emissions in agricultural production in the Travnik municipality
3. To promote and raise awareness of the need to adapt agriculture to climate change

Each of these objectives will be achieved through the implementation of specific measures:

Objective of Climate Action Plan	Measures
1. To strengthen the adaptability and resilience of agriculture to climate change	- Precision feeding – planning and managing livestock nutrition - Maintaining and improving herd health - Proper manure management - Rotation of arable land / transition from arable land to a mix of arable land / livestock - Increasing the use of sustainable production in protected environments - Crop biodiversity and agroforestry systems - Cultivation of resilient varieties - Introduction of drip irrigation - Reduced use of synthetic pesticides - Promotion and encouragement of rainwater harvesting
2. To reduce CO_2 and CH_4 emissions in agricultural production in the Travnik municipality	- Encouragement and promotion of environmentally friendly and organic agriculture, with a reduction in the use of chemical products in food production - Collaboration between science, education, and production to facilitate the transition to innovative and environmentally friendly technologies and farming methods - Establishment of support programmes for agricultural holdings aimed at reducing CO_2 and methane emissions - Incentives for energy production from renewable sources on agricultural Holdings

3. To promote and raise awareness of the need to adapt agriculture to climate change	- Raising awareness of the need to support organic and sustainable products - Support for local production - Promotion of efficient use of ingredients and food

7.1. Measures of Strategic Objective 1: Strengthen the Adaptability and Resilience of Agriculture to Climate change

The planned measures intended to achieve Objective 1—strengthening the adaptability and resilience of agriculture to climate change—are also measures whose implementation depends on the agricultural holdings themselves, which opt to adopt new technologies, ecological production, or adapt their production to climate change. Given that the Travnik municipality is primarily focused on livestock farming, fruit growing, and vegetable cultivation, the defined measures predominantly relate to these sectors.

1. Precision feeding – planning and managing livestock nutrition	
Measure description	Globally, and in the Travnik municipality as well, livestock production accounts for more than 25% of greenhouse gas (GHG) emissions from food systems. The majority of livestock emissions stem from enteric fermentation and manure. Sustainable management in livestock farming can contribute to mitigating climate change while also enhancing the sector's resilience to the impacts of climate change. One measure that can help reduce emissions within livestock management is improving livestock production through dietary changes. This process may involve integrating various dietary supplements (e.g., certain oils) into feed or enhancing the digestibility of low-quality forage, which ruminants struggle to break down and which therefore intensifies enteric fermentation. This measure aims to encourage producers to increase their attention and awareness of the composition of feed and the nutritional needs of their herds, demonstrating that feed analysis is conducted for the purpose of dietary planning and improving feed quality. Furthermore, measuring, planning, and managing livestock nutrition leads to positive outcomes for the animals, a reduction in greenhouse gas emissions, and broader sustainability benefits.
Activity holder	Agricultural farms engaged in livestock farming
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy)
Result	Increasing herd productivity and reducing greenhouse gas emissions due to planned nutrition and grazing.
Implementation period	2025-2050
Sources of financing	Agricultural holdings
Monitoring/ indicators	Number of agricultural holdings applying this measure, number of agricultural holdings analysing feed, feed analysis results, production parameters.

2. Maintaining and improving herd health	
Measure description	Care for: • Reproductive efficiency and extending the reproductive lifespan of animals • Reducing the frequency and impact of diseases, parasites, and insects This ensures a longer lifespan for individual animals while also reducing the intensity of greenhouse gas emissions. Therefore, it is essential for farmers in livestock production to plan activities related to herd health, including monitoring and diagnosing herd health, implementing biosecurity policies, using vaccines, and focusing on prevention and control.
Activity holder	Agricultural farms engaged in livestock farming
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy)
Result	Increasing herd productivity and reducing greenhouse gas emissions due to improved health of the herd.
Implementation period	2025-2050
Sources of financing	Agricultural holdings
Monitoring/ indicators	Number of agricultural holdings implementing this measure, number of veterinary interventions on agricultural holdings, production parameters.

