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BEROVO

RISK AND VULNERABILITY ASSESSMENT TO CLIMATE CHANGE

CENTER FOR
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CHANGE

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1 BACKGROUND

The EU4 Energy Transition: Covenant of Mayors in the Western Balkans and Turkey is a multi-donor project that is jointly co-financed by the European Union and the German Federal Ministry for Economic Cooperation and Development and implemented by GIZ in Western Balkans and CPMA in Turkey. This project will tackle climate change and support the energy transition in the Western Balkans and Turkey through an increased uptake of the Covenant of Mayors for Climate and Energy Initiative (CoM) in the region and support municipal authorities to translate their ambitions to reduce greenhouse gas (GHG) emissions into reality and enhance resilience to climate change impacts, while taking into account diversity on the ground.

The overall objective of the Action is to deliver on the energy transition and tackle climate change in the Western Balkans and Turkey. The specific objective is to support the CoM cities of the Western Balkans and Turkey in delivering on their pledges under the energy and climate targets.

Starting point of the project is the "Covenant of Mayors in Europe" initiative. By joining the initiative, cities commit themselves to contribute to the EU's climate protection goals and to develop a Sustainable Energy and Climate Action Plan (SECAP). In this context, one of the key activities of this project is the provision of advisory services and technical and capacity support to selected municipalities in the Western Balkans and Turkey in the development of their first SECAPs. In line with this, municipalities/cities that express their will to become part of the big CoM family, they commit themselves to achieving the set targets by 2030, as well as to develop and implement adaptation plans and actions. In RN Macedonia 3 LSGs were selected to receive support for development of SECAPs: Skopje, Kumanovo and Berovo.

- City of Skopje covers 571.46 km2 and is the largest urban settlement in RN Macedonia. The urbanized area only covers 337 km2. Skopje, in its administrative limits, encompasses many villages and other settlements, including Dračevo, Gorno Nerezi and Bardovci. According to the 2021 census, the City of Skopje itself comprised 526 502 inhabitants. Skopje signed the Covenant of Mayors in 2010 and submitted its Sustainable Energy Action Plan (SEAP) in 2011. According to the documents adopted, the city of Skopje's goal is to achieve a CO2-emission reduction of more than 20% in the period 2009–2020 by implementing projects for energy-efficient buildings, transport and public lighting. In addition, the city is regularly updating its local GHG inventory and in 2015 has adopted a Climate Strategy – Resilient Skopje.

- Kumanovo is located in the north-eastern part of Macedonia, in the Kumanovo Valley (Žegligovo) and covers an area of 509.48 km. Kumanovo is the third most populated settlement in Macedonia and has a population of 70,842. Kumanovo has joined CoM in 2013, but it has never developed a SEAP. According to the national legal obligations, the municipality has prepared and adopted an EE Programme and Action Plan for the period 2016-2018.

- Berovo is located in the eastern part of the country and covers an area of 598.7 km2. According to the last National census from 2021 this municipality has 10,890 inhabitants. According to the national legal obligations, the municipality has prepared and adopted an EE Programme for the period 2019-2021.

Assessing Climate Change Risk and Vulnerability (RVA) has gained significance since 2010, given its central role in the Cancun Adaptation Framework, the EU Adaptation Strategy and the countries development of National Adaptation Plans (European Commission, 2013). Even though most adaptation efforts are covered by public funds (EEA,2014), the private sector, particularly insurance companies, understands the importance of bringing climate change challenges clearly into their investment risk analysis in order to reduce potential losses associated with extreme events.

European cities are heavily vulnerable to the impacts of climate change. Heat, flooding, water scarcity and droughts (among others) can impact health, infrastructure, local economies, and quality of life of inhabitants. Effective climate action not only provides resilience in the face of climate impacts but also important benefits to urban areas in terms of quality of life, improved public health as well as job creation, for example.

2 METHODOLOGICAL APPROACH FOR THE RVA

A Risk and Vulnerability Assessment (RVA) determines the nature and extent of a risk by analysing potential hazards and assessing the vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. This can take the form of a single assessment or various assessments undertaken per sector, for example. According to the IPCC (2014), risk can be understood either qualitatively or quantitatively. Useful approaches for managing risk do not necessarily require an accurate assessment, unless the information is available. Two different approaches to help local authorities better understand climate change impacts, vulnerabilities and risks within their territory are proposed. They differ in the level of detail, required data, tools and technical skills needed to calculate the vulnerability to a specific hazard. A spatially explicit approach relies on climate impact models (e.g. flood-model) to produce hazard maps (e.g. flood-map) according to specific climate stressor and city biophysical attributes (model´s input). An Indicator-Based Assessment helps users to identify the factors that shape city vulnerability to climate threats through comparable composite indicators. The spatially explicit approach is most suited for greater local authorities that usually have the necessary resources and capacities to use the models and act on the main outcomes. The smaller local authorities might use a simpler qualitative approach based on the construction of composite indicators to assess their climate vulnerability and risk.

The RVA enables local authorities to identify their exposure to current and potential Climate Change impacts, vulnerabilities and risks, as well as understand the local specifics that contribute to aggravating the consequences of a specific climate hazard. Similarly, to the BEI, the RVA defines the basis for setting the priorities of investment and monitoring the effectiveness of implemented adaptation measures for a specific region or sector.

In this task the consultant identifies the past climate hazards and vulnerabilities per sector, for Municipality of Berovo.

The risk assessment includes a detailed analysis of the following individual risks, as follows:

- Climate change (stormy weather, droughts and cold waves and snow precipitation) flood forest fires and open fires
- infectious human diseases / epidemics
- risks in commercial and non-commercial facilities and institutions (critical infrastructure) energy, transport, water supply, health, finance, electronic communications and information and communication technologies, environmental protection, functioning of state bodies,
- economic impacts of past climate risks and hazards

A number of documentations are available regarding hazards relevant for selected sectors. As a good baseline were used recently published documents prepared in the framework of the Fourth National Communication on Climate Change of RN Macedonia, as for instance the Policy Brief on Climate Change Loss and Damage in RN Macedonia, Identification and assessment of the extreme weather events in RN Macedonia, the Climate change vulnerability and adaptation assessment report for the sectors agriculture, forestry and land use etc. In addition, into consideration were taken the relevant local level assessment reports and policy documents.

In addition to the desk work, the consultant performed detailed and extensive consultations with each LSGU authorities and other relevant actors in order to make a detailed assessment of the past climate risks and hazard relevant for each LSGU.

The identification of the future climate threats was done on the basis of the assessment of the past climate hazards and events and on the basis on the recently developed climate change extremes and climate hazards projections prepared in the framework of the Forth National Communication on climate change – Future climate extremes in the Skopje Region and the Report on climate change projections and changes in the extremes events in RN Macedonia.

3 GENERAL INFO FOR BEROVO MUNICIPALITY

Berovo — town in the eastern part of the Republic of Macedonia, which is located under the slopes of the Malesevo Mountains, whose municipal borders cover an area of 598 km^2. The Berovo Lake is also located near it. Berovo is located 161 km from Skopje, 47 km from Strumica and 52 km from Kocani. The municipality is made up of 9 settlements, including the town of Berovo as the largest and only urban settlement in the municipality. The population density is 23.31 inhabitants per km^2.

Berovo is located in the eastern part of Macedonia in the area of Maleshevija, i.e. the Maleshevo Valley at 846 meters above sea level. The municipality of Berovo and the rural settlements are located on the periphery of the valley.

3.1 Geographical and climatic characteristics

The municipality of Berovo is a municipality in Macedonia. The center of the municipality is the town of Berovo, which is also the only urban area in the municipality. The municipality of Berovo is located in Eastern Macedonia. The municipality extends in the historical-geographical area of Malesevija. The Maleshev Mountains stretch on the territory of the municipality. Municipality of Berovo borders with Municipality of Vinica and Municipality of Delcevo in the north, with Municipality of Pehcevo in the northeast, with Municipality of Novo Selo and Municipality of Bosilovo in the south, with Municipality of Vasilevo in the southwest and Municipality of Radovish in the west. The total area of the Municipality is 598 km^2, and the total population according to the 2002 census is 13,941 inhabitants. The municipality has a mountainous relief. The river Bregalnica rises on the territory of the Municipality, and the mountain Berovo Lake is located east of the town of Berovo.

Figure 1. Location of Berovo town

Berovo, which is part of the Maleshevo Valley, has a moderate-continental climate with climate modification in the high mountain and plain parts.

Berovo has a significantly lower average annual air temperature than the areas at the same altitude in the wider part of this valley. At an altitude of 800 m, the average annual temperature is 11.1 °C, and in Berovo it is 8.7 °C. The coldest month is January with an average temperature of -10 °C, and the

warmest month is July, with an average temperature of + 18 °C. The average annual minimum temperature is 2.8 °C and the average maximum temperature is 15.3 °C. The most precipitation occurs in the months of May and June, as well as in November, and the driest are the months of August and September. The average annual amount of precipitation is 672 mm/m3. The main maximum falls in May, on average around 76.8 mm/m3, and a secondary one in November -64.3 mm/m3. The main minimum is in August, with an average of 37.6 mm/m3, and the secondary one is in February. The number of rainy days per year is 118. In the average annual amount of precipitation, snow occupies about 15% and occurs from October to May. On average, there are 42.2 days under snow cover per year.

The relative air humidity decreases from January to August, and then increases from December, and the average air humidity is 76%. The average annual sum of the duration of solar radiation is 2,347 hours or 6.4 hours per day, with a maximum in July of 10.2 hours per day, and with a minimum in December of 3 hours per day 8.4 foggy days. The occurrence of hail is rare, on average there are 2.9 days with hail. Salt is less frequent and occurs 70 days a year, from September to May.

3.2 Demographic and social data

In recent decades, the Republic of North Macedonia is facing numerous problems related to the population, as well as numerous challenges arising from the existing economic and social conditions, which have a direct impact on the demographic trends in the country. While birth rates are decreasing, and thus the participation of young people in the overall structure of the population is decreasing, the number of old people is increasing more and more. Also, the Republic of North Macedonia faces marked regional unevenness in population growth, as well as marked differences between urban and rural areas. The Republic of North Macedonia has the character of a distinct migration area, which is characterized both by intense internal displacements and by a continuous process of emigration of the population to other countries. Internal migration flows have different intensity in different periods of time and, in principle, are on the village-city relationship or towards the city of Skopje (both from rural and urban areas). One of the most significant factors that cause these migration movements is the current state of the labour market and the high percentage of the participation of young people in the total rate of unemployed persons. The latest population census data in the Republic of North Macedonia that we can refer to is the 2021 census. Data from a more recent date, which will be used in this paper, are the data from the Statistics Office of the Republic of North Macedonia.

The municipality of Berovo is a relatively small municipality in the Republic of North Macedonia according to the number of inhabitants. According to the last census of 2021, the municipality has 10,890 inhabitants. The municipality includes several settlements and villages around the Berovo Town. Half of the inhabitants, or rather 5,850 inhabitants, live in the town of Berovo, and 5,040 inhabitants live in the surrounding villages. The municipality of Berovo has a continuous trend of decreasing population. The trend can be seen in the following graph. If in 2002 the number of inhabitants was 13,940, in 2021 that number has decreased by 3,050 inhabitants, which is a reduction of even 21.9%.

Below in the figure 1 is given the distribution of population in Municipality of Berovo in the period between 2002 and 2021.

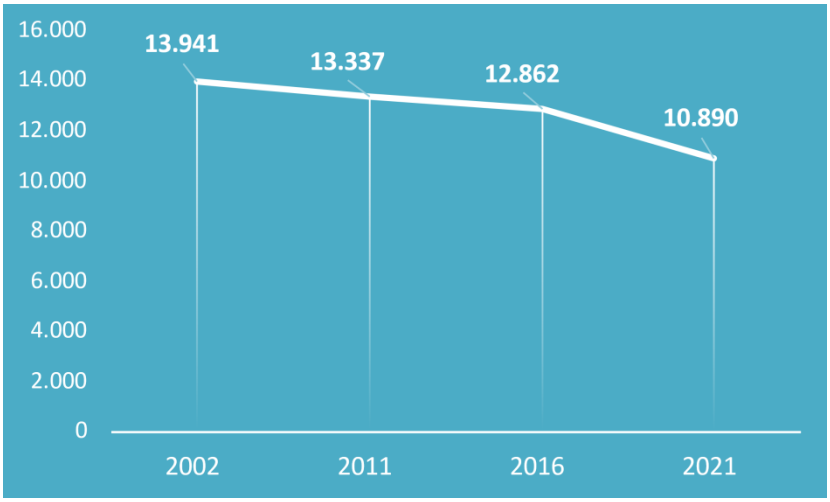


Figure 2. Total population in Municipality of Berovo, 2002 - 2021

In addition, in the Table 1-4 below is given the total residential population in Municipality of Berovo according the Census from 2021.

Table 1. Total residential population in Municipality of Berovo according to the 2021 census

Total			Men			Women		
Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
10,890	5,850	5,040	5,447	2,831	2,616	5,443	3,019	2,424

Table 2. Total residential population in the township of Berovo

Population	Households	Flats
5,850	2,268	4,153

Table 3. Number of families in Municipality of Berovo, census 2021

	Number of families	Number of persons
Total	3,317	10,890
Urban	1,780	5,850
Rural	1,537	5,040

Table 4. Number of dwellings by type of dwelling, 2021 census

	Number of dwellings	Number of people
Residential building	6,259	10,835
Non-residential building	119	4
Institutional Housing Building	6	51
Other	-	-
Total	6,384	10,890

According to the level of education, in the Municipality of Berovo the population with secondary education dominates, which together with those who completed only primary education amounted to

74.2%. This makes Berovo suitable for the development of economic sectors where highly educated labour is not needed, primarily for the development of tourism and the wood industry for which it has natural comparative advantages as a city located at a higher altitude and rich in forests and clean air.

Table 5. Educational structure of the population in the Municipality of Berovo older than 15 years

	Number of people	%
Without education	78	0.8%
Incomplete primary education	468	4.9%
Elementary education	2,606	27.0%
Secondary Education	4,548	47.2%
High education	1,654	17.2%
Master's degree	91	0.9%
Ph.D	8	0.1%
Unknown	183	1.9%
Total	**9,636**	**100.0%**

3.3 Economic characteristics of the Berovo Municipality

The municipality of Berovo has a clean and healthy living environment and clean air that are attracting numerous tourists yearly. Although Berovo in the past was very famous for the quality Berovo potato which was a brand of Berovo, and thus it was characterized as a famous agricultural economy, in the last decade agriculture has been a branch in decline in favour of the highly growing tourism. Berovo is starting to build a brand of a town that "sells clean air". Industry is almost completely absent from the economy, and tourism achieved growth of 32% last year.

The existing tourist facilities are insufficient to accommodate the potential guests from Skopje and other parts from the country, and thus the prices for accommodation are gradually increasing. This is a sector where accommodation and hospitality facilities are constantly increasing. It is also an increasingly labour-intensive sector. In the future, the Tourism sector is expected to be a leading branch of the local economy. Until now, the municipality regularly reviews and adopts a strategy for the advancement of this branch of the local economy.

Forest fires have been the biggest threat to the tourism sector in the past. In particular, the fire of late August/early September 2022 in which large areas of high-quality forest burned were a major risk for the collapse of this economic sector. In fact, forest fires in general are the greatest extreme weather caused by the heat waves as a result of global warming in the context of climate change, and represent the greatest climate risk for the economy of the Municipality of Berovo.

What's more, besides tourism, another economic activity that is on the rise is the wood processing industry. More and more new ones are starting work on the territory of the municipality and the volume of production of the existing sawmills is growing. Also, this branch is dependent on the good condition of the forest fund. Related to this industrial branch of the economy, forest fires are the biggest climate threat to the local economy.

The other economic sectors (trade, textile industry, agriculture, etc.) have little added value in the overall economy.

3.3.1.1 Entities in the Municipality of Berovo by sectors

In the municipality of Berovo, more than half of the registered entities according to the Central Registry of the Republic of North Macedonia are concentrated in three sectors: trade, manufacturing industry and transport and storage. In these three sectors operate 55% of the total number of entities. This report will interpret the analysis in relation to the year 2021, for the purpose of comparison with the census data provided throughout the other parts of this study.

More specifically, in the Municipality of Berovo at the end of 2021 most of the entities operated in the Trade sector (wholesale and retail) that is 29.3%, than in Manufacturing industry 15.9%, and 10% operates in the sector of Transport and storage. These three sectors represent more than half of the entities. Besides the number of entities per sector provides the initial insight, it is not a good parameter for the structure of the local economy nor for the importance of a particular sector as are the number of employees, or the revenues and output generated in a particular sector. These measures are analyses more in details below.

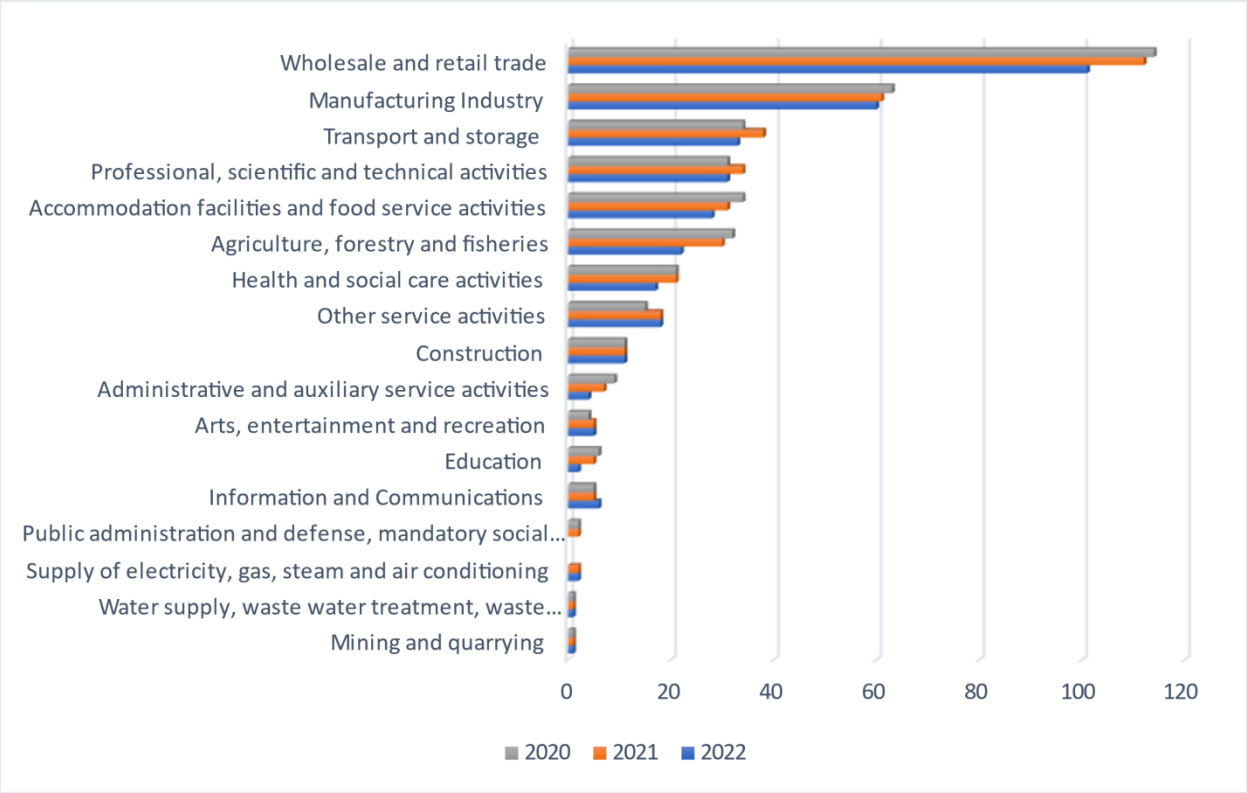


Figure 3. Number of entities in the Municipality of Berovo by sectors

The economic structure of the Municipality of Berovo, according to the size and sectors of activity, is presented in the table 6.

Table 6. Structure of enterprises by size in the Municipality of Berovo

	Total	Micro	Small	Medium	Large
December 2012	425	323	99	2	1
December 2016	414	310	100	3	1

3.3.2 Labour market in the Municipality of Berovo

Better coordination and consistency between economic and social policy are needed, so that with their joint effect, the policy of fighting poverty can be strengthened. Special attention should be paid to secondary education, due to its connection with the needs and demand of the labour market.

Socioeconomic development reflects the economic and social dimensions of sustainable development. This topic is mainly dedicated to the activities that are necessary to achieve a prosperous, innovative, competitive and developing economy with sustainable economic growth, which will enable full employment and greater social cohesion.

The social dimension of economic growth is recognized in the provision of economic resources that will enable the reduction of poverty, investment in quality education and health care, that contribute to the sustainability of the public financial system. In the context of an aging society, the exclusion of older employees from the labour market will burden the pension system, making it unsustainable.

The reasons for the current unemployment should not be sought only in the current situation, but also in the previous years of transition, the privatization process, the new market conditions, the informal economy, the weak construction of the infrastructure. If we consider the current reasons for high unemployment, they are mostly located in the insufficient demand for labour force, which, in turn, is largely the result of weak economic growth in the past decade and the world economic crisis. The labour market continues to be characterized by a high unemployment rate, especially among the young and low-skilled, with a low activity rate among women, as well as long-term unemployment.

The municipality of Berovo is among the smaller municipality in the Republic of N. Macedonia. According to the last census of 2021, Municipality of Berovo has 10,890 inhabitants, of which 1,700 are young people aged between 15 and 30 years old. The number of residents who are at working age between 20 and 64 years is 6,570 i.e. 60.3%.

More precisely, the total population with working abilities, which encompass all people aged over 15 years in 2021 amounts to 9,636. From them, 6,570 (60,3% of total population) are in the working age group (20 – 64 years old). But the total active population in 2021 amounts 4,216 and is very smaller than the idle population of 5,246. Actively employed residents of the Municipality of Berovo in 2021 are 3,458 and unemployed are 758 (compared to 1,245 in 2018).

Table 7. Overview of the structure of the labour market in the Municipality of Berovo in 2021

	Total population with working abilities (all population with age over 15y)	Active population - total	Active population - employees	Active population - unemployed	Total Idle population	Unknown
Total	**9,636**	**4,216**	**3,458**	**758**	**5,246**	**174**

Men	4,832	2,310	1,890	420	2,430	92
Women	4,804	1,906	1,568	338	2,816	82

Another specificity of the labour market in the Municipality of Berovo is that more than a halve of employed residents do not work in their municipality. Namely, the Bureau of Statistics, according to the 2021 census, shows that the number of employed residents of Berovo Municipality is 3,458. However, according to data from the Central Registry of the Republic of North Macedonia, the number of people who work in Municipality of Berovo is 1,920. Of course, this figure also includes people who are not residents of Berovo, but work here, besides their number is not significant. The difference between this two data is the people who are residents of the Municipality of Berovo and who are employed in other cities and maybe in the vicinity of Berovo. In the report for the RVA for the economic sector for the City of Skopje, on the analysis of the labour market in Skopje, it is shown the opposite situation, that there are many more people working in the City of Skopje than there are resident employees of the City of Skopje. Probably there are lot of residents from Berovo who live and work in Skopje.

Nevertheless, the number of employees is constantly decreasing depicted in the following Figure for the period 2020 – 2021. This is mostly related to the depopulation of this municipality, and the COVID – 19 had some negative impact in this period also.

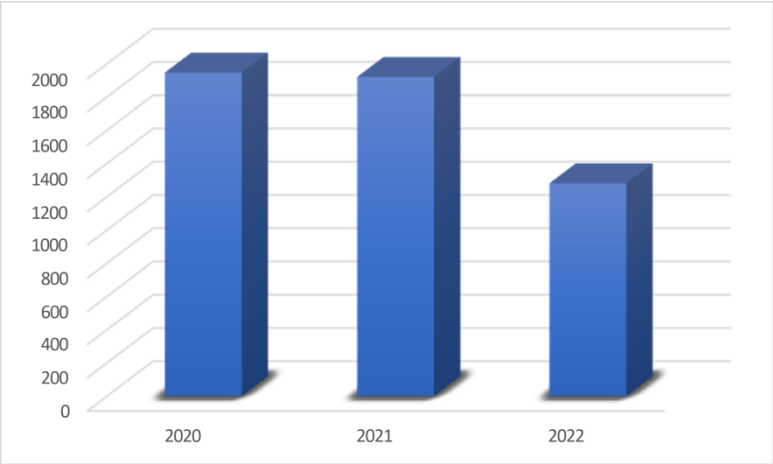


Figure 4. Number of employees in Municipality of Berovo

Table 8. Employees according to the type of occupations in the Municipality of Berovo in 2021

Type of occupations	Number of employees	%
Military occupations	48	1.4%
Members of legislative and executive bodies, state officials, senior civil servants, diplomats and directors	101	2.9%
Experts and scientists	635	18.4%
Technicians and related workers	440	12.7%
Officials	180	5.2%
Workers in service activities and sales	561	16.2%

Professional workers in agriculture, forestry, fishing and hunting	**111**	**3.2%**
Occupations for non-industrial way of working in production	**503**	**14.5%**
Operators and assemblers of machinery and plant	**280**	**8.1%**
Elementary occupations	**538**	**15.6%**
Unknown occupation	**61**	**1.8%**
TOTAL	**3,458**	**100.0%**

Furthermore, according to the data from the State Statistics Office, out of the total number of employees 3,458, the largest numbers of 3,221 are people who are workers, employed by other employers. The structure of the economic status of the employees is presented in more detail in the following graph.

