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KUMANOVO

RISK AND VULNERABILITY ASSESSMENT TO CLIMATE CHANGE

CENTER FOR
CLIMATE
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 Kumanovo.

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 INFORMATION FOR THE CITY OF KUMANOVO

Kumanovo is a city in North Macedonia and the seat of Kumanovo Municipality, the largest municipality in the country. Kumanovo lies 340 metres above sea level and is surrounded by the Karadag part of Skopska Crna Gora mountain on its western side, Gradištanska mountain on its southern side, and Mangovica and German mountain on the Eastern side. Skopje airport also serves Kumanovo.

In terms of population, Kumanovo is the largest municipality in the Republic of North Macedonia, occupying an area of 509.48 km^2. The features of the temperate-continental climate prevail throughout all seasons.

3.1 Geographical and climate (and hydrographical) characteristics

Kumanovo is located in the northeastern part of the Republic of North Macedonia, in the eastern foothills of the Skopska Crna Gora mountain, in the eastern part of the Kumanovsko Pole, in the Kumanovska Kotlina (Žegligovo), at an altitude of 340 meters, spread on both sides of the rivers Lipkovka and Kumanovka. Kumanovo is the third most populous city in Macedonia and has a population of 70,842, of which 42,840 are Macedonians. The city of Kumanovo is the administrative seat of the municipality of the same name.

Kumanovo and the surroundings that gravitate towards it are in the northern part of the Republic of North Macedonia. This territory has its northern most parts north of Kozjak, in the village of Mglince, in the valley of the Mala Reka, and the southernmost part is around the village Zivnje. From the northernmost to the southernmost part in Kumanovo area, the distance is 43 km as the crow flies, and in the east-west direction the distance is 50.4 km. The Kumanovo area is separated from the neighboring areas by parts of massive old mountains. To the west rise the branches of Skopska Crna Gora, which in this region are known under the name Karadak. To the north are the slopes of Rouen, while the slopes of Mount Kozjac descend towards the commercial district. To the east is Mount German with Slavishka Kotlina, while on the south and southeast side are the hilly terrains of Gradiska Mountain, which separates the undulating Kumanovsko Pole from Skopska Kotlina and Ovche Pole. The Kumanovo region (the old municipality of Kumanovo), within which five local government units (Kumanovo, Staro Nagoricane, Lipkovo, Orašac and Klečovce) exist today, occupy an area of 1212 km^2, which represents 4.71% of the territory of the Republic of Macedonia. There are 110 settlements in the mentioned area, mainly inhabited by an ethnically heterogeneous population.

The geological structure of Kumanovois is diverse, with different ages and mainly belongs to two zones: Vardar and Rhodope. The mountains mainly belong to the Rhodope massif, which is

considered older. This part includes the mountains of Skopje Crna Gora, Ruen and Kozjak. To the west of Kumanovo stretch the branches of Skopska Crna Gora, on which is the highest peak in the area, Ramno with 1651 meters. In the northern part of the area, parts of the Rouen mountain extend, most of which is in Serbia. East of Rouen is the medium-high Kozjak mountain. Kozjak Mountain mainly stretches between the two biggest rivers in this area, Pčinja and Kriva Reka. The Bislim Gorge on the Pcinja river is a place that abounds in natural beauty. Due to the hardness of the rocks, it cuts through, the gorge in certain places has the appearance of a canyon, with many caves along the rocky sides.

Apart from the mentioned two rivers, underground waters, mineral water sources, as well as artificial reservoirs are also found in the Kumanovo region. Apart from the rivers Pčinja and Kriva Reka, the most important rivers in this area are the Kumanovska Reka, which originates from the Lipkovska and Koynarska Reka, then the Slupčanska, Otljanska and Matejačka Reka. Kumanovska reka is set in the upper part of the basin known as r.Lipkovska. Its biggest tributary in the border of the municipality is left tributary r. Konjarka. The rest of the hydrological network consists of small rivers and rivers with no continuously discharge in them.

In the Lipkovo region, two reservoirs have been built on the Lipkovo river: the Lipkovo concrete arch dam, built in year 1958, 37 m high with an area of 0.40 km^2, and the Glazhnja reservoir, also a concrete arch dam, built in year 1971, 80 m high. , 344 meters long, with a lake covering an area of 0.97 km^2. There are several sources of mineral water in the Kumanovo region. The most famous are those near the village of Proevce, then in Lipkovo, near the village. Strnovac, in Klečovce and others. For now, the healing waters from these sources are only used in the village of Proevce, with the Kumanovska Banja and exploitation of the mineral waters in the village of Proevce and the village of Klechovce. The water temperature of the Proevski springs is 28 ^oC.