3. Proper manure management	
Measure description	Proper manure management can help reduce methane and carbon dioxide emissions. The measures included in proper manure management are: 1. Composting manure: Composting is the aerobic decomposition of manure or other organic material by microorganisms in a controlled system. This process, which lasts from several weeks to months, requires air, moisture, and organic material with a high nitrogen and carbon content. Composting manure reduces methane emissions. 2. Reducing manure storage time: This can be achieved through processing or transporting manure from storage using methods such as storing it in a pit with a slatted floor or spreading it on land during favourable weather and soil conditions. Daily manure spreading results in the greatest reduction in methane production, but even reducing storage time from months to weeks can have a significant impact.
Activity holder	Agricultural farms engaged in livestock farming
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy)
Result	Increasing herd productivity and reducing greenhouse gas emissions due to improved health of the herd.
Implementation period	2025-2050
Sources of financing	Agricultural holdings
Monitoring/ indicators	The number of agricultural holdings applying this measure, the percentage reduction in the use of artificial fertilisers.

4. Rotation of arable land / transition from arable land to a mix of arable land /livestock	
Measure description	It is recommended to add grasses or forage crops to the crop rotation to enable the introduction of grazing animals on arable land. The use of livestock for grazing winter cereals can also be included to reduce dependence on synthetic inputs.
Activity holder	Agricultural farms
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy)
Result	Protection of soil health and water quality, preserved habitats for pollinating insects, wild birds, and small mammals.
Implementation period	2025-2050
Sources of financing	Agricultural holdings
Monitoring/ indicators	Periodic soil analysis, water quality analysis, and periodic assessment of biodiversity status of flora and fauna.

5. Increasing the use of sustainable production in protected environments	
Measure description	One way to adapt production technology to climate change is by growing vegetables in protected environments, where vegetative factors such as water, heat, light, air, and nutrients can be adjusted according to plant needs. This reduces the negative impact of external conditions on the growth and development of cultivated crops. This method of production can be used throughout the year, which increases the yield and efficiency of production.
Activity holder	Agricultural farms
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy), Ministry of Agriculture, Water Management, and Forestry of the Federation of Bosnia and Herzegovina
Result	Reduced impact of climate change on production, increased yields, and production cost efficiency.
Implementation period	2025-2050
Sources of financing	Agricultural holdings, Ministry of Agriculture, Water Management, and Forestry of the Federation of Bosnia and Herzegovina, international sponsors
Monitoring/ indicators	The number of agricultural holdings using this measure, the number of greenhouses and glasshouses, increased production, and the area of land under protected environments.

6. Crop biodiversity and agroforestry systems	
Measure description	Despite the importance of biodiversity for sustaining food systems, the global food system is the primary driver of biodiversity loss. Agriculture, particularly over the last 50 years, stands out as the main cause of habitat loss, accounting for 80% of all global changes in land use, primarily through the conversion of natural ecosystems for crop production and pastures. Therefore, it is highly important to cultivate agricultural crops that are suitable for pollinators and birds, with protective strips for beetles. It is necessary to preserve field margins and establish agroforestry systems. Integrating trees and shrubs into pastures is desirable. During the establishment period (five years), trees should be protected from grazing by domestic livestock and wild animals. Appropriate pruning and management of the trees are required until they are fully established. Planting trees at suitable intervals that do not hinder cultivation or grazing improves carbon sequestration, reduces soil erosion, and enhances soil drainage. Planting fruit or nut trees can provide additional income for agricultural holdings. The implementation of agroforestry systems can significantly enhance the sustainability of agricultural production, increase biodiversity, and reduce the carbon footprint. With proper planning, support, and maintenance, agroforestry can deliver numerous ecological, economic, and social benefits.
Activity holder	Agricultural farms
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy), Ministry of Agriculture, Water Management, and Forestry of the Federation of Bosnia and Herzegovina
Result	Protection of soil health and water quality, increased productivity, and preserved habitats for pollinating insects, wild birds, and small mammals.
Implementation period	2025-2050
Sources of financing	Agricultural holdings, international sponsors
Monitoring/ indicators	Periodic soil analysis, water quality analysis, and periodic assessment of the biodiversity status of flora and fauna.