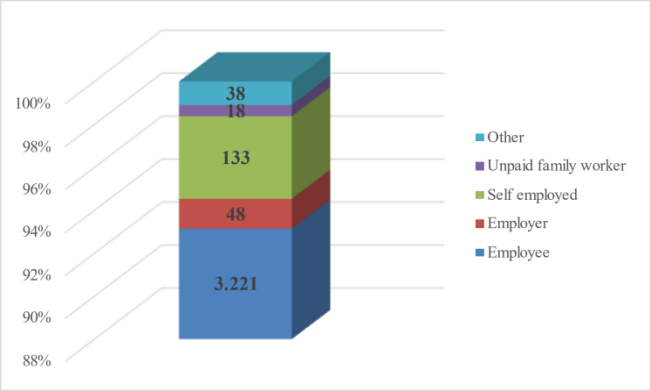


Figure 5. Structure of employees according to economic status in the Municipality of Berovo in 2021

A first impression of the size of the economic sectors in the local economy is obtained through the analysis of the number of employees by sector. The following chart gives a clear picture of this aspect. The local economy of the municipality of Berovo is dominated by two sectors, with the largest sector being the Manufacturing industry, which absorbs 27.5% of the workers in the municipality. The second largest sector is the Trade (wholesale and retail) that absorbs 15.8% of the total number of employees. This analysis is made on the data provided from the Central Registry of the Republic of North Macedonia, and encompasses only the employees that work in the Municipality of Berovo, regardless of their residence and more accurately reflects the employment by sectors in the local economy, which is the basis for climate vulnerability analysis.

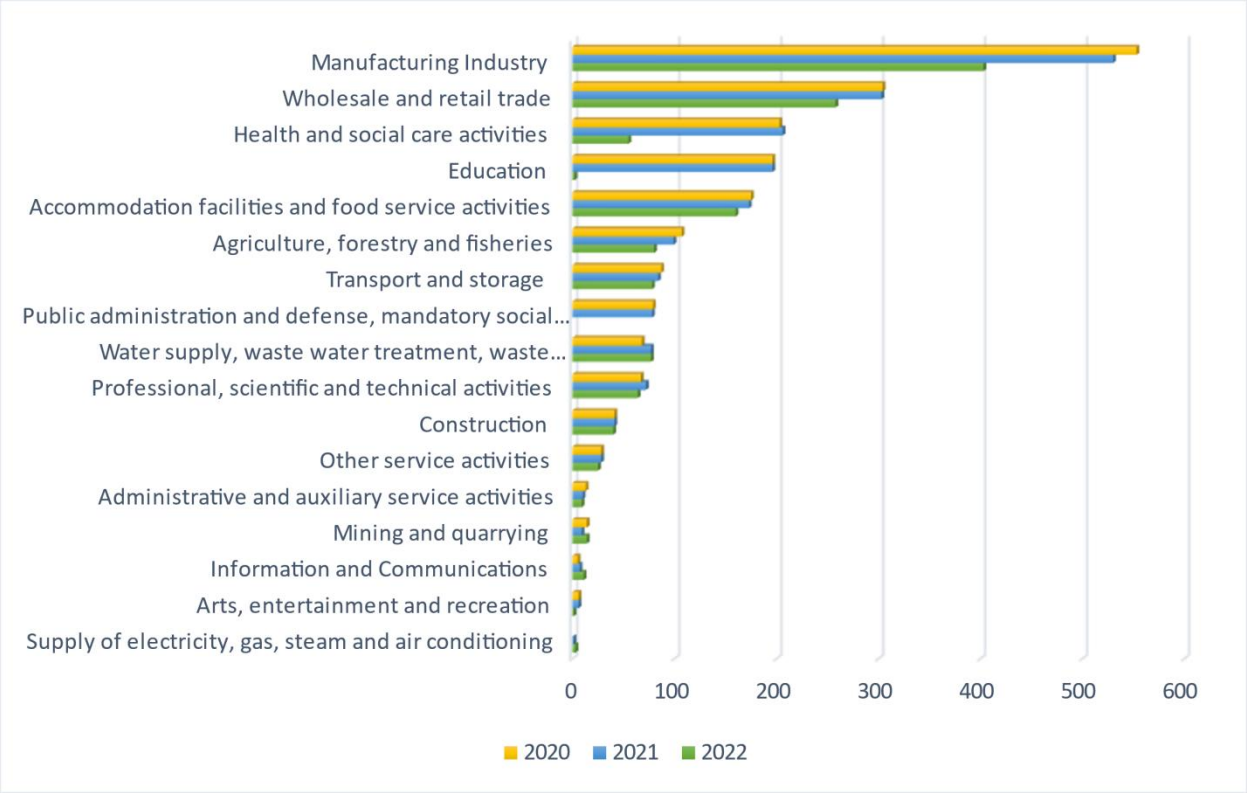


Figure 6. Number of employees by sector in Municipality of Berovo

3.3.3 Unemployment in the Municipality of Berovo

The activities of the Employment Agency of the Republic of North Macedonia, as a significant participant in the labour market, are aimed at more successfully connecting the supply and demand of labour force, as well as increasing the capacities for employment of unemployed persons, with the aim of their successful integration into the changing labour market.

When a more detailed analysis is made, it is seen that the unengaged workforce does not correspond to the needs of employers for the following reasons:

• The age structure of the unemployed is unfavourable, due to the large share of the older middle-aged labour force and those over 50 years old;

• The structure of the unemployed according to gender is also unfavourable, because the number of unemployed men is greater, and the demand for female labour is greater.

Table 9. Unemployed persons aged 15 and over by age

	Age	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Men	**420**	**9**	**45**	**45**	**61**	**42**	**45**	**46**	**45**	**59**	**23**	**-**
Women	**338**	**7**	**43**	**38**	**41**	**28**	**43**	**48**	**47**	**36**	**7**	**-**
Total	**758**	**16**	**88**	**83**	**102**	**70**	**88**	**94**	**92**	**95**	**30**	**-**

From the perspective of future changes in the labour market, to which more attention should be paid, it is important to take into account the development of the population in the Municipality of Berovo. The municipality is involved in an intensive process of population aging, which results in a reduced influx of new generations into the working contingent and a gradual aging of the workforce.

Education is a key determinant of development. The educational structure of the population is as of the unemployed persons is presented in the following table. The persons with secondary education are dominant, and together with those with primary education represent 82,2% of total unemployed work force. This is favourable structure for boosting business activities that do not depend on high educated profile, and mostly in tourism, agriculture and wood industry wood and wood processing industry wood and wood processing industry as far as the comparative advantages and location of this municipality are concerned. However, all these sectors are highly climate vulnerable sectors.

Table 10. Unemployed persons by level of education

Level of education	Number of unemployed persons	%
Without education	10	1,3%
Incomplete primary education	17	2,2%
Elementary education	171	22,6%
Secondary Education	455	60,0%
High education	98	12,9%
Master's degree	7	0,9%
Ph.D	-	-
Unknown	-	-
Total	758	100,0%

3.3.4 Revenues, profit and loss generated in the Municipality of Berovo by sectors

The number of employees by sector gives one perspective of measuring the size and the importance of different sectors in the local economy. However, in order to complete the overall picture of the significance and contribution of the separate sectors in the local economy, the other measure should be looked at, which is the output realized by each separate sector. In the Republic of North Macedonia, there is no measurement of the size of the Gross Domestic Product by municipalities. There is only one such measure per region. Specifically, Berovo belongs to the Eastern planning region, but there are also other cities and municipalities within it. Those are Municipality of Shtip and Kocani that are much larger and Municipality of Berovo is not economically significant in this region compared to the other ones.

For this purpose, the use of other measures that will give a clear idea of the size of the output by individual sectors and through this it can be gained knowledge about the size and importance of the sector in the local economy. Therefore, follows the analysis of the realized revenues from the entities in the individual sectors. We will take 2021, a pre-inflationary year, as the benchmark year for analysis. The graph gives a clear picture that the Trade sector is the largest and extremely dominant sector

according to this criterion. This sector generates 26.3% the total revenues in the local economy. Next ranked sector according to the revenues is the Manufacturing Industry sector where 16.6% of the local revenues are generated, and Agriculture with 7.1% generated revenues is on the third place. Taken together, the first three sectors generate as much as 57.3% of the total revenues in the local economy.

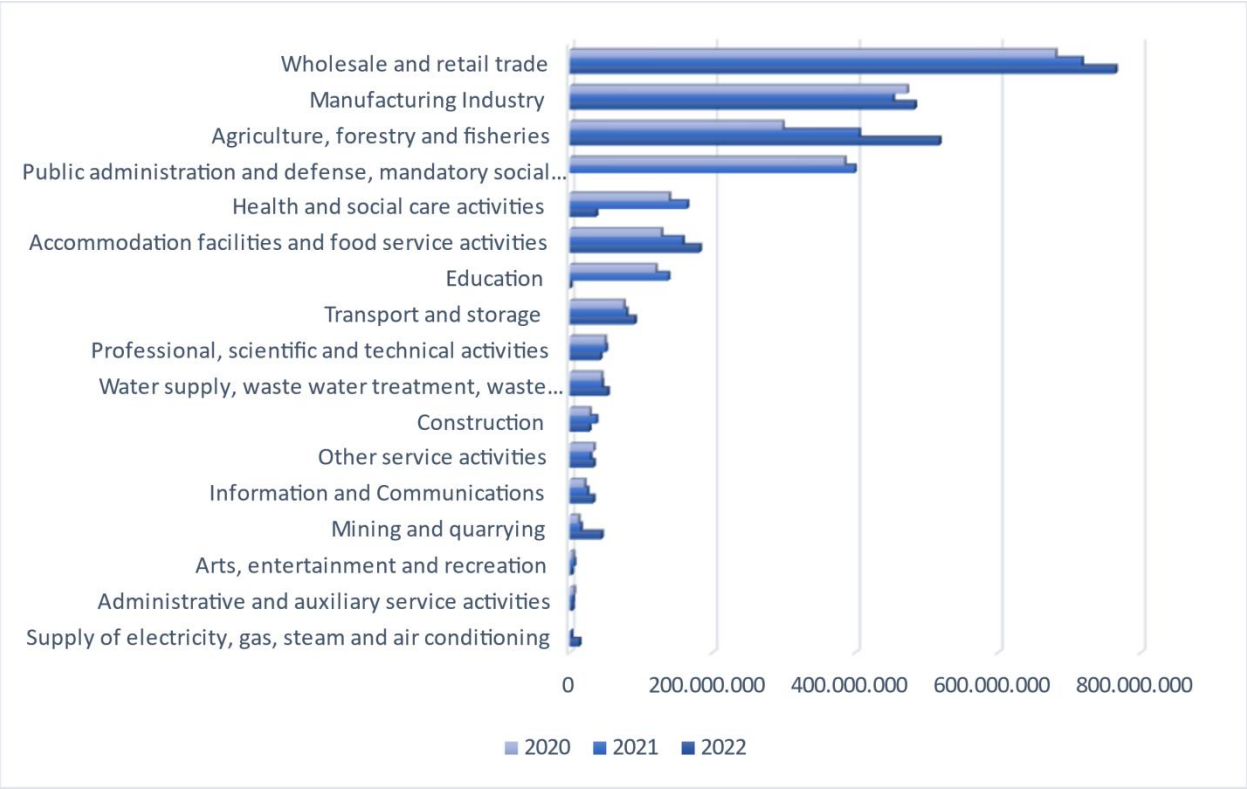


Figure 7. Revenues generated in the Municipality of Berovo by sectors

Almost identical conclusions can be reached if the realized profits in individual sectors are analyzed. If we ignore the public sector, then the most profitable business sector is Trade which generates 17.7% of the total profit earned in the Municipality, than are Manufacturing (12.9%) and Agriculture (12%). However, not all entities were profitable. The loss is 3.6 times less than the gain. Of the total loss, Trade covers 35.4%, Transport 22.2%, and Manufacturing industry 13.5%.

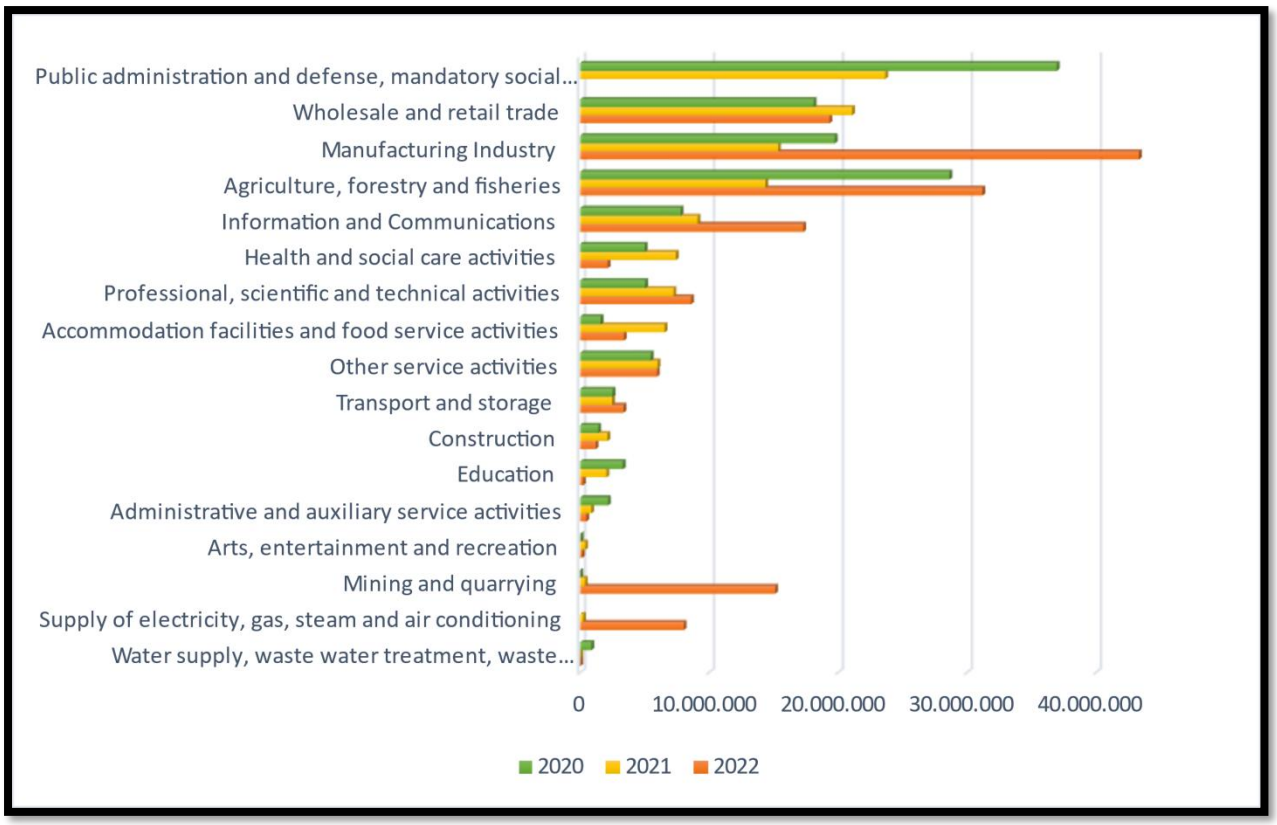


Figure 8. Profit generated in the Municipality of Berovo by sectors

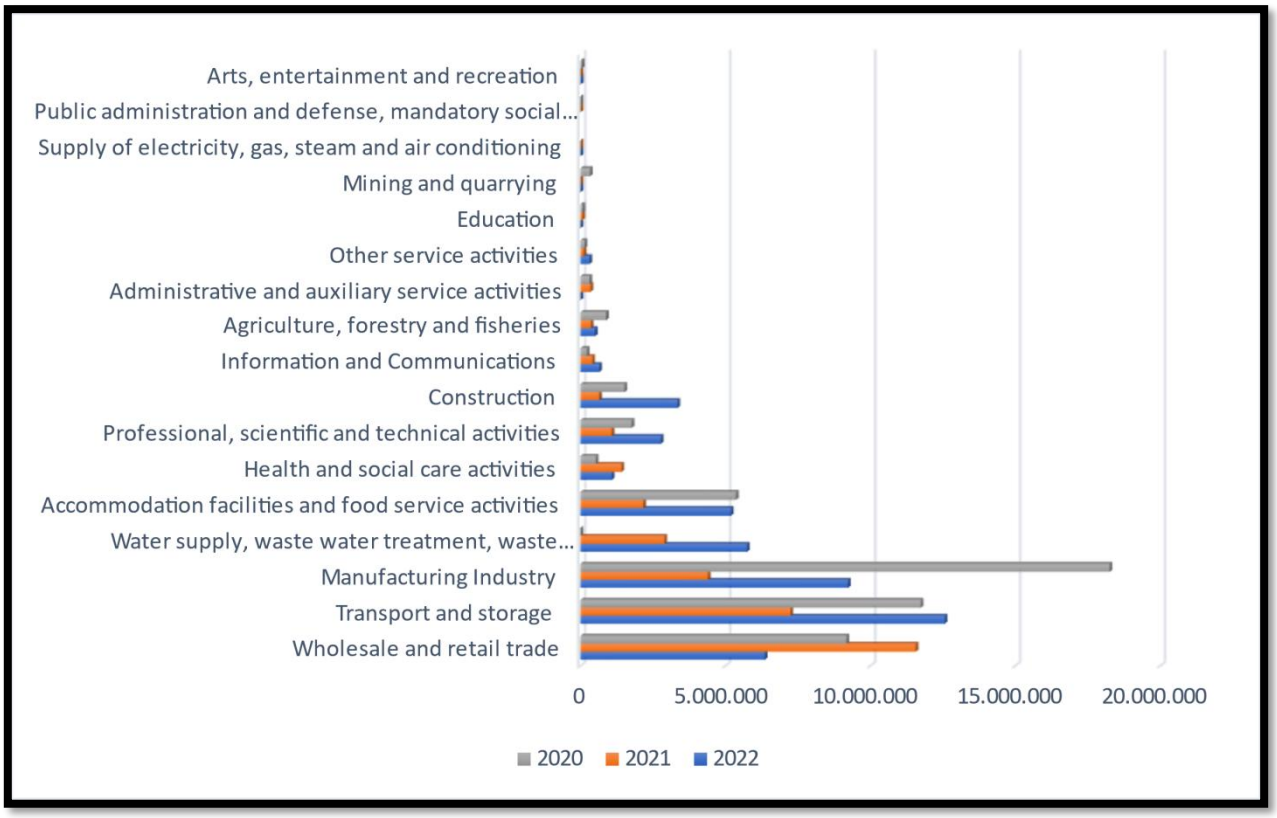


Figure 9. Loss generated in the Municipality of Berovo by sectors

4 ASSESSMENT OF THE PAST CLIMATE RISKS AND HAZARDS IN THE MUNICIPALITY OF BEROVO

4.1 Climate change (stormy weather, droughts, heat and cold waves)

The average annual amount of precipitation in the municipality of Berovo is 464.2 mm/m2. According to the data from State Statistical Office for 2011 the main maximum falls in June, on average around 123 mm/m2, and the secondary one in September 88.4 mm/m. The main minimum is in November, with an average of 0.6 mm/m2, and a secondary one in February with 14 mm/m2. The same month of June represents the main maximum of precipitation if you look at the data for the period 2006 - 2010, and the secondary maximum is the month of October. According to the data in the period 2006-2010, the main minimum is the month of February with 38 mm/m2, and secondary November with 42.1 mm/m2. According to the previous comparisons, it can be noted that there are no major shifts in the distribution of precipitation by month.

What represents a significant deviation is the average amount of precipitation for the period 2006 - 2010, which is significantly higher than the amount for 2011. As a result of global warming, the average annual rainfall is decreasing. The number of rainy days for 2011 was 95. In the average annual amount of precipitation, snow occupies 18 days and occurs from October to May, while the number of days under rain is 66 days.

4.1.1 Floods

Based on the municipality evidence the number of flood events in the period from 2009 – 2022 is as follows:

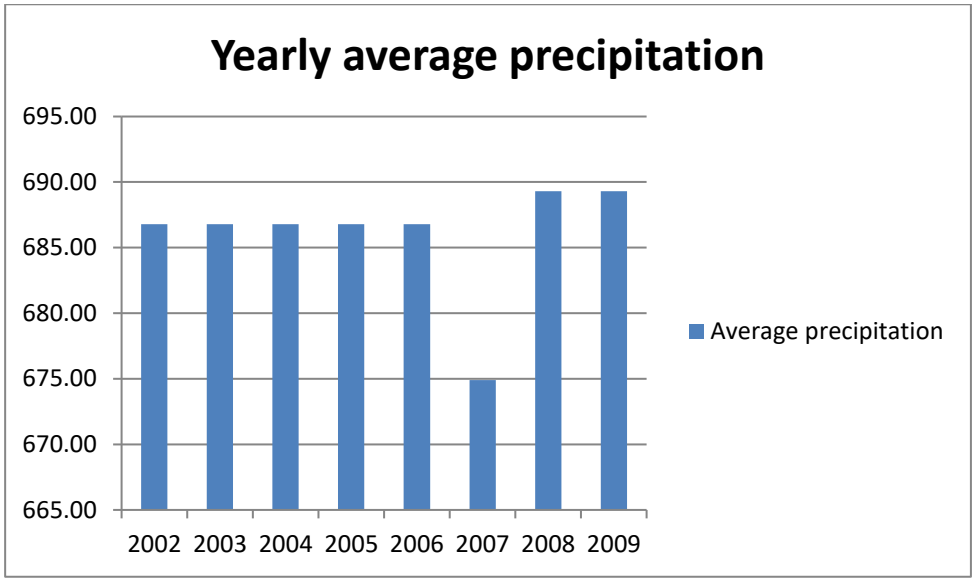
Table 11. Number of flood events in the period 2009-2022 in Berovo municipality

Year	Period when the flood occurs	Location	Damage	Water stream
2009	January May June	Berovo Berovo Budinarci	Flooded house basements at several Flooded houses Flooded arable land Flooded the school yard of the primary school	Bregalnica river
2010	04.12.2010	Budinarci Rusinovo Dzerdovi mills Ratevo dvorishte	flooded agricultural areas Damage to the local road leading to the village in 2 places. damage to a local road in the village in the upper part of the village 3 stables were broken into, from where a large amount of fodder was taken flooded agricultural lands	Bregalnica river Ratevska river Cironska river

			Danger of undermining houses Flooded agricultural areas	
2012	25.05.2012	Budinarci	Small insignificant	Bregalnica river
2014	10.06.2014 24.07.2014 06.08.2014	Berovo		Bregalnica river
2015	31.07.2015	Berovo	/	Bregalnica river
2018	20.03.2018	Rusinovo	/	/
2021	12.01.2021	Budinarci	/	Bregalnica river

The table indicates that biggest flood events occurred in the year 2010 when more locations were affected which caused significant damage to infrastructure but also agricultural areas.

Below on the graph is shown the average precipitation in the period 2002-2022, which clearly indicates that there is no significant difference and yearly average can vary from 600-700 mm yearly.



Graph 1. Yearly average precipitation

4.1.2 Heat waves

Based on the analysis conducted by the Hydromet service, and the statistical analysis it can be noted that most frequently occur short heat waves (those with duration of up to 6 days), and the longer their duration is the lower are the chance to occur.

Based on the analysis of the heat wave duration index (HWDI) the maximum durations of heat waves have also been determined. The data individually for the warm (May-October) and the cold (November-April) part of the year for Berovo are given below in the table.

Table 12. Heat wave duration in Berovo

Heat wave duration	Days
29.04.2003-14.05.2003	16
16.07.2007-25.07.2007	10
25.09.2012-02.10.2012	8

One of the characteristics of heat waves is the number of days with maximum water temperature Tx >25 °C (summer days), shown on figure below, made in GIS technology for the period 1971-2000. It is noted that Berovo area is a location where are the lowest number of summer days (0-20 days).

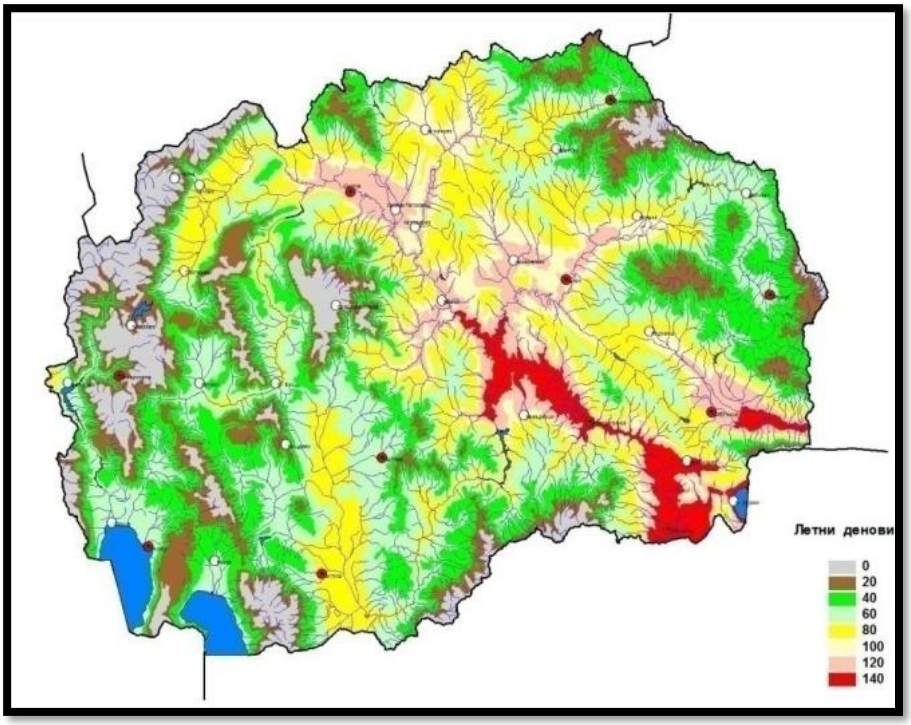


Figure 10. Average annual number of summer days - days with a maximum

The picture below (left) also indicate the number of summer days (days with maximum temperature of the air Tx>25 C for Berovo, but also the frequency of heat waves in the period 1961-2012.