Topographic and hydrographical characteristics of the area of Kumanovo are presented in Figure 1.

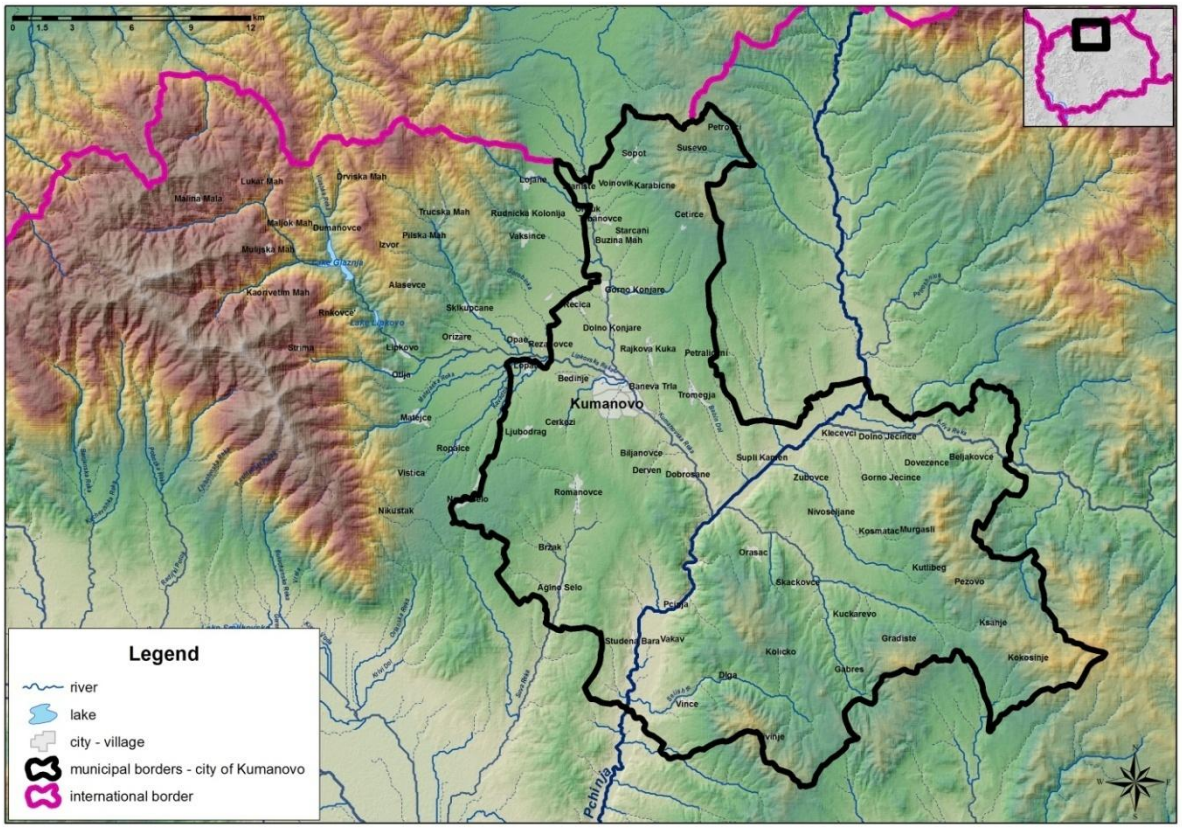


Figure 1 Topographic and hydrographic characteristics of the area of Kumanovo

Climate

Several factors have an influence on the climatic features, that is, the different values of the meteorological elements in Kumanovo. According to the geographical latitude and the proximity of the larger water bodies, it is considered that warm influences are felt in North Macedonia. But Kumanovo is located in the northern part of North Macedonia, so those influences are felt less. The relative openness of the relief comes to the fore, which allows the penetration of various atmospheric influences, especially along the Moravian-Vardar valley with a meridian stretching direction.

According to the mentioned features, it can be concluded that in Kumanovo, the influence of hot and cold air masses is felt, which conditions to distinguish two seasons in terms of climate, namely: cold and wet winter and hot and dry summer. Of the transitional seasons, autumn is more pronounced, sometimes long, and hot, which is characteristic of a moderate-continental climate. The features of the continental climate are more pronounced on the surrounding mountains.

Air temperature is an important meteorological element. Its average annual value is 11.8^{o}C (for Kumanovo), and on the slopes of the surrounding mountains it is lower, depending on the altitude.

The average annual amount of precipitation in Kumanovo is 549.3 mm/m^2, according to which it belongs to the second driest area in Macedonia. Droughts are mostly characteristic of the summer months and may continue in the fall.