7. Cultivation of resilient varieties	
Measure description	Agricultural production is dependent on the average temperature and amount of precipitation, and longer periods of drought, high temperatures, or heavy rainfall can lead to significant economic damage, such as damage to fruits or vegetables or reduced yields. Therefore, it is important to consider growing agricultural crops and varieties that can also compete in terms of quality and yield during "stressful" weather periods.
Activity holder	Agricultural farms
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy), Ministry of Agriculture, Water Management, and Forestry of the Federation of Bosnia and Herzegovina
Result	Increased productivity, decreased influence of climate change on agricultural production.

Implementation period	2025-2050
Sources of financing	Agricultural holdings, international sponsors
Monitoring/ indicators	The number of agricultural holdings that will introduce crops more resistant to climate change into production, and the number of new crops introduced.

8. Introduction of drip irrigation	
Measure description	Climate change causes changes in temperature and precipitation patterns, leading to more frequent and severe droughts in some regions and increased rainfall in others. Drip irrigation systems can be adapted to meet the specific water needs of different crops, ensuring they receive an adequate water supply for optimal growth and yield.
Activity holder	Agricultural farms
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy), Ministry of Agriculture, Water Management, and Forestry of the Federation of Bosnia and Herzegovina
Result	Increased productivity, decreased negative influence of climate change.
Implementation period	2025-2050
Sources of financing	Agricultural holdings, Ministry of agriculture, water management, and forestry on cantonal and federal level, international sponsors
Monitoring/ indicators	The number of agricultural holdings that will introduce drip irrigation systems, the yield achieved on the holdings, and the area of land covered by irrigation systems.

9. Reduced use of synthetic pesticides	
Measure description	Using an integrated management approach, synthetic pesticides are applied only when the economic threshold of pests/diseases has been reached or when mitigating circumstances require their use. Measures to reduce pesticides include prevention (crop rotation, cover crops, resistant varieties), monitoring, mechanical and physical control, and biocontrol.
Activity holder	Agricultural farms
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy), Ministry of Agriculture, Water Management, and Forestry of the Federation of Bosnia and Herzegovina
Result	Protection of soil health and water quality, preserved habitats for pollinating insects, wild birds, and small mammals.
Implementation period	2025-2050
Sources of financing	Agricultural holdings
Monitoring/ indicators	Periodic soil analysis, water quality analysis, periodic assessment of the biodiversity of flora and fauna.

10. Promotion and encouragement of rainwater harvesting	
Measure description	In order to achieve sustainable agriculture, rainwater harvesting can be applied in irrigated fields. The rainwater would be collected during the rainy period and used in the irrigation system when needed. This approach would help bridge the water consumption issues for irrigation, especially in areas facing water supply challenges.
Activity holder	Agricultural farms
Stakeholders involved	Ministry of Agriculture, Water Management and Forestry of the Central Bosnia Canton and Municipality of Travnik (Department for Development, Economy, and Non-Economy), Ministry of Agriculture, Water Management, and Forestry of the Federation of Bosnia and Herzegovina
Result	Reduction of the negative impact of drought periods, as well as the issue of water scarcity for irrigation.
Implementation period	2025-2050
Sources of financing	Agricultural holdings
Monitoring/ indicators	The number of agricultural holdings implementing this measure, production parameters.

7.2. Measures of Strategic Goal 2: Reduce CO2 and CH4 Emissions in Agricultural Production in Travnik Municipality

Planned measures that should lead to the achievement of goal 2 are measures whose implementation is influenced by decision-makers and the educational system.