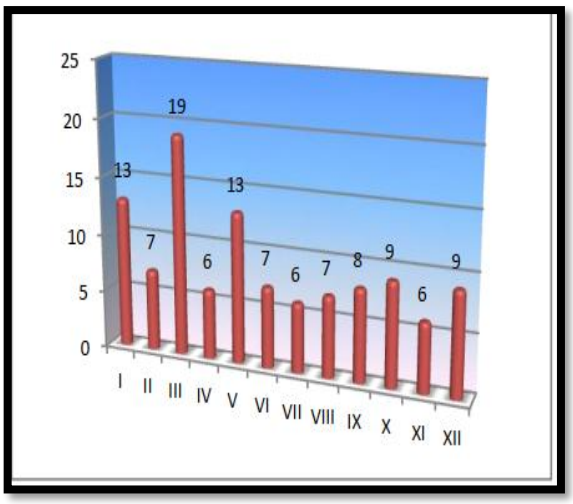


Figure 11. Frequency of heat waves

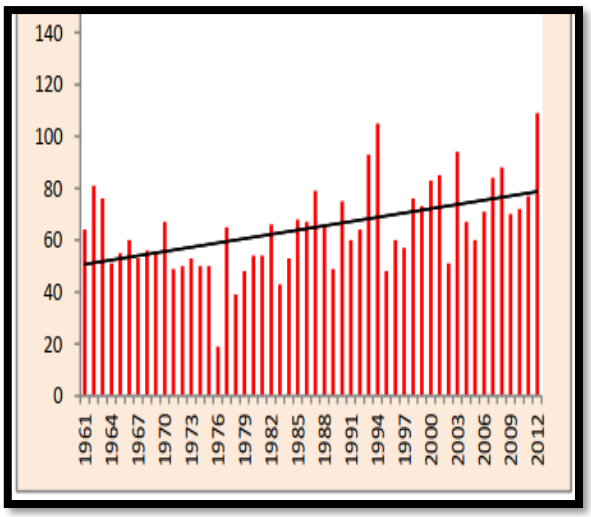


Figure 12. Summer days, (days with maximum air temperature

4.1.3 Cold waves

The analysis held by Hydromet Service for cold waves is based on the statistical analysis of the daily maximum temperatures where main conclusion is that highest frequency has the cold waves with duration of 6 days. Longer cold waves are less frequent that is, a lower number of occurrences during the analyzed period. Unlike heat waves, cold waves have a much lower frequency occurrence. The table below indicates the most important periods of cold waves in Berovo.

Of all the observed cases of cold waves as the most characteristic cases it is possible to single out the occurrences in the period 22.01-02.02.1963 and in the period 12.02-27.02.1985. In these periods, some of the longest ones have been recorded cold waves observed in the entire territory of the Republic of Macedonia[1].

Table below shows that the cold waves mainly occur in the cold months January –March and November – December, but the longest duration are evident in the years 1963 in January with 11 days duration and 1985 in February with 14 days duration.

Table 13Frequency of cold waves in Berovo.

Cold wave duration	Days
22.01.1963-01.02.1963	11
13.02.1985-26.02.1985	14

[1] Hydromet analysis of extreme weather temperatures

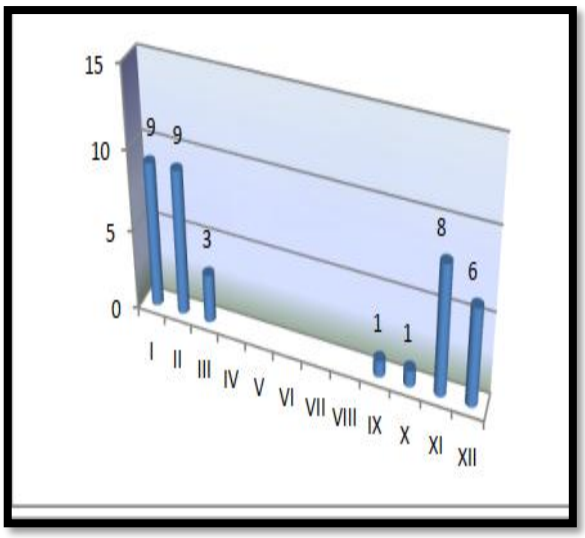


Figure 14. Frequency of cold waves occurrence in Berovo (1961-2012)

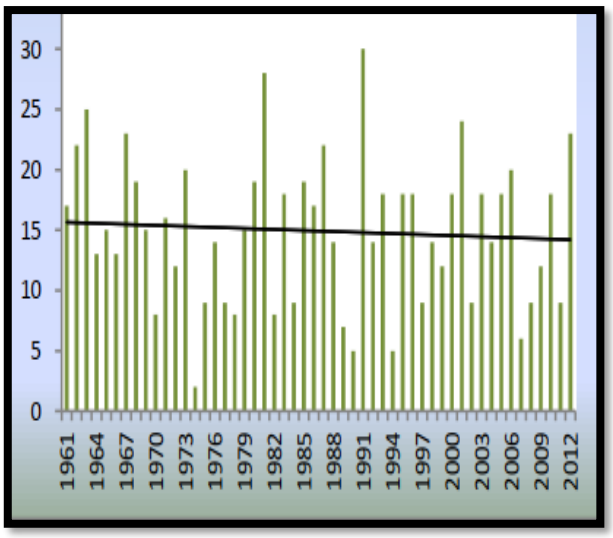


Figure 13. Ice days (days with max air temperature Tx<0 C

4.1.4 Droughts

On the map below it can be seen that the Berovo municipality is mildly affected by drought. Half of the territory is moderately vulnerable to drought and the remaining part is not affected by drought. The climatic data used for this analysis was 1981 to 2010.

The drought vulnerability is the best indicator for assessing the vulnerability to forest fires. In this case the drought indicator is just one indicator for forest fires. On the other hand, there are a lot of coniferous forests which are highly prone to forest fires. The fire risk is increasing with the activities of the local population in the forests.

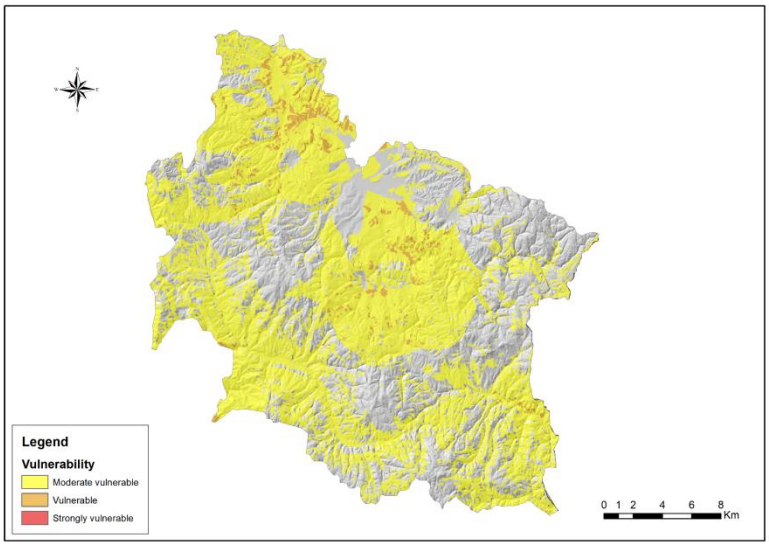


Figure 15. Drought vulnerability in Berovo

4.1.5 Forest fires and open fires

The forests in the vicinity of inhabited areas pose a risk of forest fire occurrences that is why they should be constantly monitored and protected. Forest fires are constant occurrence in the past. With the increase of dry periods the risk of forest fires are increasing. There are several events recorded for fire occurrence in the municipality. According to the data of PE "National Forests", the total number of forest fires registered in the period 1999-2021, in Macedonia is 4,938 fires, the total burned area is 203,262.66 ha, and the caused financial damage is estimated at 179,146,079 euro. According to the same source, the average annual number of forest fires in this period is 215 fires, the burned area is about 8,837 ha and the average annual financial damage is around 7,788,960 euro.

5 ASSESSMENT OF PAST AND CURRENT VULNERABILITIES AND RISKS AT RELEVANT SECTORS

5.1 Water sector

In this chapter were identified the past and current climate change hazards, vulnerabilities and risks, as well as understanding of the local specifics that contribute to aggravating the consequences of a specific climate hazards.

The city of Berovo is located in the upper part of the Bregalnica river basin and in the past was not so exposed on big river floods because in that upper part of the basin the river is starting to form so the downstream part of the basin was more prone to river floods. The city was more prone to flash floods in the past and also to drought periods as well as water scarcity, especially drinking water.

5.1.1 Average annual precipitation

According to average annual sums of precipitation in the past, they show that referring to annual average discharges, rivers in the region are not very vulnerable to climate change and don't indicate large hazards or risks. But, it should be emphasized that analyzed data are average annual data of precipitation for 1991-2020 and that even in one average year or year with precipitation and discharges below the average, it is possibility to have periods (days) with extreme amount of precipitation which will not affect the average annual precipitation or discharge, but would be potential danger and hazard of floods of the rivers (r. Bregalnica, r. Ratevska, r. Rusinska) causing inundations and flooded areas. Below on the graph are given data of annual sums of precipitation for Berovo in the period from 1961-2015 (Figure 15).

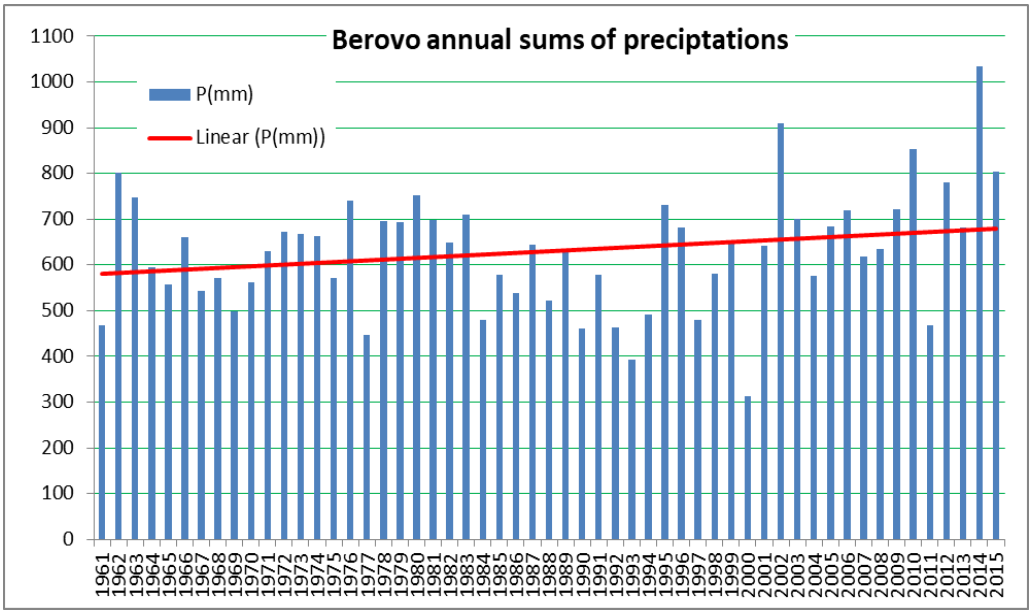


Figure 16. Annual precipitation in Berovo

5.1.2 Days with precipitation above 40 mm

Except huge river floods, the region in the past was also prone (susceptible) to flash floods caused by heavy intensive precipitation. According to the days with precipitation above 40 mm, the biggest part of the region has huge number of days with precipitation above 40 mm. There are several torrential with high slopes in the region that are potential danger of appearing of the flash floods. So, the region was very vulnerable to the flash floods in the past due to very frequently occurrence of these heavy precipitations.

In the past there were also urban floods that happened in the municipality of Berovo, mostly because of the intensive precipitation, the asphalt on the streets, lack of green areas and disposability to discharge large amount of water that falls in the short time intervals when intensive precipitation with short duration were registered. In those cases, there was uncontrolled flowing of the water on the streets causing flooding, especially at some of the well-known critical points in the city.

5.1.3 Consecutive drought days

Berovo region in the past was not so vulnerable to climate change and drought periods according to appeared (occurred) drought days and generally there were no problems with water supply of the town. Referring the consecutive drought days, it can be seen that the biggest part of the city doesn't have long duration of drought days and the same can be seen from the map that shows the average days of drought periods, with some exception in the several parts of the region where can be seen longer duration of drought days and more numbers of drought days or drought periods. In spite of this, Berovo still have some problems with potable water for drinking that is provided mainly from the Ratevo Lake and has need to investigate some new springs with bigger capacities for the purposes of water supply to the town.

5.1.4 Annual average daily temperatures

Annual average daily temperature is important to analyze mainly as indication for potential drought periods and lack of underground water. The figure below clearly shows that temperatures have tendency to increase in Berovo and analysing from 1961 until 2015 there is a constant rise of the temperatures.

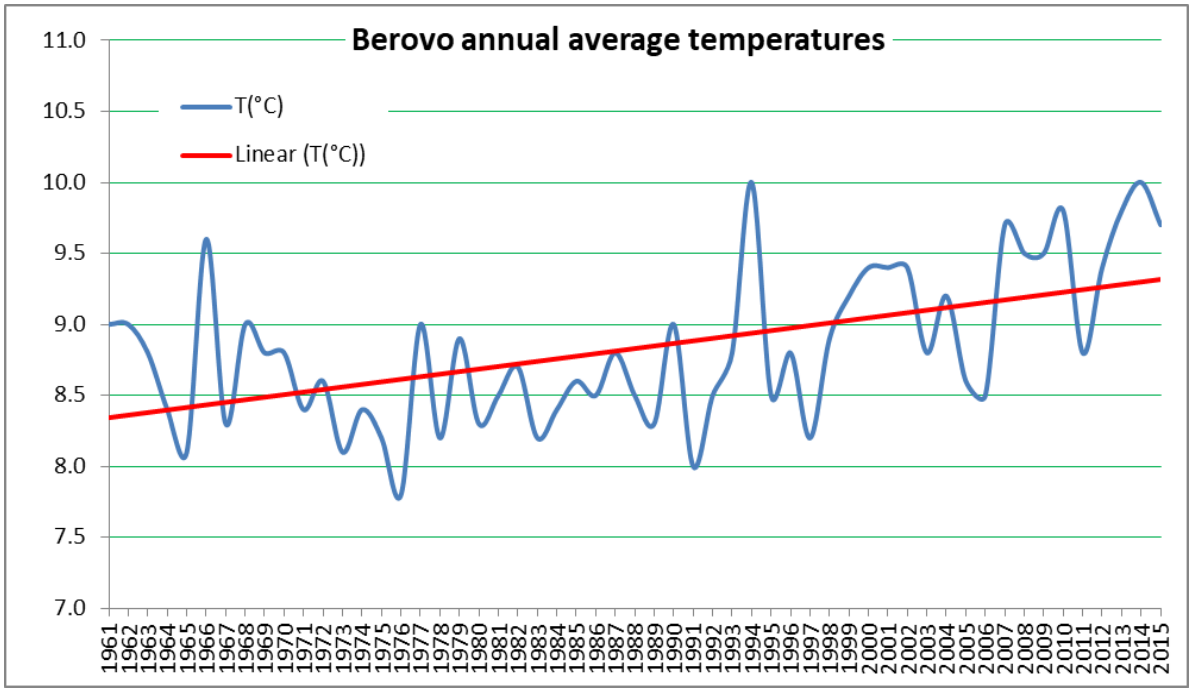


Figure 17. Average temperatures in Berovo, 1961-2015

5.1.5 Frost days

From the analyses of frost days, it is evidently wide range of spatial uneven distribution in the region, and that the biggest part of the city was vulnerable to these extremes, that can drive us to the conclusion that in case of prolonged dry summer and autumn periods and occurring of frost days in November and December it is possible to happen winter minimum of some of the rivers (mostly the smaller ones) in the region. River Bregalnica has less probability of appearance of the winter minimum.

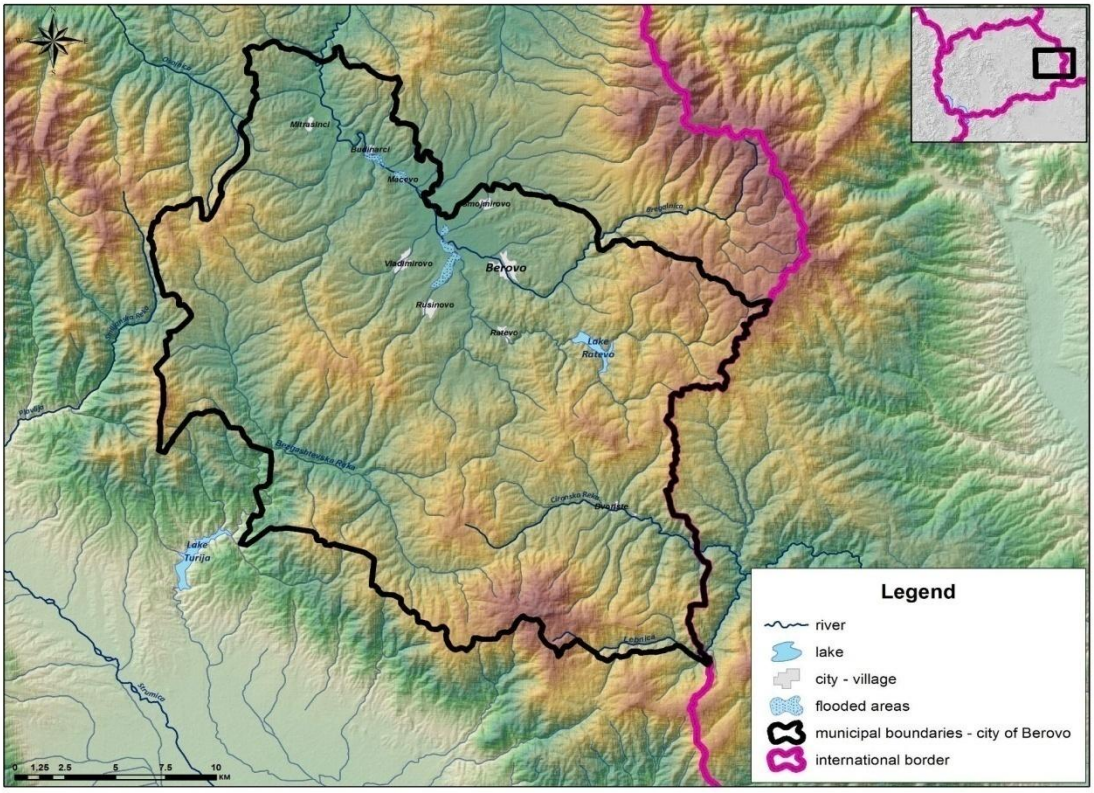


Figure 18. Water bodies within Municipality of Berovo

The figure clearly shows the water bodies within the municipal borders of Berovo, where among other are given the mostly flooded areas.

Based on the analysis and relevant data it can be concluded that in the past the municipality was very low vulnerable to heavy rains (precipitation >40mm) including daily maximum precipitation, but was medium vulnerable to annual and seasonal amount of precipitation and temperatures, and this is expected to continue in the short and medium future. In regards to drought days the vulnerability is also observed as low but in the future the risk is observed as a medium risk, both in short and in medium future.

Assesment of risk of climate extremes according to their vulnerability, exposure and hazard												
Climate extremes	Vulnerability			Exposure			Hazard			Risk		
Days with P>40 mm	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	low	medium	medium	medium	medium	medium	low	medium	medium	low	medium	medium
Daily maximum precipitation	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	low	medium	medium	medium	medium	medium	low	medium	medium	low	medium	medium
Annual and sesonal amount of precipitation	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium
Consecutive Drought Days	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	low	low	low	low	low	low	medium	medium	medium	medium	medium	medium
Annual and sesonal average daily temperatures	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	medium	high	high	medium	medium	medium	medium	high	high	medium	high	high

Assessment of risk according to vulnerability, exposure and hazard												
Water category	**Vulnerability**			**Exposure**			**Hazard**			**Risk**		
	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
River Floods	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium
Flash Floods	medium	medium	medium	medium	medium	medium	medium	high	high	medium	medium	medium
Urban Floods	medium	medium	medium	medium	medium	medium	medium	high	high	medium	medium	medium
Droughts	low	medium	medium	low	medium	medium	low	medium	medium	low	medium	medium
Subcategories	**Vulnerability**			**Exposure**			**Hazard**			**Risk**		
	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
Drinking water	low	medium	medium	low	low	low	low	medium	medium	low	medium	medium
Water for irigation	low	medium	medium	low	low	low	low	medium	medium	low	medium	medium
Water for electricity	low	medium	medium	low	medium	medium	low	medium	medium	low	medium	medium
Polution of water	low	medium	medium	low	medium	medium	low	medium	medium	low	medium	medium

5.2 Heath sector

The municipality of Berovo, which is part of the Maleševska Kotlina, has a moderate-continental climate, with a modification of the climate in the high mountain and plain parts. The locality of Berovo has a significantly lower average annual air temperature than the areas at the same altitude in the wider part of this valley. At an altitude of 800 m, the average annual temperature in Berovo is 8.7°C. The coldest month is January, with an average temperature of -10°C, and the warmest month is July, with an average temperature of 18.2°C. The average annual minimum temperature is 2.8°C, and the average maximum temperature is 15.3°C. The most precipitation occurs in the months of May and

June, as well as in November. August and September are the driest months. The relative air humidity decreases from January to August, and then increases from December.
No published data/information could be obtained so far on eventual past climate risks and hazards in the Berovo region that made significant health risks/impacts to the health of the population. According to the report from the municipality administration, few floods of symbolic dimension and impact were registered in 2012, 2018 and 2020 without any data of health impact. Regarding the fires on open spaces some are registered in 2012, 2018 and 2020 without any information on affected population and public health in the municipality. The last event appeared were the forest fires in 2021 which destroyed a huge area of forest and agricultural land, affecting as well the human life of the population in those zones. During the October SECAP workshop held with the stakeholders, the cold weather and forest fires were assessed with a moderate probability to happen in Berovo with floods and droughts with lower probability and risk. For the risk from heat waves, the participants' thoughts are low.

5.3 Agriculture sector

The vulnerability assessment was based on the possible effects of the most pronounced climate events and extreme weather events spatial and temporal dynamics over the period 1990/2020 on the agricultural sector in the Municipality Berovo, like:

- Average annual temperature and sum of precipitations dynamics
- Number of frost days and last spring frosts
- Heat waves
- Drought events
- Number of days with precipitation over 40 mm
- Length of vegetation season and
- Yearly sums

The vulnerability assessment of livestock production was estimated on the basis of daily records for minimum, maximum and average temperature as well as for precipitation. For this purpose, the baseline for the past events were taken as an average of 30 years (1990-2020), while the short, medium and long term spans of 10 years were considered starting from 2021 to 2050.

The most representative and applicable model for assessment of the vulnerability of animal production is the one developed for ruminants (cattle, sheep and goats) which are the most vulnerable to climate change. Hence, this report aims, to assess THI for ruminants (Bohmanova et al., 2007) in the past (1990-2020), short (2021-2030), medium (2031-2040) and long (2041-2050) terms.

Daily TDIs for ruminants was then summarised in annual THI load, representing the number of days above thresholds for more than 2 consecutive days, assuming body tolerance in the first two days (West et al., 2003). THI threshold value of 72 in dairy cows recently was determined as alert phase (Pinto et al., 2020). Due to uncertainty in the approach applied, the higher threshold values of 74-78, 78-83, and 83+ were used as categories for alert, emergency, and dangerous THI load, respectively (Polsky et al., 2017).

5.3.1 Average annual air temperatures and precipitation sums

Numerous very important climate extremes and indices are directly dependent on the air temperatures and precipitation such as evapotranspiration, dater deficit, humidity aridity index etc. All of these weather extremes are of particular importance for agricultural production. These two parameters give an initial estimation in the process of selection of the most appropriate production systems and designing of the cropping pattern in certain areas and selection of agricultural crops and varieties.