1. Encouragement and promotion of environmentally friendly and organic agriculture, with a reduction in the use of chemical products in food production	
Measure description	The measure falls under the category of rural development measures and pertains to additional annual payments per hectare for organic production, specifically for covering costs and income losses during the transition period (conversion) to organic farming. This measure is also outlined by the Federal Ministry of Agriculture, Water Management, and Forestry in its Rural Development and Agriculture Strategy for 2021-2027. It includes a support amount based on the income difference per unit of land due to lower yields resulting from the application of organic farming principles. Support for the transition (conversion) from conventional to organic farming would be provided over a period of five years.
Activity holder	Ministry of Agriculture, Water Management, and Forestry of the Federation BiH
Stakeholders involved	Farmers, Ministry of Agriculture, Water Management, and Forestry of the Central Bosnia Canton
Result	Increased eco and organic agricultural production
Implementation period	2025-2050
Sources of financing	Farmers, and Ministry of Agriculture, Water Management, and Forestry at cantonal and federal level
Monitoring/ indicators	The number of agricultural holdings implementing this measure, the quantity of eco and organic products.

2. Collaboration between science, education, and production to facilitate the transition to innovative and environmentally friendly technologies and farming methods	
Measure description	It is essential to create an environment that enables and encourages collaboration between science, education, and production, with the aim of facilitating the transition to innovative and environmentally friendly technologies and farming methods. The measure should support activities that promote the exchange of knowledge and information among participants in the agricultural sector and the educational system, which should result in increased sustainability and efficiency in the operation of agricultural holdings. It is crucial to provide farmers with access to and the use of research and development infrastructure, and to ensure, through strategic partnerships with research and development institutions, a smoother transition to innovative and environmentally friendly technologies and farming methods, while also enabling joint participation in EU projects.
Activity holder	Educational institutions, scientific research institutions, the Federal Ministry of Agriculture, Water Management, and Forestry.
Stakeholders involved	Farmers, educational institutions, scientific research institutions
Result	Increasing the use of innovative and environmentally friendly technologies and farming methods in agriculture.
Implementation period	2025-2050
Sources of financing	Ministry of Agriculture, Water Management, and Forestry at cantonal and federal level, farmers, international sponsors
Monitoring/ indicators	The number of farms using innovative farming methods, the quantity of ecological and organic products produced, and the number of projects in which educational institutions and farmers jointly participate.

3. Establishment of support programmes for agricultural holdings aimed at reducing CO_2 and methane emissions	
Measure description	Establish a support programme with the objective to encourage farmers to implement methods and technologies in their work processes that reduce emissions of CO2 and methane.
Activity holder	the Federal Ministry of Agriculture, Water Management, and Forestry
Stakeholders involved	Farmers, agricultural ministries at all levels of government
Result	Reduced emissions of harmful gasses
Implementation period	2025-2050
Sources of financing	Ministry of Agriculture, Water Management, and Forestry at cantonal and federal level, farmers, international sponsors
Monitoring	The number of farms using innovative farming methods that reduce CO2 and methane emissions, the quantity of ecological and organic products produced, the number of supported investment projects on agricultural holdings, and the amount of support paid for investments in agricultural holdings.

4. Incentives for energy production from renewable sources on agricultural holdings	
Measure description	There is also potential in the agricultural sector to increase energy production from renewable sources, which would not only reduce costs for purchasing energy from the supply system but also contribute to the greening of agriculture. In addition to solar panels, which can be installed on agricultural holdings, biomass from harvest and similar residues and waste, as well as biogas on livestock farms, can be used as energy sources for farm needs, and potentially for sale to energy distribution systems. In addition to encouragement, it would be highly beneficial if funds were provided within the agricultural budget or its rural development lines to co-finance investments for energy production from biomass and biogas on agricultural holdings.
Activity holder	the Federal Ministry of Agriculture, Water Management, and Forestry
Stakeholders involved	Farmers, agricultural ministries at all levels of government
Result	Increasing the use of renewable energy sources on agricultural holdings, reducing agricultural production costs, and decreasing harmful CO2 emissions released during the use of fossil fuels in the production of electricity or thermal energy.
Implementation period	2025-2050
Sources of financing	Ministry of Agriculture, Water Management, and Forestry at cantonal and federal level, farmers, international sponsors
Monitoring/ indicators	The number of farms producing energy from renewable sources, the number of supported investment projects on agricultural holdings, and the amount of support paid for investments in agricultural holdings.