The dynamics of the past and current trends for the annual air temperatures was estimated on the basis of the available spatiotemporal data for the monthly averages for the periods: 1980-2020 (WCRP CORDEX). Data presented in Figure 19 shows that the average air temperature for the majority of the territory of Berovo is significantly lower than the averages in the other parts of the country. The majority of the areas of the municipality fall within two categories 7.3-8.0 and 8.3-9.9 C^{o} of average annual air temperatures. Only a small part on the north, along r. Bregalnica is in a zone of high annual air temperatures with annual averages of 11.2-12.2 C^{o}. The most part of the agricultural area with perennial crops is in a zone with annual average temperatures of 9.8-11.2 C^{o} and only a small part of agricultural production is in the hottest zone. The general conclusion is that the annual average air temperatures have a low negative impact on agricultural production in Berovo.

The yearly sums of precipitation Figure 21 vary in a broad range from 300-420 mm in the north part of the municipality with up to 800 mm in the southern parts of the municipality. In general, the yearly sums of precipitation rise towards the west. The majority of the agricultural land unfortunately is situated in the areas with the lowest sums of yearly precipitation in the north. One part of the agricultural area planted with perennials is located in areas with higher yearly sum of precipitation of 512-625 mm. These sums of precipitation refer to the vegetation period and are somewhat lower than the yearly sums. However, against all expectations, although the Berovo area is one of the humid and mountainous areas in the country, the spatial distribution of precipitation is not in favour of agricultural production.

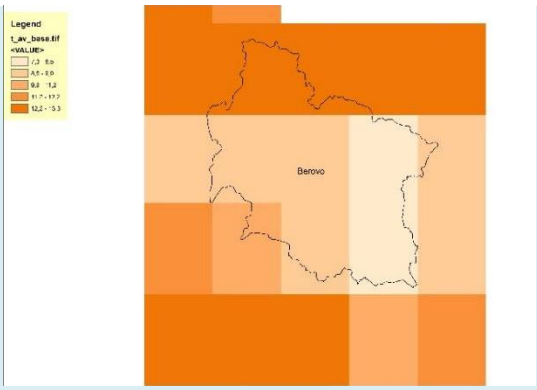


Figure 19. Average annual air temperatures (1990-2020)

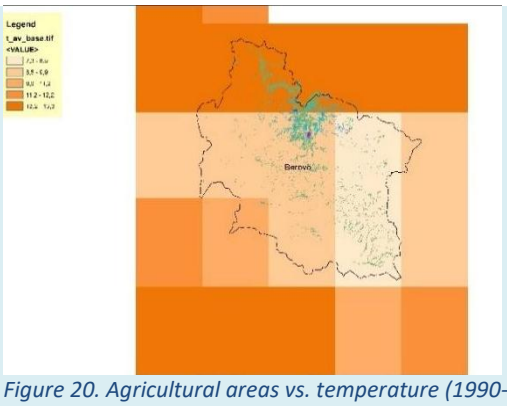


Figure 20. Agricultural areas vs. temperature (1990-2020)

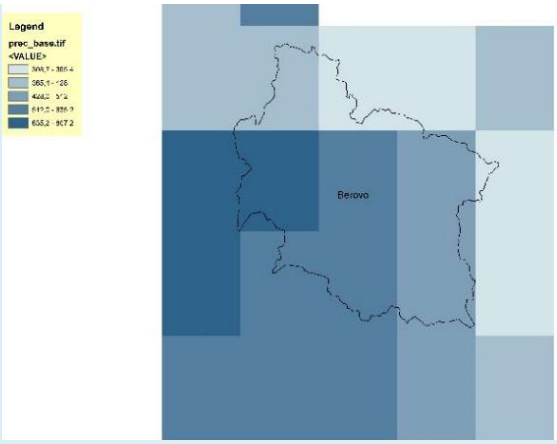


Figure 21. Average annual sums of precipitations (1990-2020)

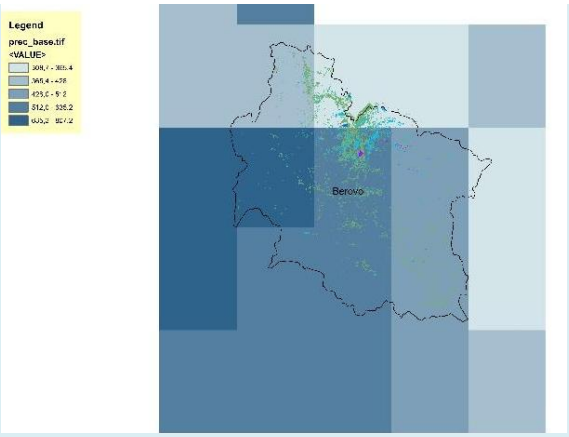


Figure 22. Agricultural areas vs. precipitation (1990-2020)

5.3.2 Frost days and last spring frosts

The number of frost days and its appearance during the winter period and spring defines the length of the vegetation season since the start of vegetation for autumn crops is considered the period with three consecutive days above 5 C°. However, another weather extreme, "late frosts" in spring, significantly affects the agricultural crops. Such events can appear much later than the start of the vegetation when plants are in a certain stage of vegetation, causing serious damages and compromising the whole season.

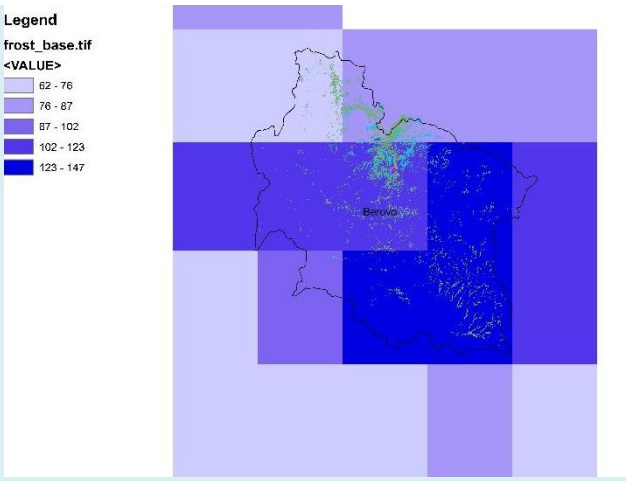


Figure 23. Frost days

The spatial distribution of the sums of frost days in the municipality of Berovo for the period of 30 years (1990-2020) are presented on Figure 23. The number of frost days in Berovo is rather high and varies in broad ranges. The most affected areas are the mountainous part of the municipality to the east on the border with Bulgaria, with a number of frost days in the ranges of 123-147 days. The number of frost days gradually decreases towards east and northeast, but still the majority of agricultural land is in the zones with a high number of frost days varying from 102-123 and 87-102 days/year. Only a small part

of agricultural land in the north is with a bit lower number of frost days (62-76). Such a big number of frost days indicate a short vegetation season and high risk of late frost. As mentioned before, the last spring frosts are of particular importance for the agricultural plants, especially for fruits, when they are in the very sensitive phase of flowering and bud formation. The exposure of agriculture to this weather extreme is rather high in the municipality of Berovo.

5.3.3 Heat waves

Heat waves similarly like the frost days are global weather extremes and closely related to the general trends of air temperatures in certain areas. Heat waves usually appear in the hottest months of the year, usually coupled with dry periods. The impact of all of these factors has a harmful effect for the agricultural crops, putting them under stress conditions with reduction of photosynthetic activities, water deficiency even on the irrigated crops. Damages could be very severe due to the fact that agricultural production is highly exposed to weather events. Heat waves are usually joined with hot winds which additionally increases the evapotranspiration emphasising the water deficit for agricultural crops. Having in mind all these facts it can be concluded that the most of the agricultural plants are highly sensitive to heat waves.

In order to evaluate the exposure of agricultural crops to hot waves, two parameters were analysed: *the average duration of the hot waves' events* and *the average number of events per year*. Out of the data presented in Figure 24 and Figure 25 it can be concluded that the area of the municipality of Berovo is not seriously affected by heat waves. The majority of the municipality area is with average duration of 0-9 and 9-11 days and only the hottest north part of the municipality is in a zone with somewhat higher duration of hot waves (13-15 days). The areas with agricultural land are located in the zone with average heat wave duration of 9-11 days.

The average number of heat waves events for the analysed period are presented on Figure 25. Out of the presented data for the analysed period 1990-2020 it can be concluded that the average number of heat events is very low for the whole territory of the municipality and varies in the ranges of 0-25 events. On the basis of these findings it can be concluded that the agricultural production is not highly exposed to the heat waves and their impact on the agricultural production in this region is rather small.

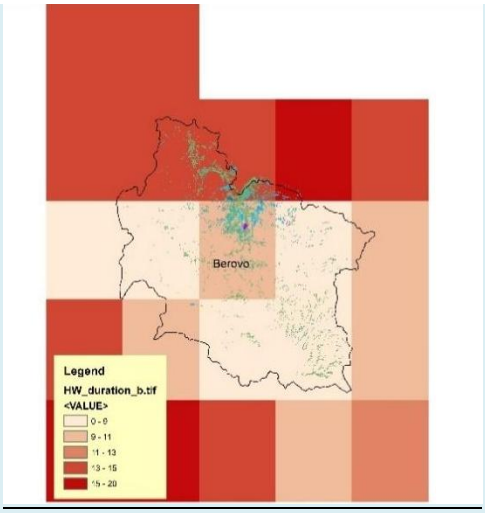


Figure 24. Average duration of longest HW events

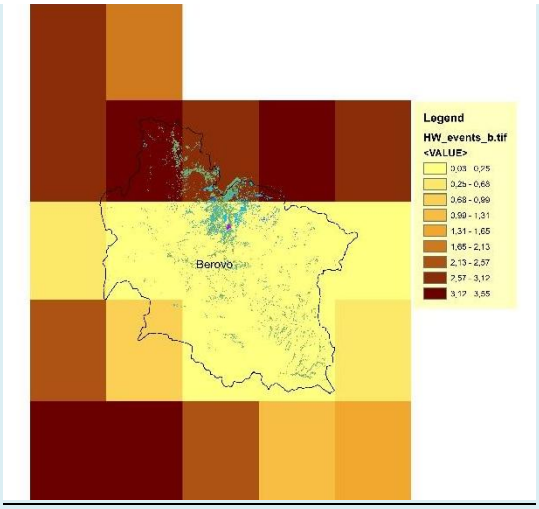


Figure 25. Average number of HW events/year

5.3.4 Drought events

Drought events during the vegetation seasons represent a serious risk for agricultural crops, especially in particular phases of plant development. Absence of rainfalls for a longer period coupled with high air temperatures when evaporation is at its peak can cause serious water deficits for the plants, causing serious stress and reduced yields.

The disturbed rainfall regime with more frequent drought events and prolonging of its duration, together with net reduction of yearly sums of precipitation are the main outcomes of the negative impact of climate change on rainfall regime.

The impact of drought events in Berovo Municipality was evaluated on the basis of their average duration of the periods and the number of events. The average duration of drought events is very important, because long periods with no rain can have a serious negative effect even on irrigated crops. Out of the data presented on Figure 26 it can be concluded that with regards to the duration of dry periods the municipality of Berovo is not seriously affected. In the eastern part of the municipality the average duration is in the ranges of 13.1-113,7 days and slightly decreases towards east where the average duration of dry events is 11.9-13.1 days. The highest duration of dry events is in the north part of the municipality where a part of the agricultural production is located. The average length of dry events in this region is 15.5-16.3 days. However, the areas with more intensive agricultural production are located on the north part of the City of Berovo, in the area with the most favourable conditions regarding dry events (11-13 events/year)

Similar pattern can be noticed with the number of events (Figure 27) as well, where the north part of the municipality is the most affected with a high number of events per year. The rest of the municipality and most of the agricultural land is less exposed to this climate extreme. The average number of events is in the ranges of 5.8-7.0 events.

In general, out of the data presented for the duration and the number of events it can be concluded that the agricultural production in some cases especially at the north part of the municipality is highly exposed to this extreme, while the majority of agricultural land is in the zone with less exposure.

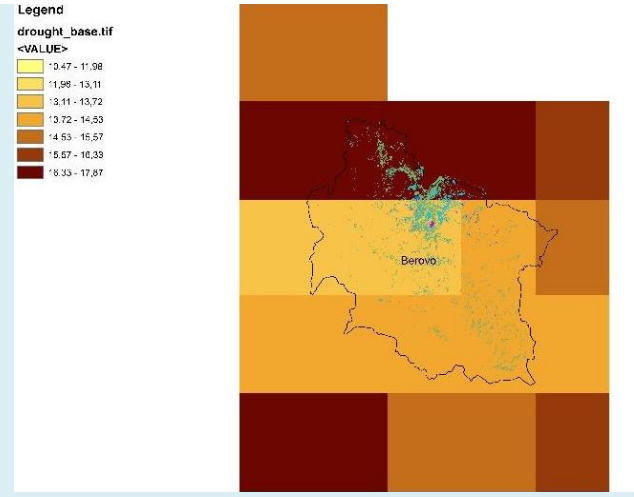


Figure 26. Maximum duration of dry periods

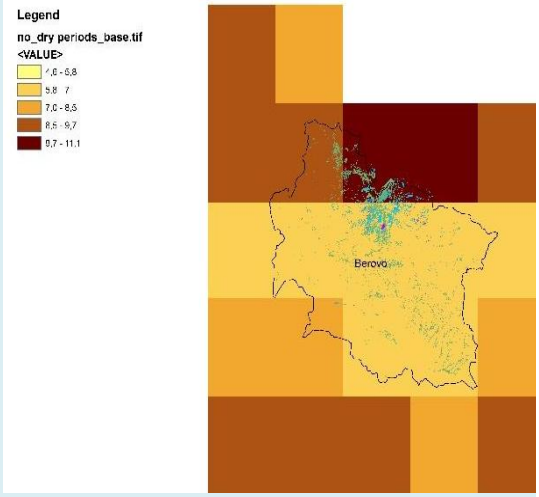


Figure 27. Average yearly number of dry periods

5.3.5 Days with precipitation over 40 mm

Appearance of intensive rainfalls is another aspect of the disturbed rainfall regime due to the negative impacts of climate changes. During such events which usually happen during the summer period over a small area, huge amounts of excessive surface water which cannot be infiltrated into the topsoil, causes torrential flows and huge amounts of run-off down streams on a sloppy terrine causing serious damages to the agricultural crops and the overall infrastructure (houses, roads, channels etc.) in these areas.

The average number of events with rainfalls bigger than 40 mm. that appear every year in the Berovo municipality for the period 1990-2020 are presented on Figure 28. Out of the data presented it can be seen that the events with high rainfall events (>40 mm) in Berovo municipality vary in a very broad range. The lowest number of events (0-1.3) is identified in the central and eastern parts of the municipality, where the most part of the agricultural land is located. Toward south and north of the municipality the number of such events significantly increases, so the number of days with extreme rainfalls at these locations is within the highest categories with 1.3-1.8 and 1.8-1.9 events. The biggest part of the municipality area and the most part of the agricultural area is with low to medium exposure to this extreme. The lower number of extreme rainfall events is most probably a result of the more balanced rainfall regime in this area.

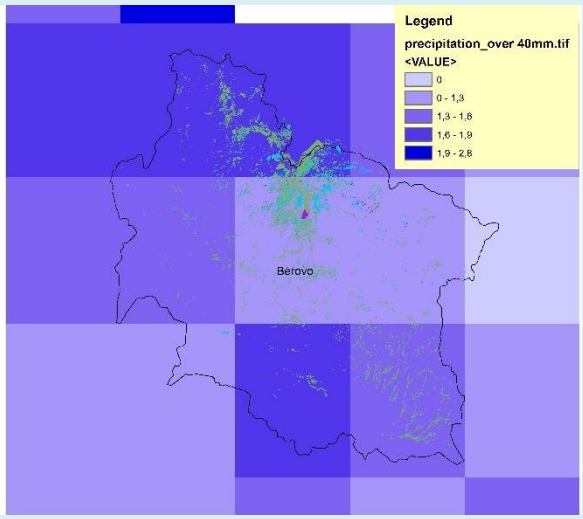


Figure 28. Events with precipitation >40 mm/year

5.3.6 Length of vegetation season

5.3.7

Length of vegetation season is a very important index for agricultural production and is closely related to the air temperatures. The projected rising of air temperatures due to global warming, indicates possible extending of the vegetation season, or shifting of start and end dates. The start of the vegetation season for the autumn crops is considered the moment when the air temperatures reach above 5 C^0, and 10 C^0 for the spring crops. Alterations in the length of vegetation season and its start and end dates, can influence the shifting of phenological phases of plant development. For these reasons phenological observations of the plants are very important for timely application of certain agro-technical operations. Shifting of vegetation season start date is related to certain risks for the plants, namely in many years in the past the appearance of late frosts caused severe damages to the orchard plantations. Such risks are even higher with earlier start of the vegetation season, because plants start growing earlier making them more vulnerable to the negative effects of late frosts.

The average duration of vegetative season in days (above 5 C^0) for the period 1990-2020 (Figure 29) for the Municipality of Berovo area, is rather low. The length of the vegetation season is shortest in the eastern mountainous parts of the municipality with 216-236 days and gradually increases towards north and west. Expectedly, the longest vegetative season was detected in the hottest north parts of the municipality along r. Bregalnica with an average number 283-297 days of the vegetative season. The most part of the agricultural area is located in areas with a rather short length of vegetation season. The most intensive zone with perennial crops of plums is in the zone with 236-258 days.

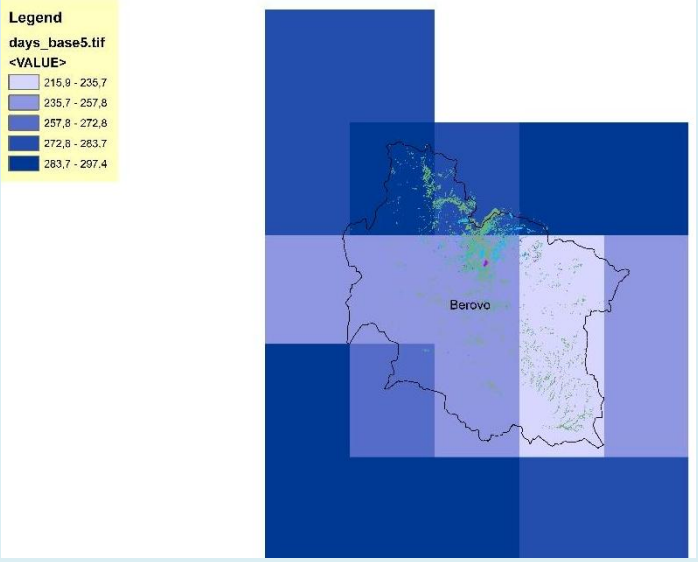


Figure 29. Length of vegetation season, (>5 C⁰)

5.3.8 Yearly sums of effective temperatures (>5 C⁰)

Yearly sums of temperatures is another climate index that is closely related to the overall climate conditions, especially air temperature (average, min,. and max), the number of days of the vegetative season etc.

The temperature sums for the Municipality of Berovo, are significantly variable as presented in Figure 30. The territory of the municipality falls with several categories of temperature sums. However, there is an obvious logical pattern of increasing of the temperature sums starting from the mountainous region towards west and north-west along the r. Bregalnica. The temperature sums in the east and south east are with the lowest values of 2761-3175 C° while the west and North West is with significantly higher effective temperature sums ranging from 4431-4827.7 C°. Of importance is to outline that the most part of the intensive agricultural production is located in areas with moderate (3074-3701 C°) to high sums of above 4000 C°. This means that this parameter has a moderate impact on the agricultural production in Berovo municipality.

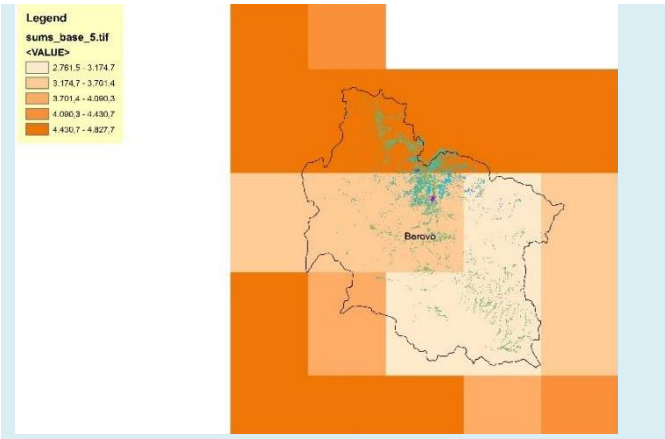


Figure 30. Yearly sums of effective temperatures >5 C^0

Thermal Humidity Index for livestock

Livestock production in Berovo is with a long tradition and is significant for the local economy. Besides ruminants, several pig and poultry farms are operating. The farms are located all around the narrow city boundaries. So for the needs of the report, the coverage will consider the whole area of the municipality. Nevertheless, the risk of the future climate change will have significant consequences on the level of the livestock production, but also on product cost. So far, the available strategic documents dealing with the adaptation capacity of the livestock in the municipality of Berovo suggest that the resilience of the sector is very low, stressing high vulnerability in the future.

Table 14. Number of heads in different livestock species in Berovo

	Cattle	Sheep	Goat	Swine	Poultry	Honey bee hives
Berovo	2290	26226	3379	3623	12422	2619

Source: SSO, 2018

Assessment of the impact of climate change - methodology

The assessment was considered the data used by Djurdjevic, 2020. The set was consisting of daily records for minimum, maximum and average temperature as well as for precipitation. For this purpose, the baseline for the past events was taken as an average of 30 years (1990-2020), while the short, medium and long-term spans of 10 years were considered starting from 2021 to 2050.

The direct influence of climate change is the heat stress of animals. It is an animal welfare issue resulting in disturbance in feeding, availability of water, and water quality, but also ensuring favourable conditions for the occurrence of many parasites and diseases. The most common proxy of heat stress is the Thermal Humidity Index load (THI). THI is calculated on the basis of temperature and humidity for each day. The load is the number of consecutive days with a certain level of THI. The different levels of THI are manifest heat stress described as alert (yellow), emergency (orange), and dangerous (red). The last one is also considered as lethal. Since, animals have individual capacities for adaptation it was considered that the THI load should be calculated if the event above threshold is lasting for at least two

days in a row. The THI was developed for ruminants (cattle, sheep and goats), since they are the most vulnerable to climate change.

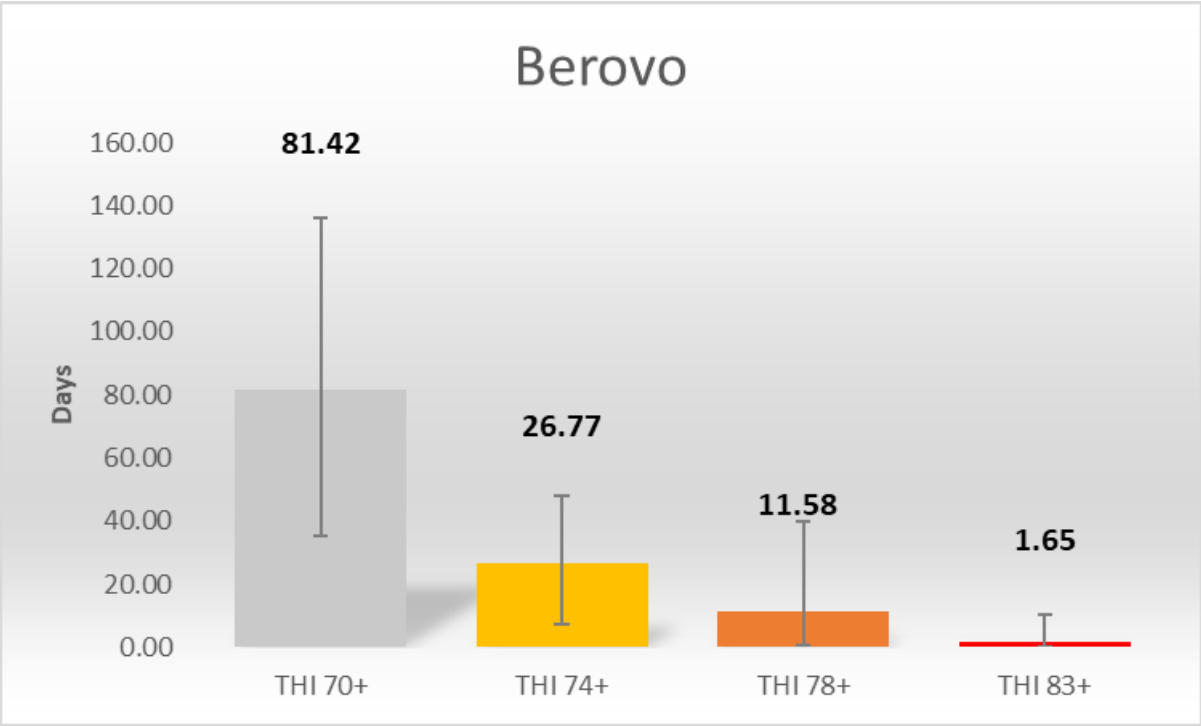


Figure 31. Average number of days for the period from 1990 to 2020 under different THI loads in the area of Berovo municipality

Past climate risks and hazards in the area of Berovo municipality were done on 22 points. In the past, the livestock was under pre-heat stress conditions for about 82 days during the summer period. However, the alert THI phase lasted for 27 days, the emergency phase was 12 days and the emergency lasted for only 2 days.