7.3. Measures of Strategic Goal 3: To Promote and Raise Awareness of the Need to Adapt Agriculture to Climate Change

Planned measures that should lead to the achievement of goal 3 are those whose implementation is influenced by measures directed at consumers and the wider public, who can also significantly contribute to the successful realization of efforts to reduce harmful gas emissions, thereby positively impacting the reduction of the negative effects of climate change.

1. Raising awareness of the need to support organic and sustainable products	
Measure description	It is necessary to strengthen consumer awareness through various education programs, loyalty programs, and campaigns promoting the sale of environmentally friendly products, encouraging consumers to prioritize organic and sustainably produced food. Certification labels, educational campaigns, and incentives for choosing sustainably produced food can be effective tools that will motivate consumers to demand organic and sustainable products.
Activity holder	Agricultural producers, educational institutions, agricultural producers' associations
Stakeholders involved	Consumers, Travnik Municipality, Ministry of Agriculture, Water Management, and Forestry at cantonal and federal level

Result	Reduced emission of greenhouse gasses through utilisation of organic and sustainable products
Implementation period	2024-2050
Sources of financing	Travnik Municipality, Ministry of Agriculture, Water Management, and Forestry of Central Bosnia Canton, Ministry of Economy of Central Bosnia Canton, international sponsors
Monitoring/ indicators	Monitoring the sales of organic and sustainable products, the number of promotional campaigns, and the number of educational sessions conducted.

2. Support for local production	
Measure description	Encouraging consumers to buy locally produced and seasonal food can reduce the carbon footprint associated with food transportation and storage. Farmers' markets, community-supported agricultural programs, and local food campaigns are effective strategies to help local populations recognize the benefits of consuming locally available food. This approach offers numerous ecological, economic, and health advantages, and in addition to its impact on climate, it also affects the food security of the local community.
Activity holder	Agricultural holdings, farmers' associations, business associations, retail chains
Stakeholders involved	Consumers, local population, Ministry of Agriculture, Water Management, and Forestry and Ministry of Economy of Central Bosnia Canton
Result	When consumers buy seasonally available food from local producers, CO2 emissions are reduced through decreased transportation, storage costs are minimized, the profitability of local agricultural holdings increases, and the number and diversification of final products grow.
Implementation period	2024-2050
Sources of financing	Travnik Municipality, Ministry of Agriculture, Water Management, and Forestry of Central Bosnia Canton, Ministry of Economy of Central Bosnia Canton, international sponsors
Monitoring	Monitoring the costs of agricultural holdings, tracking market attendance and increased sales through direct sales channels, and monitoring the increase in the number of final products on agricultural holdings.

3. Promotion of efficient use of ingredients and food	
Measure description	Educating consumers about proper food storage, meal planning, and the importance of reducing food waste can significantly reduce greenhouse gas emissions. Initiatives such as composting and food-sharing platforms can also help, as well as collecting surplus for animal feed to utilize the remaining reduced waste in feeding, for example, pigs.
Activity holder	Agricultural holdings, farmers' associations, business associations, retail chains
Stakeholders involved	Consumers, local population, Ministry of Agriculture, Water Management, and Forestry and Ministry of Economy of Central Bosnia Canton
Result	Reduction of greenhouse gas emissions through the reduction of food waste, and the efficient use of food and ingredients.

Implementation period	2024-2050
Sources of financing	Travnik Municipality, Ministry of Agriculture, Water Management, and Forestry of Central Bosnia Canton, Ministry of Economy of Central Bosnia Canton, international sponsors
Monitoring	The number of participants in food exchange platforms, the number of households using composting, monitoring of compost production, and tracking of exchanges through food-sharing platforms.