5.3.9 Conclusion on current vulnerability to extreme weather events

The current vulnerability of the agriculture in the Municipality of Berovo to the extreme weather conditions is estimated taking in account the previously identified and mapped degree of exposure of agriculture to the extreme weather conditions and the potential sensitivity of the agricultural production to the weather conditions, as a basis to estimate the overall impact of the climate. Another key point in the process of estimation of the vulnerability was the adaptive capacity of the producers to cope with these impacts.

The evaluation of the vulnerabilities was based on mapping and analysis of the past and current weather extremes for the period 1990-2020, with estimation of the potential consequences on the agricultural production,

The evaluation of the spatial consequences of the weather extremes on agriculture was enabled through spatial interaction of the weather conditions and agricultural areas in the region. Further process of the analysis consisted of selection of indicators related to the agricultural production, related to its location, crop structure, level of intensity, technological solutions applied and potential future changes of spatial vulnerability.

The vulnerability assessment was evaluated on taking in consideration the level of potential impact of weather extremes to agriculture and the adaptive capacity of the producers.
The potential impact of agricultural production which is a product of the level of exposure and sensitivity was categorised as low, medium, and high.
The adaptive capacity of agriculture was also categorised taking in consideration the levels of: economic capacity, technological level of knowledge, willingness and level of awareness to cope with effects of weather extremes, in three categories:
High – the producers are highly able, ready to cooperate and have the high technological capacities and know how
Medium – the producers are partially able, with moderate readiness to cope and limited technological capacities and knowledge,
Low – the producers are not able, with no reediness to cope and very low technical capacities and knowledge.

Table 15. Vulnerability assessment matrix

Vulnerability				
	Adaptive capacity			
Impact (exposure/sensitivity)	**categories**	high	medium	low
	high	medium	high	high
	medium	medium/low	medium	medium/high
	low	low	low	medium

Table 16. Vulnerability of most vital agricultural sectors

Agriculture	**Vulnerability**					
	Spring frosts	**Heat waves**	**Drought**	**Heavy precip. > 40 mm**	**Veg. season duration**	**∑ of eff. temp.**
Orchards	High	Medium	High	Medium	High	Medium
Vineyards	Low	Low	Low	Low	Low	Low
Vegetables	Low	Medium	Medium	Medium	Low	Medium
Livestock	Low	High	Low	L:ow	N/A	Low

5.4 Forestry sector

The main identified risks which are loosely connected to climate change and forest in the frames of the municipality of Berovo are: forest fires, flash floods and soil erosion. These problems occur in the absence of forest cover to protect the bare soil.

The forests in the vicinity of inhabited areas pose a risk of forest fire occurrences that is why they should be constantly monitored and protected. Forest fires are constant occurrence in the past. With the increase of dry periods the risk of forest fires is increasing. For the last three decades, forest fires have been a significant problem for forests and forestry, causing great economic and environmental damage. According to the data of PE "National Forests", the total number of forest fires registered in

the period 1999-2021, in Macedonia is 4,938 fires, the total burned area is 203,262.66 ha, and the caused financial damage is estimated at 179,146,079 euros. According to the same source, the average annual number of forest fires in this period is 215 fires, the burned area is about 8,837 ha and the average annual financial damage is around 7,788,960 euros. According to the estimates of PE "National Forests" -Skopje, only in the fire in Malesh and Pijanec (Delchevo, Pehchevo and Berovo region) burned about 4,405.85 hectares of forest and forest land, which is one third of the total burned area in all of Macedonia in 2021.

Flash floods are a common occurrence in the past. A lot of work was done on this issue in the last 70 years. Almost all of the torrents on the surrounding mountains are trained; also there were a lot of afforestation done. Usually, the intensive rainfall occurs in the higher parts of the catchment, and the damage occurs in the lower parts of the catchment where usually the inhabited areas are situated. In order to remedy the situation, the main works should be done in the upper catchment. The best protection of the soil is by planting trees which in order will form a stable forest ecosystem.

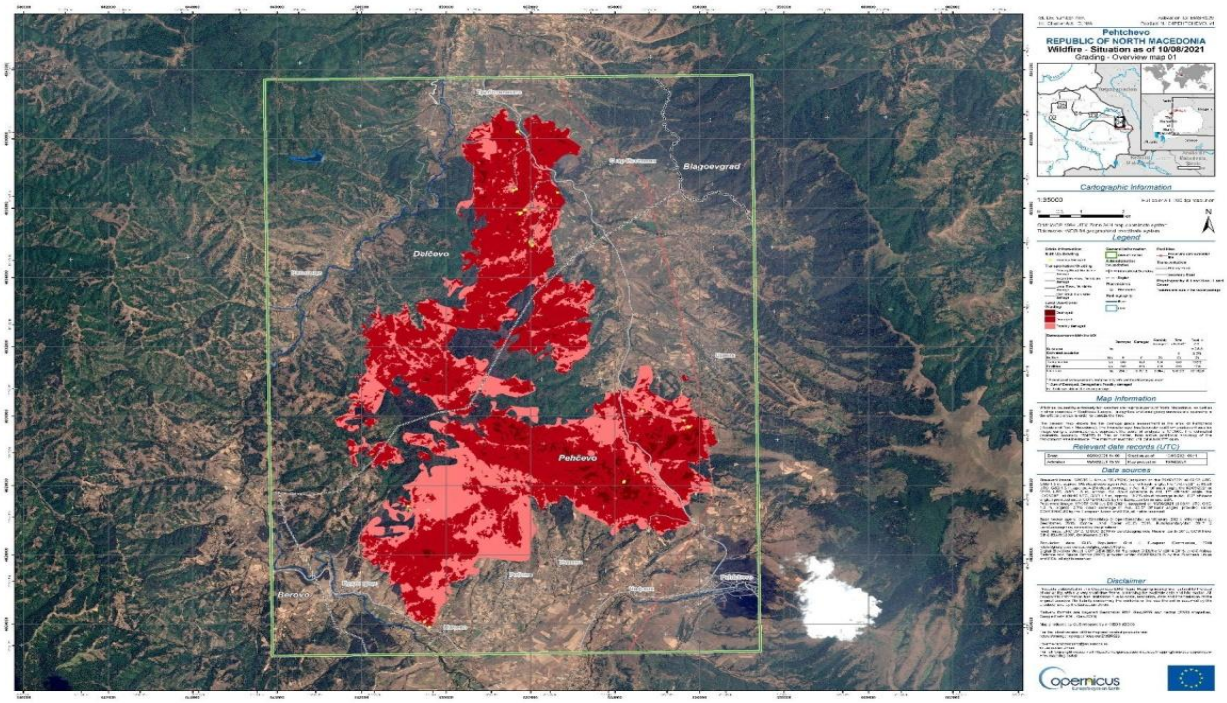


Figure 32. Map of the fire event of August 2021 in the municipality of Berovo and surrounding municipalities

The vulnerability assessment was based on the possible effects of the most pronounced climate events and extreme weather events spatial and temporal dynamics over the period 1961-2015 in the municipality of Berovo:

- Average annual temperature and sum of precipitations dynamics
- Heat waves
- Drought vulnerability
- Intensive rainfall events (precipitation over 40 mm)

5.4.1 Average annual air temperatures and precipitation sums

Annual average air temperatures and the sum of annual precipitations are of particular importance in defining of the general climatic conditions in certain areas. The increase of temperatures can affect the growing patterns of the forests. On the other hand, the temperature increase can increase the current coverage of the pests and diseases which was limited by lower temperatures.

It can be seen on the two graphs that the temperature and rainfall have tendency of increase and on average for the period 1961 to 2015 the tendency for temperature increase is 2° C and the tendency for rainfall increase is 40 mm. So, for the last period of 55 years, it can be concluded that there is increase of temperatures and rainfall. It should be noted that the hydrometeorological station taken into account is in the town and these values are different in the upper parts of the catchment, higher rainfall and lower temperatures, but the trend should be the same.

The Berovo valley is with average precipitation of around 620 mm. The aridity index of the municipality is humid climate, which means that currently there is no significant lack of water.

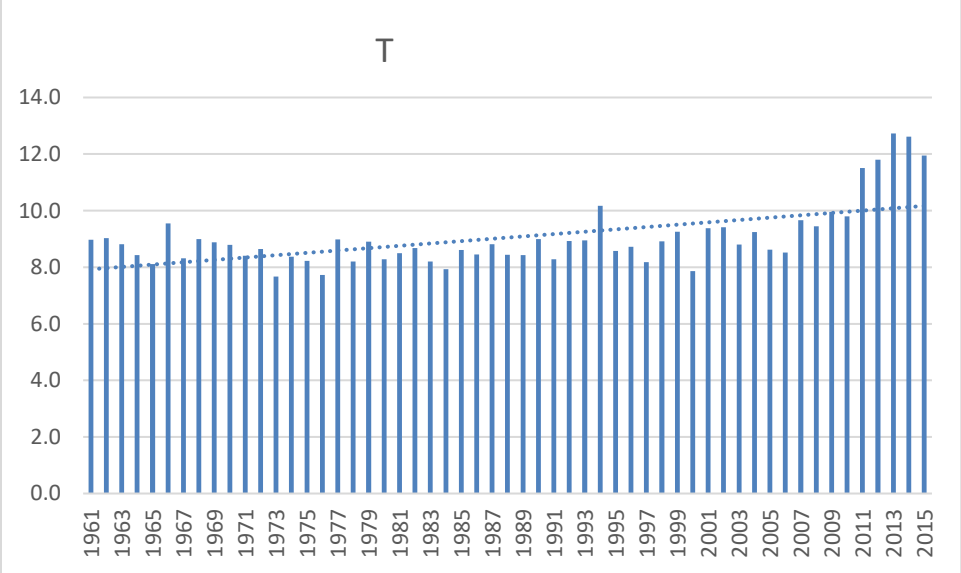


Figure 33. Average anual air temperatures (1961-2015)

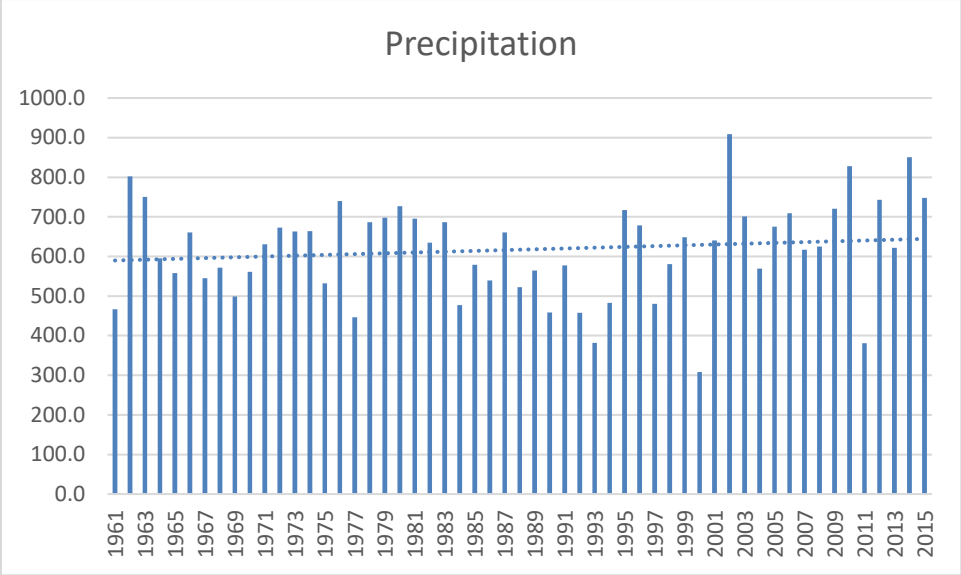


Figure 34. Average annual sums of precipitations (1961-2015)

5.5 Economy sector

There are no official measures of the impact of extreme weather conditions on economic variables or directly on the loss of local GDP for any municipality, not even at the central level. Do and how do rising temperatures affect productivity, personal consumption, company costs, wages or investments? And possibly, how is the impact on local GDP? There is no official record, so we have to make a qualitative assessment of the climate risk.

Economic entities are living organisms that go through stages of change and adaptation. It is difficult to assess whether a business entity has changed its business model due to the effect of climate change or if it has happened for other reasons. In fact, climate change, in addition to risks, creates opportunities for businesses, especially those that are green-oriented. For example, in the previous years, businesses for the production of electricity by utilizing the electricity with the installation of photovoltaic experienced an expansion. But the reason for this was an enormous rise in the price of electricity from conventional sources on world exchanges and at home market, caused by the global inflation. A number of businesses have opened for electricity production with photovoltaic, and a number of businesses have changed their business model and reoriented to this business. They were not driven by climate change, but by other economic factors.

The municipality of Berovo is located at a high altitude and is surrounded by large areas of forest which is a source of clean air, making Berovo a recognizable tourist destination for air spa. Thanks to the forests, this municipality has a growing tourism. In addition, forests are a source of raw material for the growing wood processing industry. The surrounding population benefits greatly from forest fruits, the famous Berovo forest honey, etc. Forests are a large significant segment for the life of the population and overall for the local economy of this Municipality. The biggest climate threat for the Municipality of Berovo comes from the rising temperatures and drought that cause the forest fires.

In the last few years, the Municipality of Berovo is constantly subject to forest fires. In 2021, a forest fire of enormous proportions occurred, a total of 16 forest fires were recorded, causing one of the greatest damages in history. The total direct damage was estimated at 1.2 billion denars (19.2 million euros). These fires left behind a huge devastated area. Forest fires are the biggest climate threat to the local economy of the Municipality of Berovo.

In the local economy of the Municipality of Berovo, the trade and manufacturing industry sectors have the greatest importance. However, agriculture and forestry and the tourism sector take a significant part. The largest number of entities in the municipality is registered in the trade sector, i.e. 29.2%, followed by the manufacturing industry with 15.8%. However, the manufacturing industry absorbs the largest number of employees (27.6), and 15.8% are employed in the trade sector. The largest volume of revenues (26.3%) and profit (17.7%) were realised in the trade sector. Right after it is the manufacturing industry, which generates 16.6% of revenues and 12.9% of profits.

Agriculture, forestry and fisheries have a significant part in the local economy, where 5.2% of the workforce is employed; it generates 15% of the revenue at the municipality level and 12% of the profit in the municipality and is in the third place in terms of revenue and profit.

The tourism and hospitality sector absorbs 9% of employees, generates 5.8% of the total income of the local economy and 5.5% of the profit.

In all sectors, in the past and present, extreme weather events caused by climate change are assessed as having moderate to low vulnerability of individual economic sectors, except for forest fires, which, with rising temperatures in summer and droughts, represent the greatest climate risk and vulnerability for the local economy. Therefore, overall **the general assessment is that the local economy of the Municipality of Berovo is moderately to low vulnerable to extreme weather events.**

Table 17. Assessment of past and current climate risk and vulnerability of local economy of the Municipality of Berovo

ECONOMIC SECTOR	EXTREME WEATHER EVENT	CURRENT VULNERABILITY
HOUSING	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Low
	Landslides	Not known

	Forest Fires	High
INDUSTRY	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Low
	Landslides	Not known
	Forest Fires	High
TRADE (WHOLESALE AND RETAIL)	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Low
	Landslides	Not known
	Forest Fires	High
CONSTRUCTION AND CIVIL ENGINEERING	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium

	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Not known
	Forest Fires	High
TRANSPORT AND STORAGE	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Not known
	Forest Fires	High
TOURISM AND HOSPITALITY	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Low
	Droughts	Medium
	Storms	Low
	Landslides	Not known
	Forest Fires	High

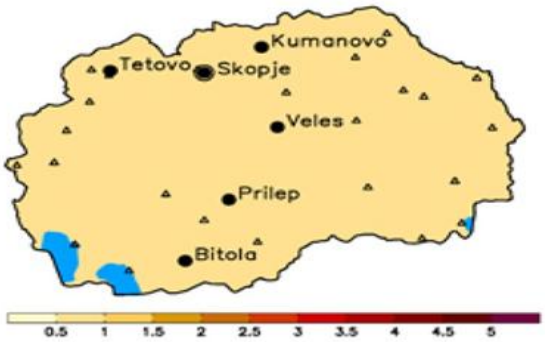
6 IDENTIFICATION OF FUTURE CLIMATE THREATS (SHORT, MEDIUM AND LONG-TERM)

The identification of future climate threats on a short, medium and long term was analyzed and predictions are based on the Report on projections for climate changes and for the changes at the extreme climate events in the Republic of North Macedonia, developed within the Project fourth National Plan on Climate Change and Third Biannual Report on Climate Change within the UNFCCC. For the purposes of this report, a period from 2016-20235 and scenario RCP 4.5 was analyzed for all relevant sectors for this report for Berovo Municipality.

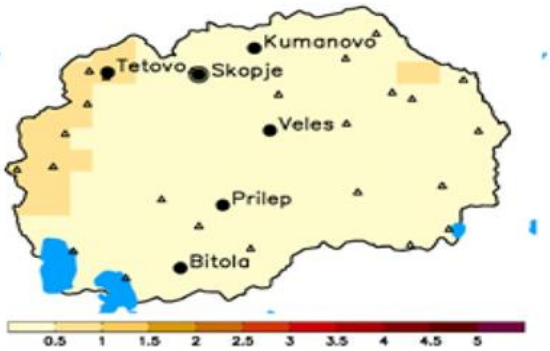
6.1 Water sector

In this chapter are identified and presented the future climate threats for the Berovo region on a short term, for the period 2016-2035. This chapter analyze the climate extremes that mostly affect the water resources and that have large impact of them.

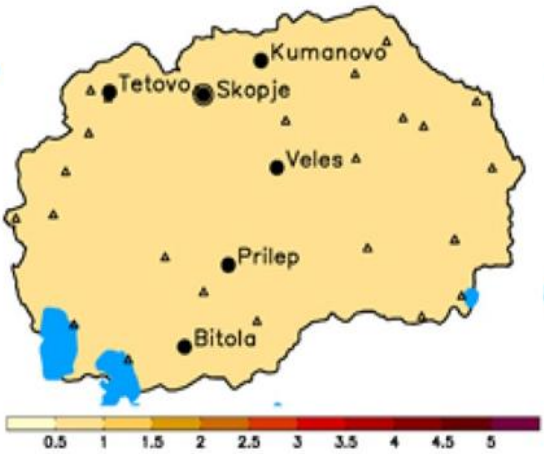
6.1.1 Temperatures and precipitation for period 2016 – 2035, scenario RCP 4.5



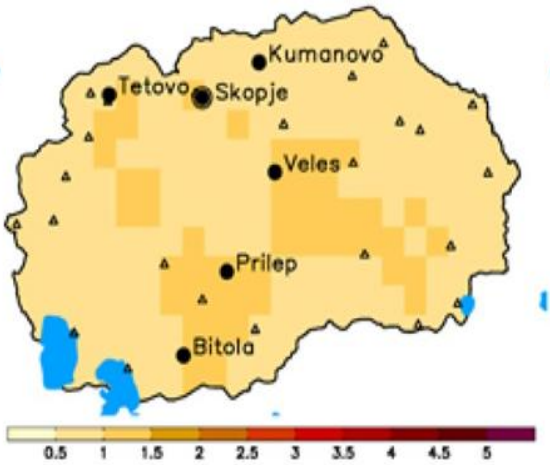
Average annual temperatures



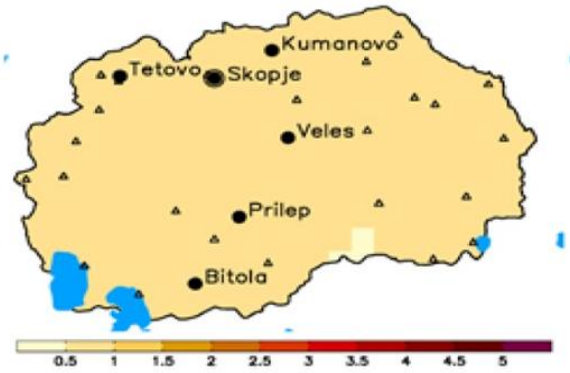
Average winter temperatures



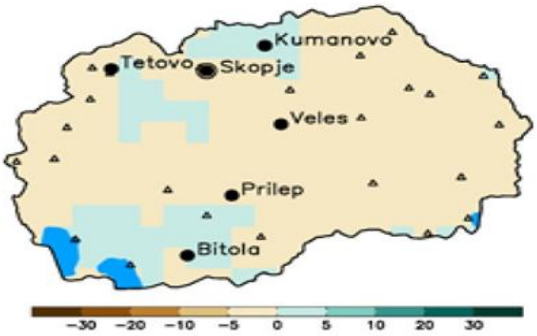
Average spring temperatures



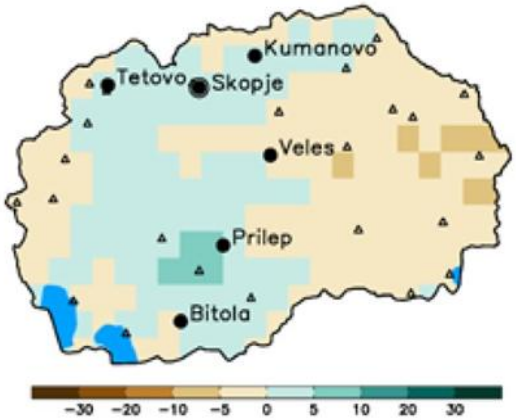
Average summer temperatures



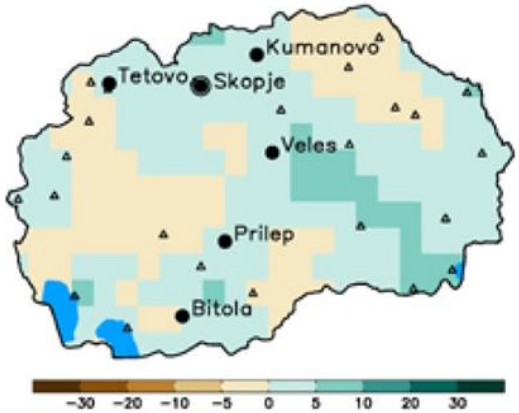
Average autumn temperatures



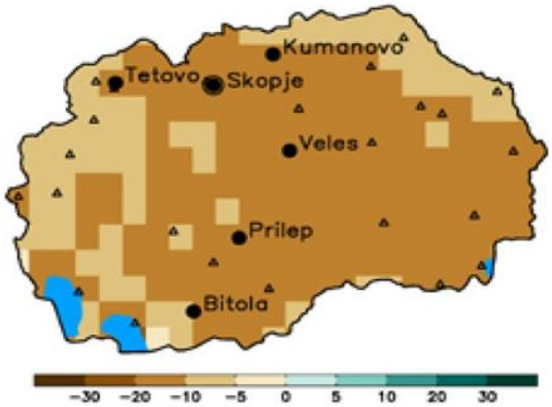
Average annual precipitation



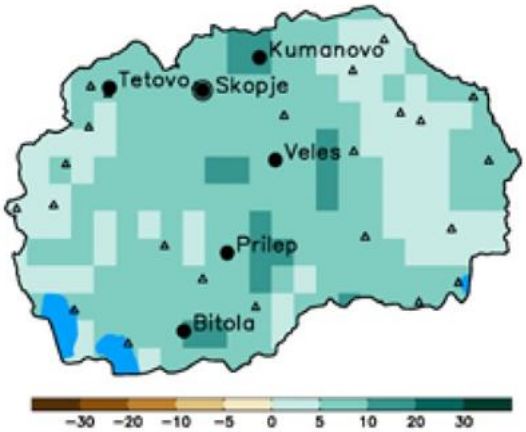
Average winter precipitation



Average spring precipitation



Average summer precipitation



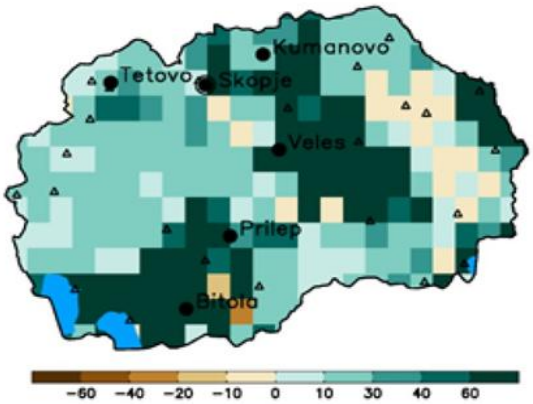
Average autumn precipitation

According to the scenarios for the future climate extremes such as increase of temperatures and precipitation, in the future it is expected an increase of the air temperatures and decreasing (or remaining the same) the average sums of precipitations. This predictions will affect the water resources through occurring short and middle term drought periods and decreasing of the average discharges in the r.Bregalnica, r.Serava, r.Markova and r.Kadina, that partly belong to the Berovo region. Furthermore, it will contribute at decreasing of groundwater levels, possible decreasing of the

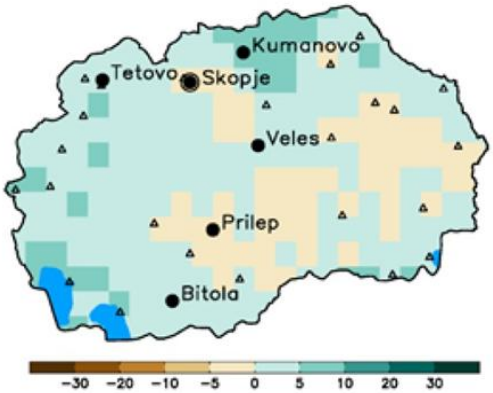
capacity of the springs, as well as decreasing of the water inflow in the water accumulation, i.e. Kalimanci accumulation, which is downstream from the city.

However, it must be noted that the scenarios are prepared using annual average data and that there is possibility individual periods (several days) with heavy precipitation that will not affect the annual average sums but it is possible to make floods on the rivers and also to increase the groundwater levels in the region.

6.1.2 Days with precipitation above 40 mm and number of events with extreme precipitation for period 2016 – 2035, scenario RCP 4.5



Number of events with extreme precipitation

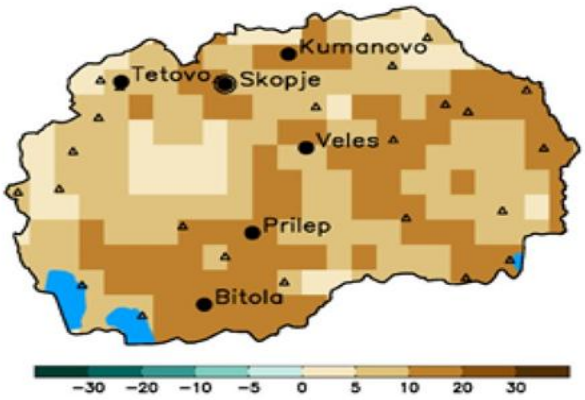


Max daily precipitation

According to map of the days with precipitation above 40 mm and map of the number of events with extreme precipitation, there are indications that region of Berovo has serious possibility of occurring intensive precipitation in the future causing flash floods on the small rivers and torrents in the region, as well as appearances of urban floods in the town of Berovo. Although in the future period are expecting decreasing of the average sums of precipitation, we cannot exclude the possibility of short duration intensive precipitation that will not affect the average annual sums of precipitation, and to expect more frequently to happen causing flash floods and urban floods in the region.

6.1.3 Drought days for period 2016 – 2035, scenario RCP 4.5

Berovo region is expected to be vulnerable to climate changes and drought periods according to increasing temperatures and future estimation of drought days and number of events. Referring to the map of future possible consecutive drought days, it can be seen that the biggest part of the city has many consecutive drought days.



Consecutive drought days

It can cause problems with water supply at the region and providing (supplying) drinking water in future. Also, during the summer periods the capacity of the springs will decrease and also groundwater levels of wells is expected to decrease. Consequently, in the future might be needed to investigate new ways for additional replenishment of water from other sources and other river basins.

6.1.4 Seasonal oscillation of the extremes

Regarding to seasonal oscillations of climate extremes, it should be expected seasonal oscillations in the water discharges, seasonal oscillations of the groundwater levels and capacities of the springs. It is expected to have abrupt transitions from one extreme to another, for example directly from drought period to floods without transitional period between them.

6.2 Health sector

According to the projected RCP4.5 climate scenario, in the Berovo region, an **increase in future temperature** is expected to be in the range of 1-1.5C (especially during the summer). Like in other cities the change in **heat wave duration will increase** for 1-2 days and the duration of the waves will increase for 5-10 days. The number of tropical nights will increase for 5-10 nights and the summers are expected to be extended for 20-30 days. An average **decrease of future cold wave duration** from about 2-3 days is expected and the same is with the expected **decrease in future frost and ice days.**

Regarding the future projections of the days with **precipitation** above 40 mm. in the Berovo region in the RCP4.5 scenario during the summer, it will decrease by 20% on average and during the autumn it will increase for the same percentage with an increase of the rain accumulation in certain vulnerable areas in and around the city with the potential risk of flooding.

The **number of consecutive dry days will increase** from 0-3 days in the first half of the century. The risk of droughts will be lower. [2]

6.2.1 Assessing the vulnerability score

[2] Djurdjevic V. Report on Climate Change Projections and Changes in Extreme Climate Events in North Macedonia

When assessing the vulnerability and health risks, the socio-economic and public health indicators show the following: in the demography of the area of Berovo significant is a lower density of inhabitants per km2 compared to the national average, a higher percentage of the population over 65 (more than 50% of them living in Berovo) lower natural growth and higher mortality rate. [3] Drinking water quality is at a satisfactory level except in the rural areas where there is no proper maintenance and disinfection[4]. Air quality monitoring started this year (2022) and according to the initial results it seems that there will be pollution periods during the winter due to the domestic heating as the main source . The current health profile of the Berovo population is similar to the national one. The main cause of death among the older population are circulatory and malignant diseases, and the main morbidity cause are circulatory and respiratory diseases.[5]

No any vector transmissive disease had been registered so far and among other infectious diseases, a higher trend is among enterocolitis, and salmonellosis which is similar to the whole country and could be an indicator for water quality and food safety problems, especially in the rural areas. The number of doctors and doctors' specialists is lower than the national one (359 citizens on one doctor).[6] Regarding the current health care capacities in the region the primary health care clinic in Vladimirovo village (7 km. from Berovo) is not operating in this period which can be a risk for the local population in case of emergency. 23 is the the average monthly number of intervention of the Emergency health care vehicles.

All these indicators make Berovo relatively vulnerable to some of the predicted climate extremes.

Although health data with sufficient quality covering a longer historical period have not been obtained, nor have specific studies been registered on the direct connection of climate change with health for the Berovo population, indirect socio-demographic indicators and the risk prediction confirms that the occurrence of high temperature and heat waves, especially in the summer period (on a short and long term) and cold waves in the winter (on a short term) will be the priority climate change risks for the population in Berovo (with moderate or high probability to happen). Flooding risks could be assessed as moderate to happen and to cause public health impact. Considering the recent history, a wide area of forest in the municipality and future projections of higher temperatures and significant droughts, forest fires could also be a high climate change risk, especially for the population in the affected regions. (Table 18 and Table 19).

[3] State Statistical Office 2021
[4] Drinking water quality in Berovo, Center of public Health Kochani 2022
[5] Report on population health in North Macedonia, Institute of public health (IPH) 2021
[6] Health Map of the regions in North Macedonia, IPH 2020

Table 18. Past and Future Climate hazards and health risks in Berovo

Climate hazards/extremes	**Probability**	**Past and current health impact/risk**	**Probability to happen**	**Future expected change in hazard/impact intensity/frequency**	**Time frame**
Extreme Heat (Increase Temp, Prolonged number and duration of heat waves, extended summer days	**Moderate to Low**	Increased heat mortality; Increasing additional deaths and cardio respiratory diseases, especially among the elderly and chronically ill patients Increased cardio respiratory diseases Increased water and food borne diseases during summer Possible spread of new vector-transmitted infectious diseases Increase in heat-related consultations, emergency calls, and hospital admissions Overheating of HC buildings, impact on infrastructure and supplies	Moderate-**to low**	Increasing of the Temp.' number and duration of heat waves, extending summer	**Short term** **Medium-term** **Long term**
Low temperature and cold waves	**Low to moderate**	Increased morbidity and mortality for vulnerable and elderly people especially during extremely cold days with high air pollution	**Low**	**Low**(winters will be warmer)	**Short term** **Medium-term**

Extreme precipitation and rain accumulation Flooding	**Moderate**	Increased population exposure to a range of negative health impacts like drowning, injuries, mental health effects, and increased spread of waterborne infectious diseases. Damaging in the infrastructure, transport, and healthcare facilities including the accessibility Deterioration of the epidemiological situation especially drinking water quality in the affected areas(esp. microbiological quality) The increased need of emergency and mental health support River-side communities at greatest risk	L**ower**	Will increase especially in autumn and decrease in summer	**Short term** **Medium-term**
Droughts	**Low**	Decreased availability and quality of drinking water with the increased trend of waterborne infectious diseases	Low to moderate	The risk could **increase**	**Mid to Long term**
Forest fires	**Moderate to high**	Destroyed huge areas of forest and wood mass, increased emission of fine particles and ozone precursors Increase risk of premature deaths and adverse chronic and acute cardiovascular and respiratory health outcomes. (Possible risk/impact)	**High**	will **increase** in the dry and forest areas in all three municipalities	**Short to Long term**

Table 19. Vulnerable groups and RVA indicators for the Health Sector

Climate hazards (extreme)	**Vulnerable groups**	**RVA indicators for health risk/impact assessment**	**Other Vulnerability and adaptive capacity indicators***
Extreme Heat (Increase Temp, Prolonged number and duration of heat waves, extended summer days	Patients with chronic cardiovascular and respiratory diseases Elderly (65+) Lonely pensioner households and the elderly accommodated in the institutions Homeless Communal, agricultural and other workers working outdoor Population groups living in risky and/or affected locations	All-cause and cause-specific mortality related to extreme heat/heat waves disaggregated by sex, age, and geographic location (**Source : SSO, IPH, CPH**) Spread and trend of infectious and waterborne diseases, heat stress, and pollen allergies (**Source: CPH**) Daily and monthly data on emergency calls during the (climate extreme)heat events (**Source : EMS**)	Drinking water quality, especially in rural areas (**Source :CPH**) Air quality indicators and warnings (**Source MoEPP, IPH**) Accessibility of the HC services (average time to reach HC service) (Source "MoH, LSG) **Socio-economic indicators:** Population density per km2 compared to the national average (Skopje 341/km2) (**Source: SSO)** Percentage share of the vulnerable groups (65+) compared to national average(**Source: SSO)** Number of lonely pensioner households and elderly accommodated in the institutions (**Source : SSO, LSG, SCC)** Percentage and structure of the population living in risky or affected areas (**Source: LSG**)

Low Temperature and cold waves	Patients with chronic cardiovascular and respiratory diseases People living in poor households Elderly (65+)	All-cause and cause-specific mortality related to extreme cold/cold waves disaggregated by sex, age, and geographic location (**Source : SSO, IPH, CPH**)	Percentage share of the vulnerable groups (65+) compared to national average(**Source: SSO)** Number of lonely pensioner households and elderly accommodated in the institutions (**Source : SSO, LSG, SCC)**
Extreme precipitation and rain accumulation Flooding	Population living in risky or affected areas	Daily and monthly data on the trend of waterborne diseases, injuries and fatalities) monitoring of the epidemiological situation in the region due to worsening of the drinking water supply and sanitation (**Source: CPH**)	Drinking water quality, especially in rural areas (**Source: CPH**) Percentage and structure of the population living in risky or affected areas **Source: LSG**
Droughts	Population living in risky or affected areas	Daily and monthly data on the trend of waterborne diseases (**Source: CPH**)	Drinking water quality, especially in rural areas (**Source: CPH**) Percentage and structure of the population living in risky or affected areas **Source: LSG**
Forest fires	Elderly and patients with chronic diseases Remoted and socially deprived population groups especially in rural areas	- Daily and monthly data on health care and emergency calls, during the events in the regions affected (**Source EMS**)	Regular data/information on affected areas with the structure of the population groups at risk (**Source LSG**)

***Other (optional) indicators of sensitivity and adaptive capacities**: Life expectancy; natural growth, birth rate, mortality rate, index of aging, at poverty risk for the general and population 65+ **(Source: SSO),** Number of inhabitants per one doctor **(Source: IPH, SSO),** the status of the health care facilities **(MoH, LSG, WHO checklist)**

6.2.2 Indicators, data processing, and monitoring

Regarding the indicators, two groups of indicators should be introduced: those directly linked with the climate's extreme impact on the health of the population and those that are indirectly influencing the impact or the sensitivity and adaptive capacities of the sector and municipality. (Table 19). The indicators presenting the demographic and socio-economic sensitivity including the status of the healthcare facilities and the number of medical staff or the number of medical doctors could be in the optional group. The sources of the indicators are various local and national agencies or in some cases direct research and estimations. The local self-government should establish a working group (committee) that will process, analyse the data and advise the adaptation measures and monitoring.

Among the various **population group the most vulnerable on the Climate change impacts** are

- Patients with chronic cardiovascular and respiratory diseases
- Elderly (65+)
- Lonely pensioner households and the elderly accommodated in the institutions
- Homeless
- Communal, agricultural and other workers working outdoor
- Population groups living in poor households in risky and/or affected locations (Table 19)

6.3 Agriculture sector

Identification of the future climate trends is at the heart of the process of identification of future risks, priorities and designing and implementing effective adaptation strategies. Climate change trends are one most effective tool for identification of future climate threats and risks. However, more accurate identification of future climate trends usually is a cumbersome and complicated task, due to the need of well-organised and long-term monitoring of weather parameters, adopted and calibrated models for forecasting of the meteorological parameters and climate on a short, medium and long term, with satisfactory accuracy and resolution.

The analysis of the future climate was based on the available meteorological data provided during the preparation of the Fourth communication of climate change, developed by WCRP CORDEX. Meteorological data were organised into four periods: the first period refers to the past and current climate trends and hazards (baseline period - 1990-2020), and future projections on a short term 2016-2035 and a mid-term - 2045-2065. For this analysis the RCP 4.5 scenario was used for modelling of future trends.

The future climate trends and threats are evaluated through the future dynamics of the average air temperatures and precipitation as well as of four extreme indices which have the most prominent influence in the agricultural sector.

6.3.1 Temperatures

With comparing the projections of the future trends of the annual and air temperatures in vegetation for two periods 2016-2035 and 2046-2065 for the municipality of Berovo with the referent period 1985-2005 it can be concluded that the average air temperatures are expected to increase over a short term period (2016-35) for about 0.5-1 C° while on a medium term period (2045-65) the increase for the most part of the municipality except south-eastern parts in the mountainous zone, will be for about 1.5-2 C° . The increase of temperature in the mountainous part is expected to be up to 1.5 C°. However, in a short term period, agricultural production will be significantly affected due to this expected increase of the average annual temperatures, while in the medium term period, the impact will be much higher.

This negative impact will be mostly the result of the increased evapotranspiration, plant water demands and water deficit. Plants during the vegetation period will be under stress as a result of insufficient water and high temperatures.

The average temperatures during the vegetation season (Figure 37 and Figure 38) are expected to rise in the Municipality of Berovo especially in its northern part. Out of the presented data it can be seen that the average rice on a short-term period is expected to be 1.0-1.5 while on a long term the rise of the air temperature in the north is expected to be in the ranges of 2.0-2.5 C°.

Figure 35. Annual air temperatures 2016-2035

Figure 36. Annual air temperatures 2046-2065

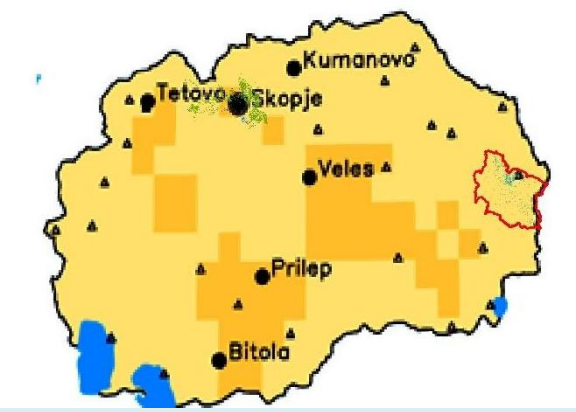


Figure 37. Air temperatures in vegetation 2016-2035

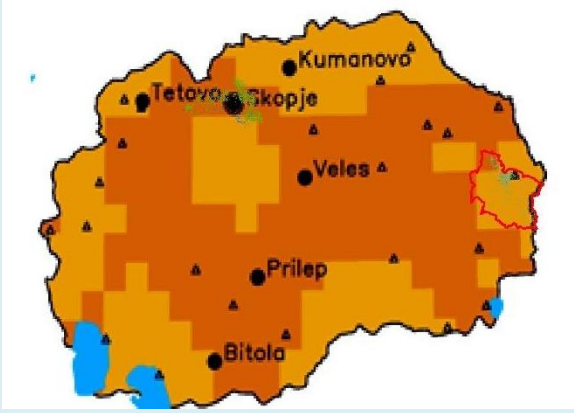
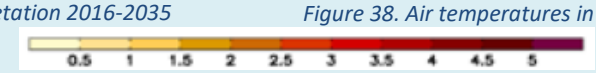


Figure 38. Air temperatures in vegetation 2016-2035



6.3.1.1 Heat waves

With regards to the heat waves, out of the data presented in Figure 39and Figure 40, it can be concluded that the number of events will raise in average for one event compared with the period 1985-2016, while on a mid-term this rise will be for about 1-5 events which is a serious increase and affects the whole territory of the municipality including all agricultural land. The negative impact of heat waves has already been elaborated, so it can be concluded that this weather extreme is expected to be a serious risk to agriculture in the future.

Figure 39. Heat waves 2016-2035

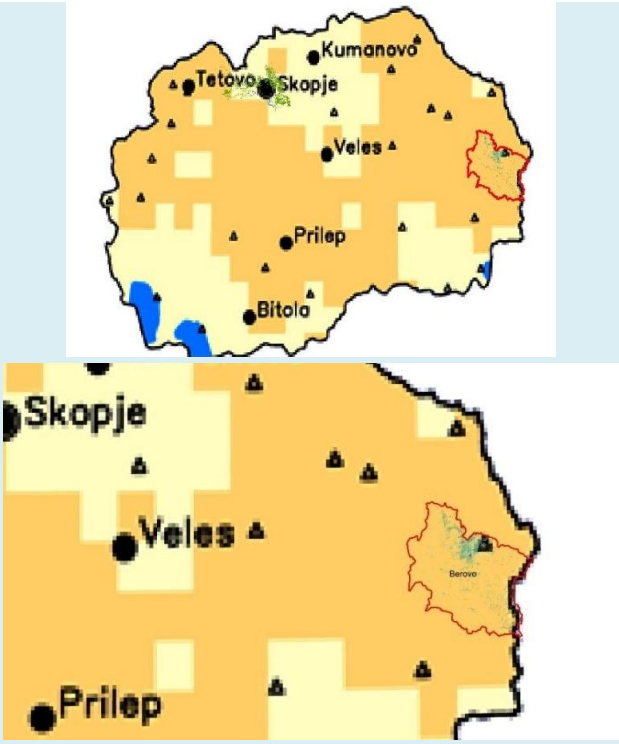


Figure 40. Heat waves 2046-2065

6.3.1.2 Extreme precipitations

Projected trends of the extreme rainfall events for the municipality of Berovo indicate a great variability. In the eastern and south eastern part of the municipality, the projections are that the number of days with extreme precipitations will decrease in a short-term period for 5-10 days, while in the eastern part of the municipality the number of extreme rainfalls will increase for 10-20 days. In a long-term period (2046-2065) the number of days will generally increase in all parts of the municipality for 10 days compared to the base period, mining the eastern part will benefit with more precipitation, while the eastern parts will be in steady state. For the agricultural production this increase can cause a certain risk, but taking in consideration the spatial distribution of these changes and the location of the agricultural land in the municipality, our estimations are that the impact will be low for the agricultural corps.

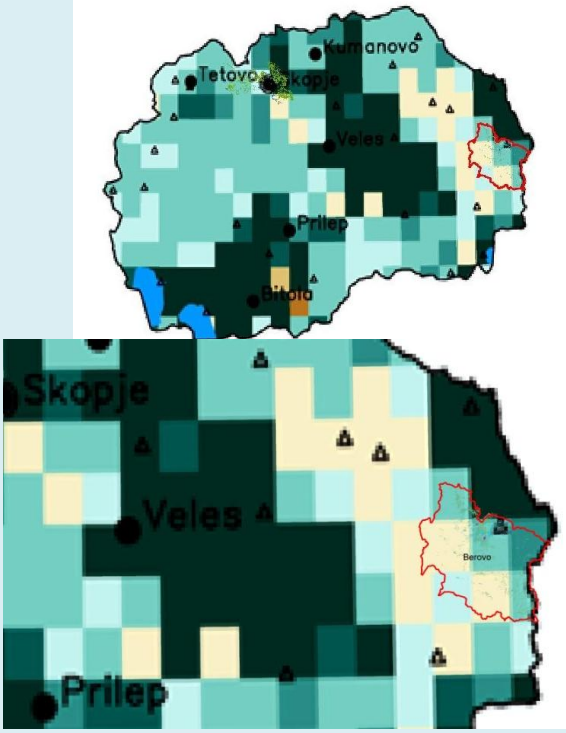


Figure 41. Intensive rainfalls 2016-2035

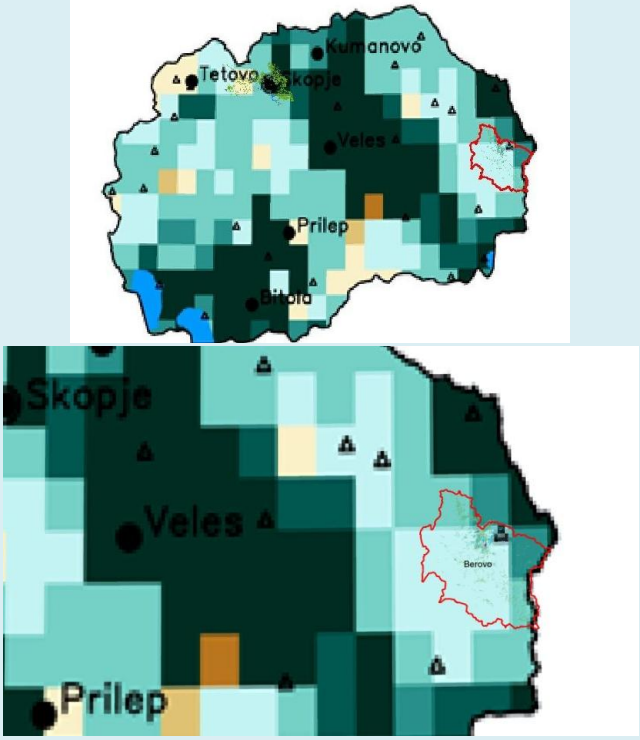
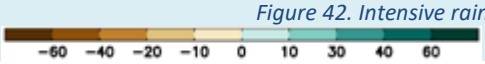
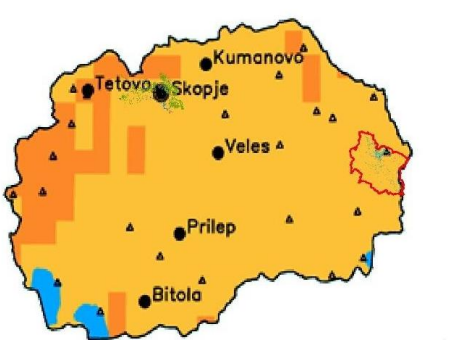


Figure 42. Intensive rainfalls 2046-2065



6.3.1.3 Frosts

As presented in the Maps 21 and 22, the number of frost days, similarly like in the whole territory of the country, is expected to decrease for about 5-10 days on a short-term period 2016-2035 and for about 10-20 days on a medium term (2046-2065). The decrease of the number of frost days will be evenly distributed over the whole areas of the municipality of Berovo. This means that the overall agricultural areas will evenly be affected with this decrease of frost days. Frosts are one of the biggest risks for the agricultural production in the Municipality of Berovo, especially late frosts in spring. Late firsts cause serious damages to orchards (plumbs) which together with livestock production are the two dominant branches of agriculture.



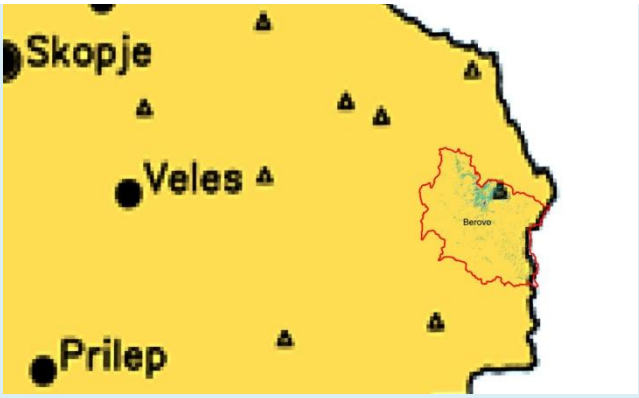


Figure 43. Frost days 2016-2035

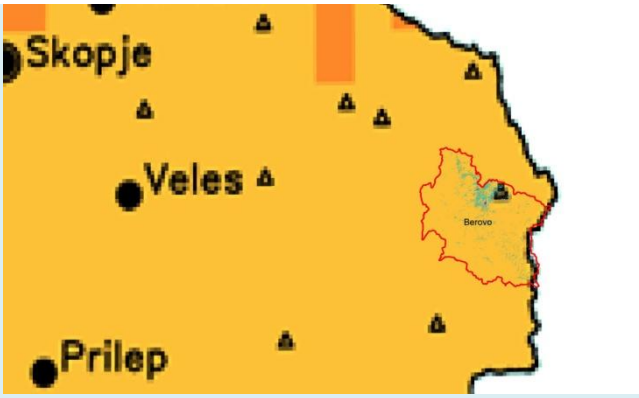
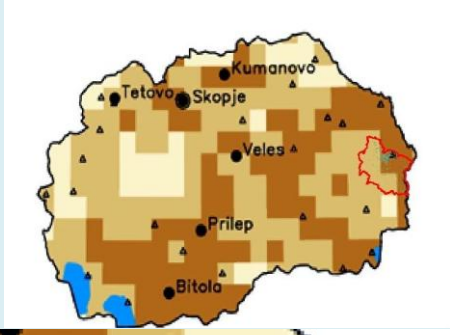


Figure 44. Frost days 2046-2065

6.3.1.4 Drought

The drought periods in Berovo Municipality are expected to increase in the short term period. The increase of dry period in the eastern part of the municipality will be for 5-10 days in a short-term period (2016-2035), while the eastern parts are expected to be more exposed with an average increase of drought for about 10-20 days. In the mid-term period (2046-2065) the expectations are that the eastern part of the municipality will remain with the same duration of the dry periods, while in some areas on east the duration of dry periods is expected to decrease. This is very beneficial for the agricultural production since the most intensive perennials are located exactly in these parts of the municipality.