8. IMPLEMENTATION OF THE ACTION PLAN

For the successful implementation of the Action Plan, several steps will be taken, including ensuring the organisation of its execution, monitoring, and structural adjustments.

The implementation of the Action Plan measures should be structurally organised and involve as many stakeholders as possible from various sectors of society: the academic community, local authorities, farmers, and agricultural associations. A Monitoring Committee for the implementation of the Action Plan should be formed from their representatives.

Monitoring of the measures' realisation will be offered to the Travnik Municipality, which should incorporate these measures into its next Travnik Municipality Development Strategy.

Based on the proposed measures, relevant organisational units participating in the Action Plan's implementation will be identified. For each organisational unit involved in its execution, it will be necessary to consider a new definition of roles that includes activities related to the implementation tasks.

9. SOURCES OF FUNDING

The sources of funding for the measures will include the agricultural holdings themselves, local, cantonal, and federal authorities, as well as domestic and international donors.

Previous sources of funding for rural development and for starting businesses for young people have included:

- Travnik Municipality
- CEM – Centre for Youth Education
- Mozaik Youth Bank

Each year, the Ministry of Agriculture, Water Management, and Forestry of the Central Bosnia Canton (SBK/KSB), along with the Federal Ministry of Agriculture, Water Management, and Forestry, allocate funds for the further development of agriculture. These funds are provided either through subsidies for agricultural production or subsidies for investments in production, such as the construction of facilities and the purchase of equipment.

For the continued development of agriculture, the Federal Ministry of Agriculture, Water Management, and Forestry plans to invest 183 million BAM (93.55 million EUR) in 2025.

10. CONCLUSION ON THE IMPORTANCE OF CLIMATE ACTION PLAN MEASURES FOR AGRICULTURE

The measures of the Climate Action Plan for agriculture play a vital role in addressing the challenges posed by climate change. They enable the adaptation of agricultural systems to new conditions, reduce their negative impact on the environment, and ensure sustainable food production for future generations. An integrated approach that involves collaboration among all stakeholders—from farmers to consumers, scientists, and policymakers—is essential for achieving the goals of the Climate Action Plan and preserving our planet.

The measures in this Climate Action Plan can collectively make a significant contribution to reducing agriculture's impact on climate change and increasing the resilience of agricultural systems to climate extremes, thereby ensuring long-term sustainability and food security. In

other words, through these measures, the agricultural sector will strengthen its adaptability and resilience to climate change. Additionally, the implementation of these measures will decrease CO_2 and CH_4 emissions in agricultural production in the Travnik municipality. Beyond farmers and local authorities, the residents of the Travnik municipality themselves will also contribute to achieving the outcomes of these measures. Through the planned measures, they too will become aware of the need to adapt agriculture to climate change.

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List of abbreviations

GDP – Gross Domestic Product (Bruto domaći proizvod - BDP)

GAV – Gross Added Value (Bruto dodana vrijednost - BDV)

EU – European Union

EUKI – European Climate Initiative

GHG – Greenhouse Gases

Ha – Hectare

IMSOC – Information Management System for Official Controls

MSC – Mercalli-Cancani-Sieberg (scale)

OPG – Family Agricultural Holding (Obiteljsko poljoprivredno gospodarstvo)

VAT – Value Added Tax (Porez na dodanu vrijednost - PDV)

SCU – Centre for Lifelong Learning (Središte za cjeloživotno učenje)

SECAP – Sustainable Energy and Climate Action Plan

SOC – Soil Organic Carbon

SOFI – Smart Organic Food Initiative

UEZ – Association for the Economy of Communion (Udruga za ekonomiju zajedništva)

UN – United Nations

UNFCCC – United Nations Framework Convention on Climate Change

VUK – Križevci University of Applied Sciences (Veleučilište u Križevcima)