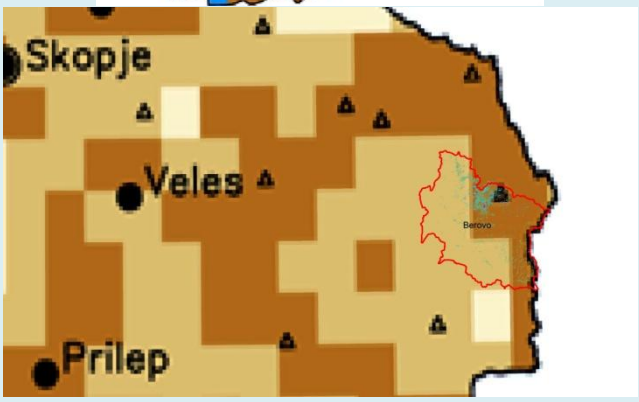


Figure 45. Drought 2016-2035

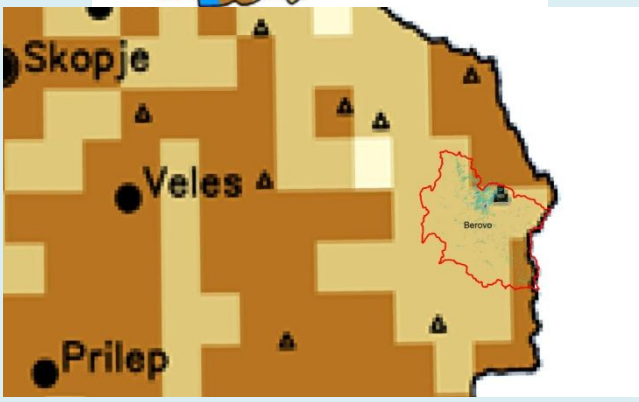
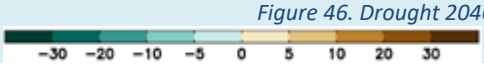


Figure 46. Drought 2046-2065



6.3.2 Livestock

All mean annual THI loads were averaged for the periods.

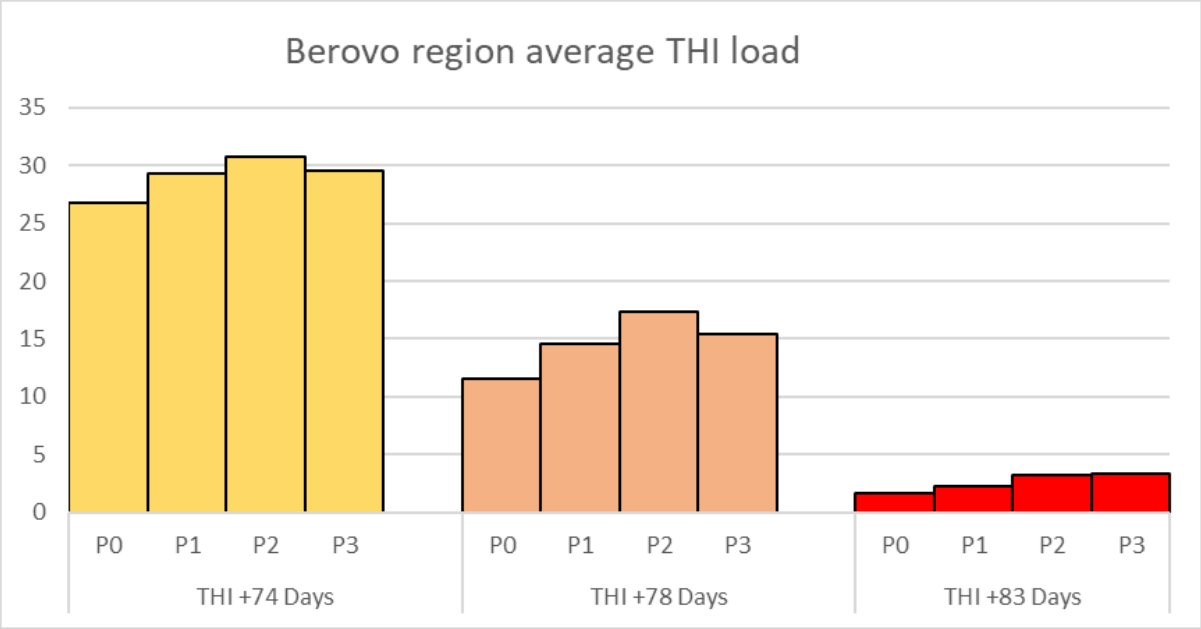


Figure 47. Average THI loads in ruminants in the area of Berovo municipality, for the reference period (P0: 1990-2020), short (P1: 2021-2030), medium (P2: 2031-2040) and long (P3: 2041-2050)

The estimated average annual THI load in P2 for the alert, yellow phase with THI between 74 and 78 was 30 days, in an emergency, orange phase with THI between 79 and 83 - 18 days, and in dangerous, red phase THI over 83 – 3 days. Overall average annual exposure of the ruminants in phase over emergency would last above 30 days for the period from 2021 to 2050. The average annual THI load would be 15% higher than in P0. Worth to mention is that the +83THI load will be over 3 days in P2 and P3, compared to P0 when it lasted less than 2 days. However, the spatial distribution is not even.

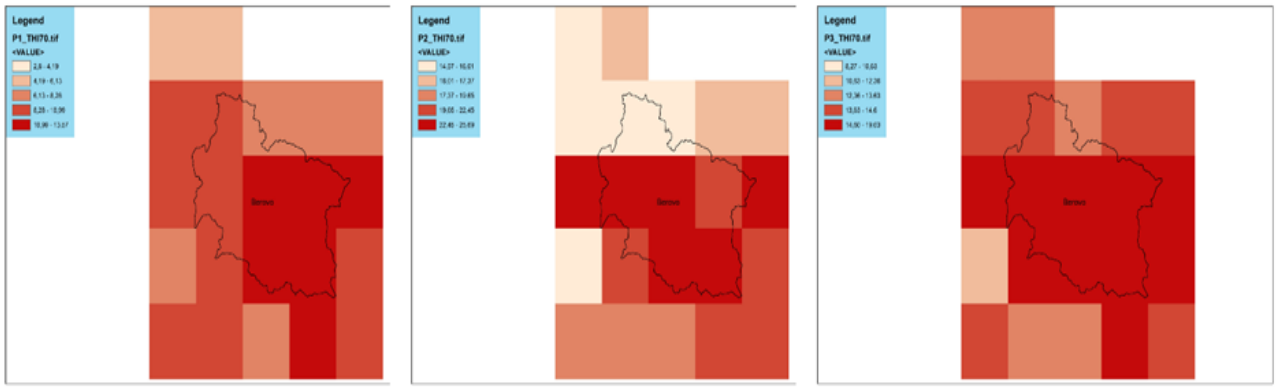


Figure 48. Spatial distribution on pre heat phase (THI 70+) as a difference between reference period (P0: 1990-2020) and short (P1: 2021-2030), medium (P2: 2031-2040) and long term (P3: 2041-2050)

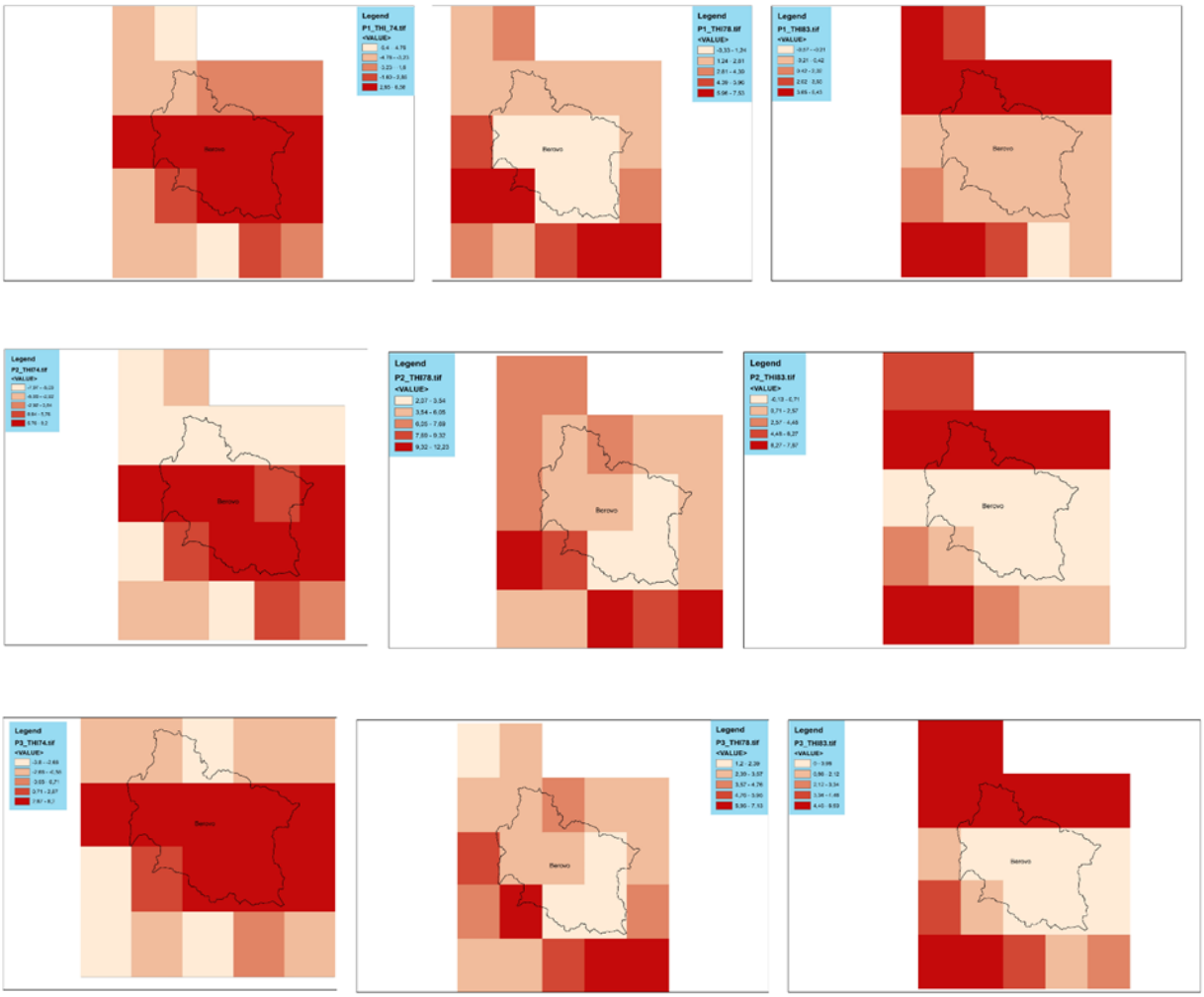


Figure 49. Spatial distribution of 3 THI loads in alert (yellow THI 74+), emergency (orange THI 78+) and dangerous (red THI83+) in the area of Berovo municipality, expressed as the difference from the reference period (P0: 1990-2020) and short (P1: 2021-2030), me

During these periods there will be an increased area where the THI will be higher. The THI 74+ load in the areas on the west and southwest will last longer for almost 8 days, compared to the reference period. It is also expected that the increase of THI 78+ load will increase in the south and southeast area of the municipality. There the load will last for 8-12 days longer than in the reference period. The dangerous period of THI 83+ load will be increased mostly in the northern and southwest part of the municipality, where the duration should be expected to last additionally for 5-7 days.

Change in THI load in the area of Berovo municipality from the reference point

	P1	P2	P3
THI +70	5.13	**10.49**	7.95
THI +74	2.51	**4.04**	2.75
THI +78	2.97	**5.77**	3.88
THI +83	0.53	1.49	**1.71**

The trend observed in the average annual THI load is that the maximum can be expected in P2 for pre-heat, alert and emergency phases, but in P3 the dangerous phase will last almost double. Due to climate change, the vulnerability of intensive livestock production systems will be comparably higher. To overcome the possible losses the changes in technology applied on larger dairy, pig, and poultry farms are essential. The new technologies in housing should provide an optimal environment, ideally, within the comfort zone for specific species, physiological status, and production level, and maintain temperature, humidity, and ventilation resulting in higher productivity. Special attention should be paid to nutrition and feeding regime. Special diets should be applied during the heat waves that will reduce the additional produced heat from digestion, with excessive access to fresh water. Also, the regime of feeding should be changed towards periods of a cooler period of the day. Additionally, livestock breeds used in production systems should be towards more robust animals with higher heat tolerance, but still with a production level that can ensure high-quality products and profitability of the farms. Climate change could have an impact on disease outbreaks in livestock. The occurrence of diseases can be directly on animals exposed to extreme weather conditions, or indirectly by the presence of vectors whose spatial distribution is usually very dependent on climatic conditions. The occurrence of diseases generally does not have an impact on health status in the country but significantly influenced the economic profitability of farming. However, some contiguous diseases are transmitted by vectors or by wild animals, and the spreading of those vectors can be enhanced by climate change. Such diseases as Bluetongue, Rift valley fever, West Nile fever, African horse sickness, African swine fever, etc. are important for determining the health status in the country. However, the occurrence of other diseases like Avian influenza is not transmitted by vectors, but they can be also related to climate change due to the change of the routes of migratory birds.

The country was already faced with Bluetongue disease in 2014, and Lumpy skin disease in 2016. Hence, it is of vital importance to investigate the risks and vulnerability of livestock to outbreaks of diseases that can happen due to climate change. It means taking action towards adopting farm management and technologies in preventing outbreaks, but also preventing further spreading. Also, it will influence the way of animal move (wild animals and livestock in grazing). Veterinary service needs to be trained to make early diagnose of the diseases, prevent the risk of spreading, and eradicate them. However, those activities need to be applicable, effective, appropriate, and economically reasonable.

6.4 Forestry sector

Identification of the future climate threats is in the heart of the process of identification of future risks, priorities and designing and implementing of effective adaptation strategy. Climate change trends are one most effective tool for identification of future climate threats and risks. However, more accurate identification of future climate trends usually is a cumbersome and complicated task, due to the need of well-organized and long-term monitoring of weather parameters, adopted and calibrated models for forecasting of the meteorological parameters and climate on a short, medium and long term, with satisfactory accuracy and resolution.

The analysis of the future climate was based on the available meteorological data models for prediction done by Gjurgevic for the latest 4-th Climate change communication. There were used two future periods: Short term (2015-2035) and Mid-term (2046-2065), in order to assess the future climate.

6.4.1 Temperatures

The future trends of the temperatures are evaluated using the "medium" RCP 4.5. The trends of the average air temperatures are estimated as a difference between the base period 1986-2005 and the future: short and mid-term periods. Out of the data presented it can be seen that a slight increase up to 1 degree is expected on short-term and on mid-term it is expected an increase of 1.5-2 degrees.

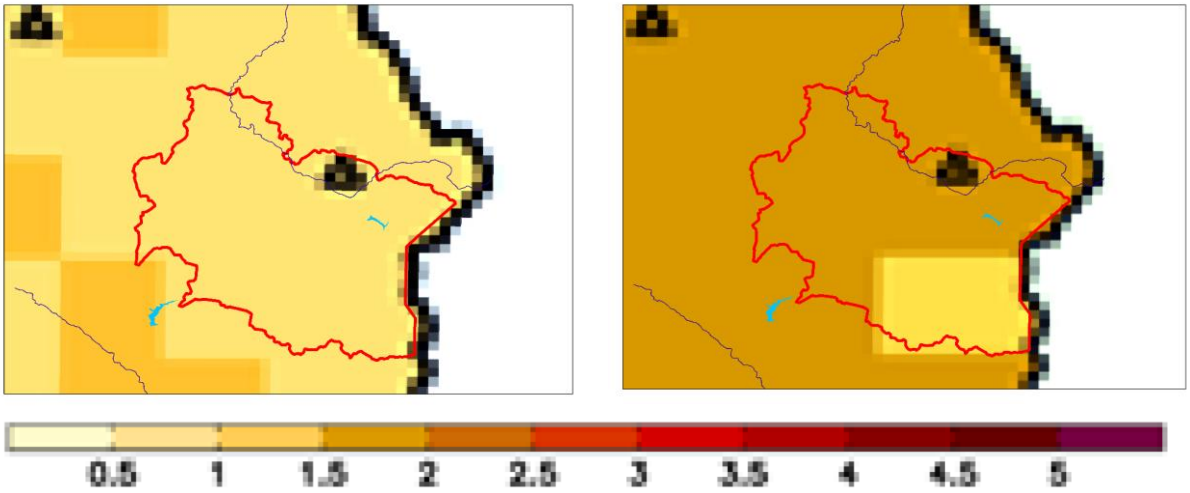


Figure 50. Projected change of average air temperatures 2046-2065 related to 1986-2005

Figure 51. Projected change of average air temperatures 2015-2035 related to 1986-2005

6.4.2 Precipitation

The future trends for the precipitation show a decrease of the annual precipitation sums. It can be seen on the maps below that on short-term it is expected a slight decrease of precipitation of 5 %. On medium-term it can be seen a decrease of annual precipitation up to 10 %.

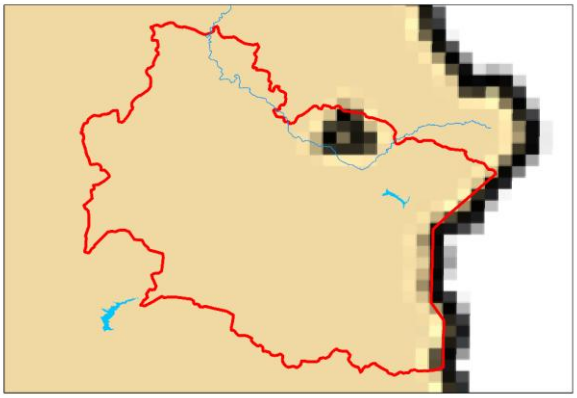


Figure 52. Projected change (%) of annual precipitation 2015-2035 related to 1986-2005

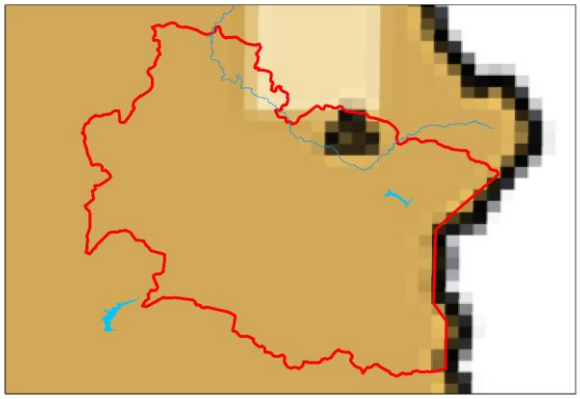


Figure 53. Projected change (%) of annual precipitation 2046-2065 related to 1986-2005

6.4.3 Drought vulnerability

From the maps below it can be seen that on short and mid-term the projected consecutive days are increasing. On short term part of the territory is covered with 5-10 consecutive dry days and the other part is in the higher category 10-20 consecutive dry days. On mid-term territory is covered with 5-10 consecutive dry days.

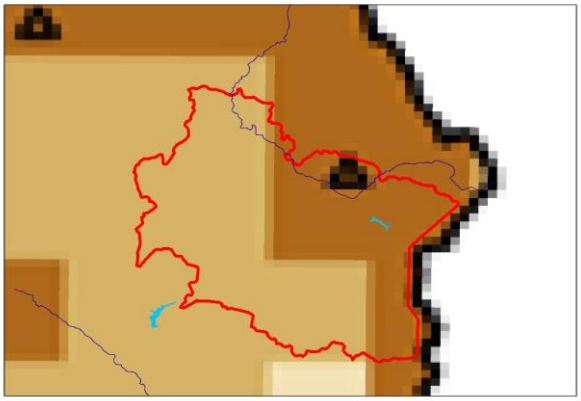


Figure 54. Projected change of consecutive dry days 2015-2035 related to 1986-2005

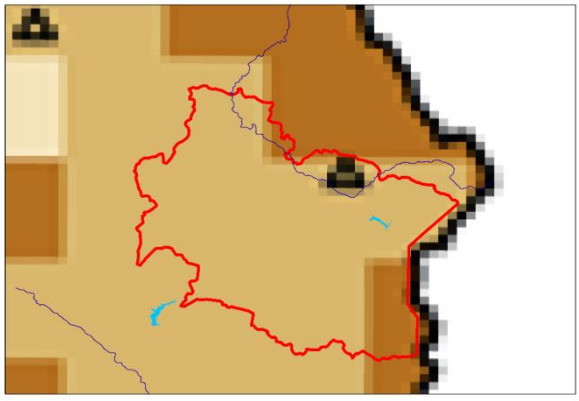


Figure 55. Projected change of consecutive dry days 2046-2065 related to 1986-2005

6.4.4 Intensive rainfall

From the maps below it can be seen that on short and mid-term the projected daily accumulated rainfall are increasing. On short term part of the territory is covered with increase of extreme rainfall events of 10 to 20 %. On mid-term, the results are similar as the first period.

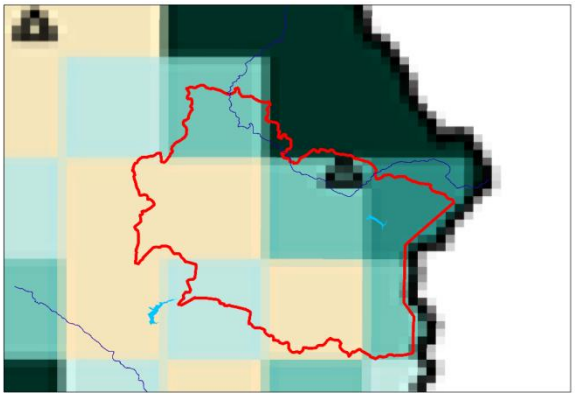


Figure 56. Projected change of extreme rainfall events (%) 2015-2035 related to 1986-2005

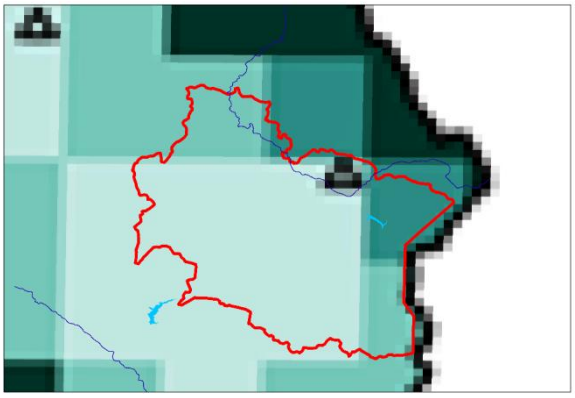


Figure 57. Projected change of extreme rainfall events (%) 2046-2065 related to 1986-2005

<u>Main problems in the sector forestry related to climate change</u>

1. **Illegal forest activities**
    a. Decrease of forest cover consecutively changes of land cover (forest to bare land or meadow) because of not appropriate forest cuts. Only the best trees are cut, leaving the sick and small trees which in long term will decrease the quality of the forest and if intensively used (cut) could totally remove the forest as land cover.
    b. If the illegal forest activities are with lower intensity, it will decrease the quality of the forest and in term decrease the ability to store carbon.
2. **Forest fires**
    a. The climate change scenarios predict longer dry periods in the summer, longer heat waves and increased temperatures. This in effect, will increase the vulnerability of the forests to forest fires.
    b. Forest fires are a large emission source and will increase the emission quantities in total. If the forest is coniferous, it will wipe out the forest land cover switching it to bare land. In this sense the carbon pool is diminishing on long term basis.

c. If the burnt land is deciduous or mixed, after few years, if the fire was not devastating, the vegetation will come back, but it will take time for compete forest revitalization, at least 20 years to get the carbon pool as before the fire.

3. **The chain effect of forest fires to increase the vulnerabilities and risks to torrential floods**
   a. The climate change scenarios predict longer dry periods in the summer and not even distribution of the rain events. In turn the rain events will be with much larger amounts of water. The combination of forest fires in which the land is left bare and torrential events in which the loose soil will be removed, leaving the forest soil poor with nutrients.
   b. The forest fire affected bare land is prone to the adverse effects of the water (erosion, torrential floods). The soil after fire is loose; the organic matter is burnt and transformed in inorganic compounds. The organic matter is the agent which is keeping the structure of the soil in good condition. Without humus layer the soil is loose and prone to erosion. If it is not conserved with the immediate effects of the surrounding vegetation (grasses, herbaceous vegetation or trees) it can be easily washed away. This is on-site effect of the erosion.
4. **Soil erosion and torrential streams off-site effects**
   a. Not planned removal of the forest ether by illegal cut, forest fires, pests or diseases can lead to large bare areas which can increase the risks of torrential floods and in turn cause damage to downstream inhabited areas and loss of human lives
   b. The soil erosion and torrents impact the site where they occur (on-site), but the larger impacts, expressed as damage to property and human lives, happen far from the site of origin. These are off-site effects. The larger downpours happen up in the mountains where the rainfall amount is the highest. If this water amount is not stored in the subsoil or in the forest, the water flow on the surface and then it will concentrate in the smaller streams and connecting with the larger streams downstream, and on the end the large water wave will create damage in the lower parts of the catchment, where most of the larger inhabited areas are situated. This in turn may flood the inhabited areas and create damage to property and loss of human lives.