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Amra Kraksner completed her primary and secondary education in Zenica, where she also graduated from the Faculty of Mechanical Engineering at the University of Sarajevo. After completing her studies, she worked at the Zenica Steelworks (ArcelorMittal Zenica) and later with international organisations UNIDO and CHF. Subsequently, she spent five years at the Regional Development Agency for Central Bosnia and Herzegovina, first as an education manager and later as a strategic manager. Since 2007, she has been employed at the University of Vitez, where she serves as the head of the Institute and Centre for Lifelong Learning. During this period, she has worked on implementing numerous projects and drafting strategic documents. She is a member and founder of the Project Association, with which she has contributed to the implementation of several projects in the fields of ecology and rural tourism.

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Anto Bilić is the president of the Centre for Lifelong Learning, where he oversees strategic planning, budget management, and staff coordination, while also representing the Association in collaboration with institutions and the local community. He is an experienced business manager with extensive expertise in the creative sector and graphic industry. Previously, he worked as an operations manager at the construction company Geotehnika and as a sales manager at Bandag Protektiranje.

He holds an MBA for entrepreneurs and has participated in numerous international conferences and workshops in the fields of entrepreneurship, ecological agriculture, sustainable tourism, and digital innovations. Anto actively contributes to the development of rural areas and business initiatives by organising training sessions and fostering partnerships with domestic and international organisations. He is fluent in Croatian and German and possesses strong organisational and communication skills.

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Iva Rojnica was born on 25 November 1991 in Zagreb. She grew up in Davor and completed secondary education at the Nova Gradiška Gymnasium. She earned her undergraduate degree at the Križevci College of Economics, majoring in Plant Production, and her graduate degree at the Faculty of Agriculture, University of Zagreb, majoring in Plant Sciences. She is currently pursuing a postgraduate degree in Agricultural Sciences at the same faculty. After completing her studies, she worked on professional training at the Laboratory for Testing the Quality of Agricultural Reproductive Material, later as an assistant, and is now employed as a lecturer at the Križevci University of Applied Sciences.

Her scientific work falls within the field of biotechnological sciences, specifically agriculture, with a focus on plant production. Her research and interests encompass general plant production, conservation agriculture, agroclimatology, and climate change. She teaches courses such as

Fundamentals of Plant Production, Basics of Agroclimatology, and Core Professional Practice. She is an active member of the Croatian Soil Tillage Research Society (HDPOT), the Croatian Agrometeorological Society (HAgMD), and the VGUK Alumni Association, where she also serves as secretary. She participates in scientific and professional projects, including the Assessment of Conservation Tillage as an Advanced Crop Cultivation Method and Soil Degradation Prevention, as well as the Smart Organic Food Initiative (SOFI).

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Mag. ing. agr. Alma Zečević graduated from the Faculty of Agriculture at the University of Zagreb, with part of her studies completed at foreign universities, including the University of Hohenheim in Germany and BOKU University in Austria. She is currently employed as a consultant at a private company based in Zagreb, providing professional support to farmers in preparing and implementing projects funded by the European Agricultural Fund for Rural Development. Through her work, she has gained significant insight into the challenges faced by agricultural producers, particularly regarding access to funding and aligning their needs with the sector's realistic possibilities.

Since the beginning of her academic career, her interest has focused on ecological agriculture, with an emphasis on analysing both technological and legislative aspects. She strives to integrate agriculture into broader discussions led by experts and representatives in ecology, environmental protection, and climate change. Aware of the sector's often unjust marginalisation in such debates, she highlights the importance of understanding agriculture as both a key driver and victim of climate change through her volunteer work. She advocates for the protection of farmers' and agricultural workers' rights and for ensuring dignified working and living conditions in rural areas.