6.5 Economy sector

6.5.1 How Climate Change May Affect the Economy – a general overview

Assessing the impact of climate change is, at best, an extremely complex exercise with uncertainty about both the degree of future global warming and the subsequent impact on global activity. There are clearly some benefits as well as costs as the planet warms. There is also the unknown of how technological progress will respond and potentially alter the path of global warming. Any assessment also involves taking a very long-run view, well beyond that normally used by financial market participants. However, increasing awareness of the issue means there is a growing demand for a view from shareholders who are either concerned about how the companies they own impact the

environment, worried about the effect of climate change on the value chain of those companies, or a combination of both.

While economic activity affects climate change, so too does climate change affect economic activity. Economic activity can be affected in the short and long terms by climate change. Of note, while no single extreme weather event can necessarily be attributed to climate change, scientific and statistical analyses can estimate the effects of climate change on the change of likelihoods of single extreme events and on extreme events overall. Given the scientific consensus about the relationship between climate change and trends in extreme weather events, this report includes the overall economic impact of extreme weather events as part of the economic effects of climate change.

The effects of climate change on the economy include both positive and negative components and involve estimation uncertainties, and research estimates vary. The research community generally agrees that long-term economic effects are likely, on balance, to be increasingly negative and widespread—and catastrophic for some locations—although the magnitude of effects is a continuing area of research. In particular, evidence suggests that human preparation and adaptation to anticipated changes *can* reduce adverse impacts and capture opportunities, but the degree, comprehensiveness, and ancillary consequences of adaptation are challenging to predict.

This section discusses some of the avenues through which climate change affects economic activity and gross domestic product (GDP). It is not necessarily a straight line from climate change to changes in overall economic activity (often measured by GDP). Rather, climate change more directly affects various inputs used to generate overall economic output, and there may be many variables—including the implementation of policies—that intervene between potential and actual effects.

Two of the main avenues through which climate change can affect GDP in the short and long terms are **productivity** and **investment** effects. Productivity is a key determinant in long-term economic growth—as productivity increases, economies can produce more goods and services with the same level of resources, which in turn tends to increase well-being and income. Business investment is also a determinant of long-term growth insofar as it contributes to the domestic capital stock, which is directly related to the economy's overall productive capacity. Research suggests that climate change could negatively impact productivity and business investment, as rising temperatures and heat waves could result in lower output per worker. Declines in productivity and production could decrease businesses' incentive to invest, particularly in a scenario in which physical capital is routinely damaged or destroyed due to the effects of extreme weather events to a point where further investment becomes unattractive. Climate change can also bring some benefits (such as fewer extreme cold events) and opportunities, although the net effects of climate change on the economy are generally expected to be increasingly adverse and widespread on net.

Climate change—notably the projected increase in certain extreme weather events—is also expected to affect the overall economy through its impacts on specific sectors, such as housing, infrastructure, and agriculture. Housing stock could be at high risk of climate-change-induced hazards, and properties are vulnerable to complete destruction or being rendered unusable by flooding risk alone. Transportation infrastructure, which supports the production and movement of goods and services, could be damaged with climate change. While transportation systems are typically designed to withstand certain magnitudes of extreme weather events, an increase in the frequency and severity of extreme weather events would increase the residual risk. Heat waves, heavy precipitation, and other storms can additionally cause delays and disruptions on roads, public

transit systems, airports, and the like, adding to the costs of production and interfering with consumption.

Short-Term vs. Long-Term Impacts

Climate change may have differing effects on the economy in the short and long terms. In the short term, any extreme weather events made more frequent or severe by climate change may result in positive, negative, or no changes to output, depending on the extent to which business activity is disrupted and rebuilding efforts of pre-existing structures takes place. Other manifestations of climate change, such as temperature change, may also affect the economy in the short term in ambiguous ways. For example, warmer temperatures may boost crop production in some cases but not others.

Given the literature and research developments at this point, economists generally agree that the long-term economic effects of climate change are likely to be increasingly negative on balance. Absent deep GHG mitigation, research generally indicates that output is likely to be negatively impacted by climate change over the medium to long run. The overall negative impact would likely be due to decreasing incentives for businesses to invest, as well as to decelerating or decreasing productivity growth (as described below). The magnitude of any future impacts is uncertain and debated. Of note, if the long-term productivity growth rate (as opposed to a temporary shift in the level) changes as a result of climate change, the long-term *growth rate* of GDP may also be affected, leading to an ongoing accumulation of losses.

Productivity

Productivity measures how efficiently inputs are producing outputs in an economy. In other words, productivity is the ratio of the amount of land, labour, capital, energy, etc., that is used to produce goods and services to the amount of goods and services produced. Productivity is a key determinant of long-term economic growth. As productivity increases, economies can produce more goods and services with the same level of resources, which in turn tends to lead to increased income and well-being. There are two common measures of productivity: labour productivity and total factor productivity. Labour productivity measures the amount of hours worked relative to the amount of output in an economy, while total factor productivity considers not only labour but also other factors of production such as land and capital.

Labour is a major channel through which climate change might affect the workforce and thus economic output. Warming directly affects labour supply (working hours) by changing the allocation of time to labour beyond certain thresholds, especially in working conditions that are highly exposed to the climate—eg, in the agriculture sector to avoid lasting damages to health due to heat exhaustion or heat stroke, or even death. Climate change also reduces performance during working hours (labour productivity) when workers under severe heat stress slow down and take more breaks to rehydrate and cool down. Additionally, excessive body temperature and dehydration can increase the number of mistakes made, resulting in increased accidental injuries. As labour accounts for a substantial share of the total valued added, as much as 50% in some sectors depending on the sector and country, studies using economic models have found that the climate effects on labour are among the most important drivers of total economic costs of climate change. Possible effects on the

working population due to temperature shocks that are unmitigated through adequate thermoregulatory infrastructure will lead to a reduction in economic activity and reduce the capacity for economic growth, especially in low-income and middle-income countries. These effects have distributional implications in terms of increased inequality and poverty.

The effects of rising average temperature are likely to affect productivity differently across different sectors, regions, and countries. For example, labor-intensive production may see greater decreases in labor productivity during extreme heat, as a worker doing physical labor outdoors is more likely to be affected than is an office worker on a hot day. One of the largest potential contributors to productivity loss is extreme heat. One municipality is likely to see smaller productivity losses than other municipality do as a result of this phenomenon, if it has a temperate climate and its workforce is relatively less concentrated in outdoor labor-intensive industries.

In terms of its uses in agriculture and forestry, land can also become less productive as a result of rising average temperatures (or more productive in the case of relatively cool areas, such as when growing seasons lengthen). Scientists expect rising global temperatures overall to increase precipitation but also its variability in many locations. The effects of changing precipitation on productivity would depend strongly on its timing (e.g., during a growing season), its variability and predictability, and its intensity (of precipitation or lack thereof, as drought). The net effect of changing precipitation is uncertain and would vary by location. Generally, climate change, including extreme weather events, is likely to "increasingly disrupt agricultural productivity.

Business Investments

Business investment refers to spending by private businesses and nonprofits on physical capital—long-lasting assets used to produce goods and services. An increased stock of physical capital increases the capacity of businesses to produce goods and services and can therefore affect the greater economy. In the short term, an increase in business investment directly increases the current level of GDP, because physical capital is itself produced and sold. In the long term, economic growth generally depends on growth in the economy's productive capacity (rather than swings in supply and demand), and a larger physical capital stock increases the economy's overall productive capacity, allowing more goods and services to be produced with the same level of labor and other resources. In turn, faster economic growth generally translates into faster income growth and improved living standards.

The effect of climate change on average investment over a longer period is of particular concern due to its connection with long-run economic growth. (Over short time periods, business investment in any given year may fluctuate significantly as a result of extreme weather events, but this effect would be transitory—and potentially positive—in a time period in which damaged or destroyed physical capital was replaced.) The logic behind this concern is that if climate change causes declines in production, income, and productivity, it will lower businesses' incentive to invest, thereby lowering the investment rate. There is, as of yet, not clear evidence that longer-term trends in business investment have been altered significantly by climate change, as research to try to quantify this potential effect is limited and results vary.

6.6 Assessment of the future climate risk of the local economy of the Municipality of Berovo

The overall aggregate effect of climate change on economic growth will most likely be negative in the long run. Although there will be winners and losers from climate change at varying levels of warming, the impact of rising temperatures will be widespread, in part due to the financial, political and economic integration of the world's economies. Global warming will primarily influence economic growth through damage to property and infrastructure, lost productivity, mass migration and security threats. The balance between winners and losers turns increasingly negative as temperatures rise.

Global warming is expected to increase the frequency and severity of extreme weather events, bringing with it property and infrastructure loss. How climate change will shape the global economy? Global growth will be hindered by rising operational costs as global temperatures rise, with studies suggesting that a worst-case impact of a 1% reduction in GDP growth per year could be realized. However, climate impacts are not expected to have an equal negative impact on all economies in the world. The regional impact is expected to vary according to the ability of economies to adapt. The following graph provides a synthetic view, derived from the conclusions of a large number of studies, and can be seen in detail the regional impact of climate change on national economies in all countries of the world. Many countries will not be as vulnerable to climate change as others. In particular, the Republic of North Macedonia is in the group of less vulnerable to climate change. It is because of the assessments of world researchers about the great adaptability of our economy. And the biggest contribution to the Macedonian economy is made by the local economy of the Municipality of Berovo, as we point out in more detail above.

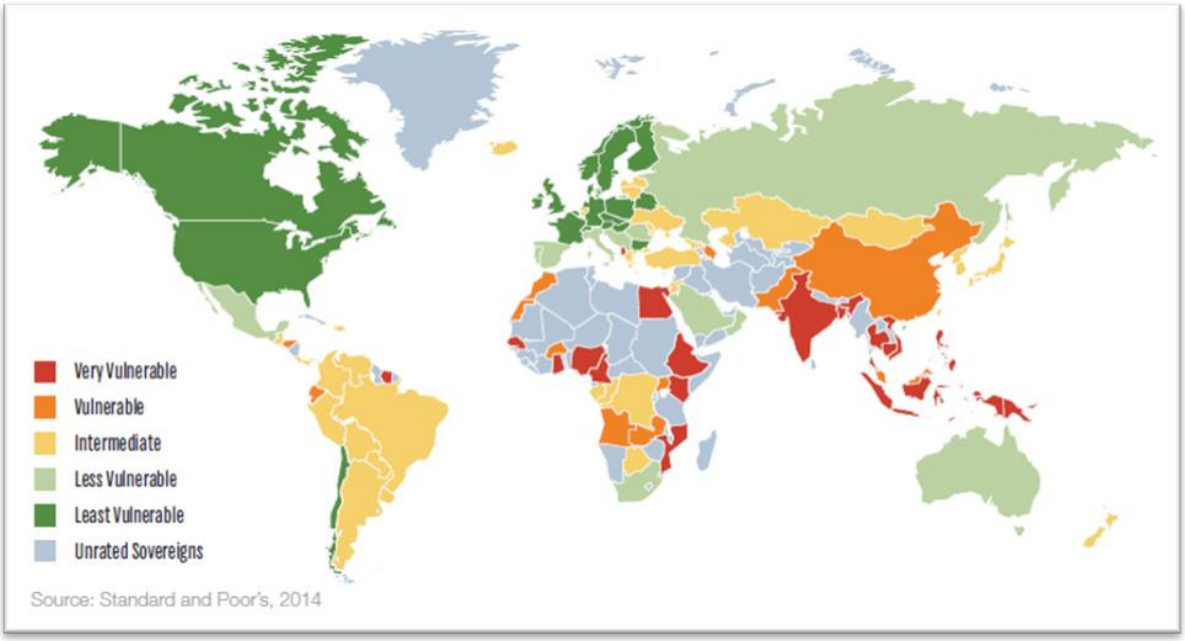


Figure 58. The impact of climate change on the global economy

At this moment there is great uncertainty and we cannot predict with great precision in which direction the local economy of the Municipality of Berovo will change, in which way local businesses will adapt. Assuming that the structure of the economy will remain the same or approximately the same, the assessment of future economic risks is given in the following table.

An increase in the intensity of the majority of extreme climate events is expected, especially the increase in temperatures in all seasons, more frequent heat waves, and a decrease in extreme cold days, with increased precipitation and the possibility of flash floods that may become more frequent. Due to the expectations for worsening climatic conditions, an increase in climatic risks is expected in the local economy in the Municipality of Berovo in relation to the current vulnerability. However, the general assessment is that the economy of the Municipality of Berovo will be moderately vulnerable to future climate risks. It is because of the expectations for strong adaptability of local businesses and change of business models according to the new economic conditions.

A greater climate risk is expected in the household sector, caused by expected increases in heat waves, but also possible heavy torrential rains. Its consumption would be lower on a short term, due to increased uncertainty, e.g. surrounding housing wealth and future income prospects. But it is expected to be higher on a medium term, due to increased household demand to replace destroyed goods, or hoarding behaviour.

Rising temperatures would have a negative effect on industry, especially the construction and agriculture sectors, and other outdoor activities. The need of workers in these sectors for shelter, for cooling, health protection, but also the greater number of work stoppages due to cooling, as well as complete work stoppages, will potentially lead to reduced productivity in the local economy. However, this is not expected to reduce the incentive for entrepreneurs to invest. However, construction has a small relative contribution to the overall economy.

Rising temperatures can have a negative impact on the touristic sector of the Municipality of Berovo since it will increased operating costs of the hotels, accommodation facilities and restaurants. On the other side, rising temperatures in this municipality will not be as high and can be shelter for people from other more heated cities. Subsequently Berovo would be attractive destination for more tourists, potentially lading to positive effect in rising truism.

Rising temperatures would have a potentially high negative impact, but also on interruptions in the transport of goods. Here, there may be increased costs for transportation and storage of the goods, which would negatively affect the profitability of the companies.

Expectations for an increased frequency of torrential rains, floods and strong storms would lead to the destruction of the homes of the population. It would also lead to damage and destruction of the companies' real estate, plants and equipment, and the companies' production facilities. This would lead to business discontinuities until the reconstruction of destroyed and destroyed real estate, plant and equipment. In the end, the force of the blow may be the complete bankruptcy of some companies, and a large part may suffer great damages. But the effect can spread throughout the economy, primarily on the financial system. Namely, it would have a negative impact on the ability of the companies to return the loans taken from the banks and default. Through this transmission mechanism, the negative effects will be transferred to the banks, but also to the insurance companies, which would ultimately be called upon to compensate the insured's damaged property.

In that way, the climate risk would be transferred to other parts of the economy through several routes and transmission mechanisms.

Ultimately, reduced production, such as industrial production due to the destruction of production facilities, and agricultural production due to the destroyed crop due to floods or reduced crop due to heat waves and droughts, would have a distortion in the market of goods and services. With unchanged demand, reduced supply would lead to an inflationary effect on certain markets. It can certainly be substituted by imports, but the final effects will depend on the state of the global economy.

However, the biggest threat to the local economy associated with rising temperatures and drought caused by climate change is forest fires. Their occurrence and increased intensity can completely destroy the tourism industry and the wood processing industry that have grown, causing enormous damage to the local economy.

Table 20. Assessment of the future climate risk of the local economy of the Municipality of Berovo

ECONOMIC SECTOR	EXTREME WEATHER EVENT	FUTURE CLIMATE RISK
HOUSING	Extreme Heat	High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	High
	Droughts	High
	Storms	Not known
	Landslides	Not known
	Forest Fires	Very High
INDUSTRY	Extreme Heat	High
	Extreme Cold	Medium
	Extreme Precipitation	High
	Floods	Medium

	Droughts	High
	Storms	Not known
	Landslides	Not known
	Forest Fires	Very High
TRADE (WHOLESALE AND RETAIL)	Extreme Heat	High
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Not known
	Landslides	Not known
	Forest Fires	Very High
CONSTRUCTION AND CIVIL ENGINEERING	Extreme Heat	High
	Extreme Cold	Medium
	Extreme Precipitation	High
	Floods	Medium
	Droughts	High
	Storms	Not known
	Landslides	Not known
	Forest Fires	Very High

TRANSPORT AND STORAGE	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Not known
	Landslides	Not known
	Forest Fires	Very High
TOURISM AND HOSPITALITY	Extreme Heat	High
	Extreme Cold	Low
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	High
	Storms	Not known
	Landslides	Not known
	Forest Fires	Very High

7 CLIMATE CHANGE ADAPTATION MEASURES

7.1 Adaptation measures for economy sector

7.1.1 Measures for industry adaptation to climate change

1. Assess exposure to climate risks: Manufacturers need to assess the risks that extreme weather events bring to their operations, including disruptions to their supply chain, damage to infrastructure, property, and the safety of their employees. Subsequently, they should carry out prioritization of investments in resilience measures.

2. Implementation of an emergency preparedness plan: Manufacturers should develop a plan for responding to extreme weather events, including procedures for shutting down operations, securing equipment and supplies, and evacuating employees if necessary.

3. Investing in climate-resilient infrastructure and technology: Manufacturers should invest in infrastructure and technology that can withstand extreme weather events, such as flood barriers, backup generators, and climate-controlled facilities. These investments can help minimize the impact of extreme weather events on production and supply chains

4. Diversification of supply chains: Local manufacturing industries should diversify their supply chains, reduce their dependence on regions prone to extreme weather events, and reduce the impact of extreme weather events on their operations. This may include sourcing materials from multiple suppliers, using alternative transport routes, and maintaining safety stock.

5. Implement sustainable practices: Local manufacturing industries should implement sustainable practices that reduce their greenhouse gas emissions and mitigate the effects of climate change. These practices may include using renewable energy sources, reducing waste and water consumption, and improving energy efficiency.

6. Alternative energy sources: Investing in alternative energy sources, such as wind and solar energy, can help reduce the industry's dependence on fossil fuels, which contribute to climate change.

7. Water management: Water management strategies, such as water conservation and water recycling, can help reduce the impact of droughts and floods on the industry.

8. Cooperation with local government and local communities: local manufacturing industries should cooperate with the government and local communities to develop policies and programs that promote climate resilience and reduce the impact of extreme weather events. This can include investing in research and development, providing training and education to the workforce, and supporting community-led initiatives.

9. Public-private partnership: Cooperation between the public and private sectors can facilitate the development and implementation of adaptation measures, as well as increase the industry's resilience to extreme weather events.

7.1.2 Measures for tourism adaptation to climate change

1. Development of climate-resilient tourism infrastructure: This involves designing and building tourism infrastructure such as hotels, resorts, and attractions that can withstand extreme weather events. This can be achieved by using materials that are resistant to flooding, strong winds, and other extreme weather conditions.

2. Implement early warning systems: It is important to establish early warning systems to warn tourists and tourism operators of upcoming extreme weather events. This can help them take necessary precautions and avoid danger.

3. Diversification of tourism products and services: Tourism destinations can diversify their tourism products and services to include activities that are less vulnerable to extreme weather events. For example, coastal destinations can develop land-based attractions and activities that are not affected by sea level rise.

4. Encouraging responsible tourism practices: Tourism operators and tourists should be encouraged to adopt responsible tourism practices that reduce their impact on the environment. This includes minimizing waste, conserving energy, and reducing carbon emissions.

5. Developing tourism adaptation plans: Tourist destinations should develop adaptation plans that address the specific risks and vulnerabilities of their area. These plans should be regularly reviewed and updated to ensure they remain effective.

6. Increasing awareness and education: It is important to increase awareness and education among tourism operators and tourists about the risks and impacts of extreme weather events caused by climate change. This can help them make informed decisions and take the necessary precautions to protect themselves and the environment.

7.2 Adaptation measures for forestry sector

Short-term measures

- Development of a complete program for adapting forestry to climate change;
- Locating 5 monitoring stations in the forest regions for continuous monitoring of climate changes;
- Procurement of appropriate vehicles and equipment for preventing and suppressing forest fires (early response / first attack)
- Opening of an educational center/training center for sustainable use of forests
- Storage of biomass

Long-term measures

- Adaptation of management plans in the forestry sector with climate change trends.
- Introduction of technologies for efficient use of biomass in forestry

- Promotion of green energy production opportunities
- Implementation of a pilot project for the production of renewable energy from biomass.

Identification of critical places in terms of natural disasters

Development of risk maps which will include:

- Floods and flash floods (Law on water, Protection against harmful effects of water)
- Defining erosive areas and areas threatened by erosion and
- Fires

Implementation of risk zones in existing planning documents (urban plans...)

Monitoring of forest cover loss from illegal logging

Identification of critical places and increased control of them

7.3 Adaptation measures for health sector

7.3.1 Policy level – planning, monitoring, financing

- Develop a Climate Action Plan in the municipality with the health sector as part of it
- Establish an intersectoral body and process to monitor the impact of climate change on the health sector and human health in general
- Introducing an evidence-based heat protection action plan or implement the National Heat Action Plan
- Development and constant promotion of general guidelines for the population during heat waves, floods, and other extremes.
- To establish an integrated (intersectoral) information system, with timely, spatially disaggregated data/information of all-cause and cause-specific mortality, climate-sensitive health outcomes and, hospital admissions, water and food safety and security, social issues and disaster risk data etc.
- Introducing of a special fund for dealing with climate change and climate extremes.

7.3.2 Health care facilities and infrastructure and health protection on the national and local level

- To enhance the regular public health-related climate actions (heat waves warnings, air quality and pollution, pollen concentration in air (if possible), vector-transmissive diseases distribution, water and food security and safety (especially in the rural settlements,etc);
- To introduce an early warning system during weather extremes (especially heat, floods, and forest fires) and prepare the health sector for appropriate response;
- To enhance knowledge and skills of the management and human resources (clinicians and public health) in the health care facilities to deal with various climate extremes and climate impacts.

- To provide healthcare facilities with essential medical products, service delivery, technologies, and healthcare infrastructure for climate adaptation and resilience
- Urgently invest inessential measures for disaster risk mitigation for all eath facilities in the municipality
- Conduct as many as possible climate change and health field epidemiological- research studies on prioritized health risks per specific regions and micro-locations (heat, flood, drought, wildfires) with the aim to assess the level of risk and impact and future impact
- Providing healthy and safe working conditions and enough health workers who are well trained, informed, and knowledgeable to respond to climate risks and minimize environmental threats resulting from the operation of the health care facility.
- To check the current status and enhance monitoring and assessment:
    - The healthcare facility should have sufficient information regarding water, sanitation, chemical use, healthcare waste management, and energy services considering climate resilience and environmental sustainability.
    - The health sector should be capable to assess and manage water safety and security, sanitation, chemicals, and health care waste and energy-related risks to workers, patients, and served communities, by including assessments of climate resilience and environmental sustainability in responding to hazards and identifying and reducing exposures and vulnerabilities[7].
- Municipality and health facilities should have established special procedures and budgets for emergency preparedness and response to climate hazard

7.3.3 Health-specific actions for monitoring and addressing climate-driven vulnerabilities:

Setting up procedures, legal and institutional mechanisms for systematic collection of the following data – health and non-health indicators:

- Daily or monthly morbidity and mortality data (with causes of death), hospital bed occupancy with proper sex and age disaggregation for the last 10 years
- Incidence of food, water-borne, vector-borne diseases, pollen allergies, number of office/clinic visits on monthly /daily level for last 10 years; the causes of disease/visit, emergency care calls with sex and age disaggregation
- Food safety data
- Long-term health and social care data (for the vulnerable groups) and
- Epidemiological and/or research data evidence on the direct or indirect impact of climate change on health on general or vulnerable groups of population in the municipality as well

[7]https://www.mdpi.com/1660-4601/17/23/8849

- Field research on homelessness, elderly, and socially and economically deprived population groups in the municipality
- Design of health adaptation measures attributed to heatwaves and floods;
- Design and implementation of measures for preventing health hazards by water consumption and water usage;

7.4 Adaptation measures for water sector

- Strengthening of hydro-meteorological monitoring
- Strengthening the capacities for early warning
- Modernization of weather modelling facilities
- Regular cleaning of the channel network
- Proper management of water management systems
- Improvement in the coordination between the relevant institutions
- Regular detection of critical flood points
- Reduction of losses from water supply systems
- Development of river basin management plans
- Development of flood management plans
- Modernization of water supply and reclamation systems
- Atmospheric sewerage with a capacity adapted to the number of inhabitants
- Correct dimensioning of bridge structures whose pillars can be critical points
- More green areas
- Construction of small reservoirs, embankments and cascades in the upper parts of river basins
- Planned afforestation
- Correct implementation of urban plans and proper adherence to them
- Measures to raise awareness among citizens (organization of consultations, symposiums, workshops) and rejection of the habit of throwing garbage and garbage into rivers and monitoring hydro and weather alarms
- Rational use of water resources (especially drinking water)
- Adherence to existing legal norms (regulations) and their improvement in the future
- Proper management of public utilities
- Regulation of torrents
- Creation of flood hazard and risk maps
- Defining the critical drains (sinks) dangerous for causing floods and preparing appropriate documentation for dealing with them
- Development of a comprehensive program for the response of water management (water resources) to the threat of climate change