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Peter Fabjan brings 25 years of entrepreneurial experience in logistics, hospitality, and trade, as well as in the non-profit sector with associations dedicated to actively involving youth in society (K.V.A.R.K. and Safehouse). Since 2015, he has been employed as a project manager at the Association for the Economy of Communion. He has participated in management, marketing, project management, and mental training courses within European projects such as Multifunctional Agriculture as a Driver for Innovation in Rural Europe, Multifunctional Agriculture: Rural Education for Action, and Youth-worker Exchange on Entrepreneurship Education. He has also attended training and education programmes on social innovations and social and green entrepreneurship, including the UN Green Entrepreneurship Programme, Social Innovation Summit, and EoC – Training for Trainers. In recent years, he has coordinated and administered a short food supply chain alongside local ecological food producers. He continued his lifelong learning in 2022 by completing the Laudato Si – Dialogue for Integral Ecology programme at the Croatian Catholic University in Zagreb. He is one of the co-founders of the KLIK energy cooperative – Križevci Laboratory for Climate Innovation – aimed at creating a sustainable and resilient local community on the path to a green transition towards climate resilience.

Reviewers' comments:

"The document Climate Action Plan for Agriculture in the Travnik Municipality, authored by Amra Kraksner, Anto Bilić, Iva Rojnica, Alma Zečević, and Peter Fabjan, is conceptually structured across a total of 12 chapters addressing the themes of agriculture and climate in Bosnia and Herzegovina and the Travnik Municipality.

In the introductory chapter, the exposure of Bosnia and Herzegovina and Travnik to climate change is outlined, along with the theoretical and methodological nature of this commendable document.

The following chapter presents a broader context and aspects of agriculture in Bosnia and Herzegovina, with a detailed analysis of crop production (cereals, industrial crops, forage crops, fruit, and vegetables), livestock production (milk and dairy products, eggs, meat, fish, and honey), and other characteristics of agriculture in Bosnia and Herzegovina, among which the significant topic of financial allocations for agriculture stands out. This is followed by the central theme of this action plan: Agriculture in the Travnik Municipality. Here, a comprehensive overview is first provided of the social (geographical and socio-demographic characteristics) and economic (number and structure of economic entities, tax revenues, and foreign trade exchange) capital of the analysed municipality.

The agricultural resources of the Travnik Municipality are analysed according to categories of land use and types of agricultural production. Available data illustrate the traditional nature of agricultural production, both in the crop production segment and in livestock production. On the other hand, it is important to highlight that traditional agricultural practices can simultaneously serve as a key pillar of the municipality's climate resilience. To preserve the existing ecosystem and food-agrotechnical system for future generations, the Action Plan includes the topic of the complex process of soil organic carbon sequestration, which improves soil quality."

Dr. Sandra Kantar

"Climate change represents one of the greatest threats to the planet's future, making it essential to take urgent and effective steps to reduce greenhouse gas emissions and ensure sustainability for future generations. As in most European countries, Bosnia and Herzegovina has national documents addressing climate change adaptation across all economic sectors. However, there are no documents that specifically outline goals and measures for reducing greenhouse gas emissions in individual economic sectors or at local/regional levels.

Thus, it can be said that the Climate Action Plan is a unique document in Bosnia and Herzegovina, proposing concrete measures for the agricultural sector in the Travnik Municipality. These measures constitute a key component in addressing climate change by reducing greenhouse gas emissions, adapting to extreme weather conditions, and ensuring the long-term sustainability of agricultural production. Agricultural holdings, consumers, and public administration/decision-makers are highlighted as the main actors in implementing these measures. Although the measures are generally well-designed, the document notes several challenges in their implementation, including high initial costs, limited access to technologies, and the need to change traditional agricultural practices. Many farmers face economic difficulties and restricted access to modern technologies, making it crucial to secure financial resources and encourage farmers to transition to sustainable agricultural practices. Furthermore, research conducted prior to drafting the Climate Action Plan has shown that farmers need greater focus on education, such as the 'Green Educational Programme,' which was implemented as part of the SOFI project activities, within the framework of which this plan was also developed."

Dr. sc. Kristina Svržnjak

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