The Kumanovo region is distinguished by distinct windiness, mostly north and less northwest wind. The average frequency of this wind is 331%. The average monthly speed is different, and the annual average is 3.2 m/s.

The average annual sunshine is about 2,200 hours, and it is higher in the surrounding mountainous terrain. Annually in Kumanovo, the average number of (clear) days is 84, while there are an average of 97 cloudy days annually.

We would single out a few of the more characteristic climatic conditions of the Kumanovo region. The lowest temperature recorded in Kumanovo and Kumanovsko was -24 °C, measured on January 27, 1954, and the highest +40 °C on August 22, 1952. The average annual amount of precipitation is 549.3 mm/ m^2. The most common wind that blows in these areas is the north, followed by the northwest. The northern one is most common in January, June, and July, and the northwestern one is most common from May to October. Average annual sunshine in Kumanovo is 2200 hours.

3.2 Demographic and social data

The demographic and social aspects of the Municipality of Kumanovo have a significant impact on the local economy. Based on the data from the Census of Population, Households and Apartments from 2021, the Municipality of Kumanovo has 98,104 inhabitants (compared to 105,484 inhabitants registered at the previous census in 2002). The municipality is experiencing a significant depopulation, where in 20 years the population has decreased by 7,380 inhabitants, i.e. a decrease of 7%. The municipality of Kumanovo includes the city of Kumanovo and the surrounding villages and settlements. Only the city of Kumanovo numbers 75,051 inhabitants (compared to 70,842 in 2002), an increase of 5.9%.

The following tables shows the basic demographic data for the Municipality of Kumanovo.

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

Total			Men			Women		
Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
98,104	75,051	23,053	48,805	37,056	11,749	49,299	37,995	11,304

Table 2 Total residential population in the township (City) of Kumanovo

Population	Households	Flats
75,051	23,451	27,179

Table 3 Number of families in Municipality of Kumanovo, census 2021

	Number of families	Number of persons
Total	28,274	98,104
Urban	21,648	75,051
Rural	6,626	23,053

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

Type of dwelling	No.
Residential building	27,171
Non-residential building	724
Institutional Housing Building	1
Other	1
TOTAL	27,897

According to the data from the 2021 census, with its total number of residents, the Municipality of Kumanovo is the largest municipality in R. N. Macedonia. This means that the development of the economy is in close co-operation with the quality of life of this population. From the data it can be concluded that the share of women in the total population of the municipality is 50.3%, and men are 49.7%. In this regard there are no noticeable deviations that are within the gender structure at the state level.

In terms of the literacy of the population, the value of this educational structure for the development of the economy is remarkable. In this regard, the data that out of the total number of people older than 15 years, the participation of literate people is 95.4% shows an absolute favorable opportunity to boost economic development. Table 5 shows the educational structure of the Municipality of Kumanovo population aged 15 and over. In addition to literacy for the development of the economy is also the structure of the level of education. The economy depends on the educational structure, both through the prism of improved demand and consumption, as well as through the quality workforce, which is better created by more educated staff. The Table 5 gives the educational structure of the population of the Municipality of Kumanovo at the age of 15 and over.

Table 5 Educational structure of the population in the Municipality of Kumanovo older than 15 y

Level of education	Number of people	%
Without education	1,702	2.1%
Incomplete primary education	3,199	4.0%
Elementary education	22,073	27.3%
Secondary Education	38,626	47.7%
High education	11,722	14.5%
Master's degree	966	1.2%
Ph.D	112	0.1%
Unknown	2,553	3.2%
Total	80,953	100.0%

The analysis of the indicators of the number of households shows that it is an average representation of four members. It means that family values are represented. Family values make it possible to develop both family businesses and participation in the economy with its own resource possibilities.

The analysis shows that households have 1.2 apartments on average, and 3.15 people live on average in each apartment, which indicates a good balance between the number of apartments and the number of population.

The data in the Table 5 show that the population with secondary education has the largest participation in the educational structure. In the total number of inhabitants this population participates with 47.7% in 2021 (compared to 38% in 2002). The participation of the population with primary education of 27.3 in 2021 (compared to 35% in 2002) represents a potentially good supply of labor in labor-intensive activities such as tourism and hospitality, construction and industry. The relatively low participation of the population with higher education and scientific staff should cancel the raising of this educational level.

3.3 Economic characteristics of Kumanovo

3.3.1 Entities in the Municipality of Kumanovo by sectors

In the Municipality of Kumanovo at the end of 2021 operated the most of the entities operates in the Trade sector (Wholesale and retail) that is 30%, than in Manufacturing industry 14%, and 10.2% operates in the sector of Professional, scientific and technical activities. 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 Figure 2.

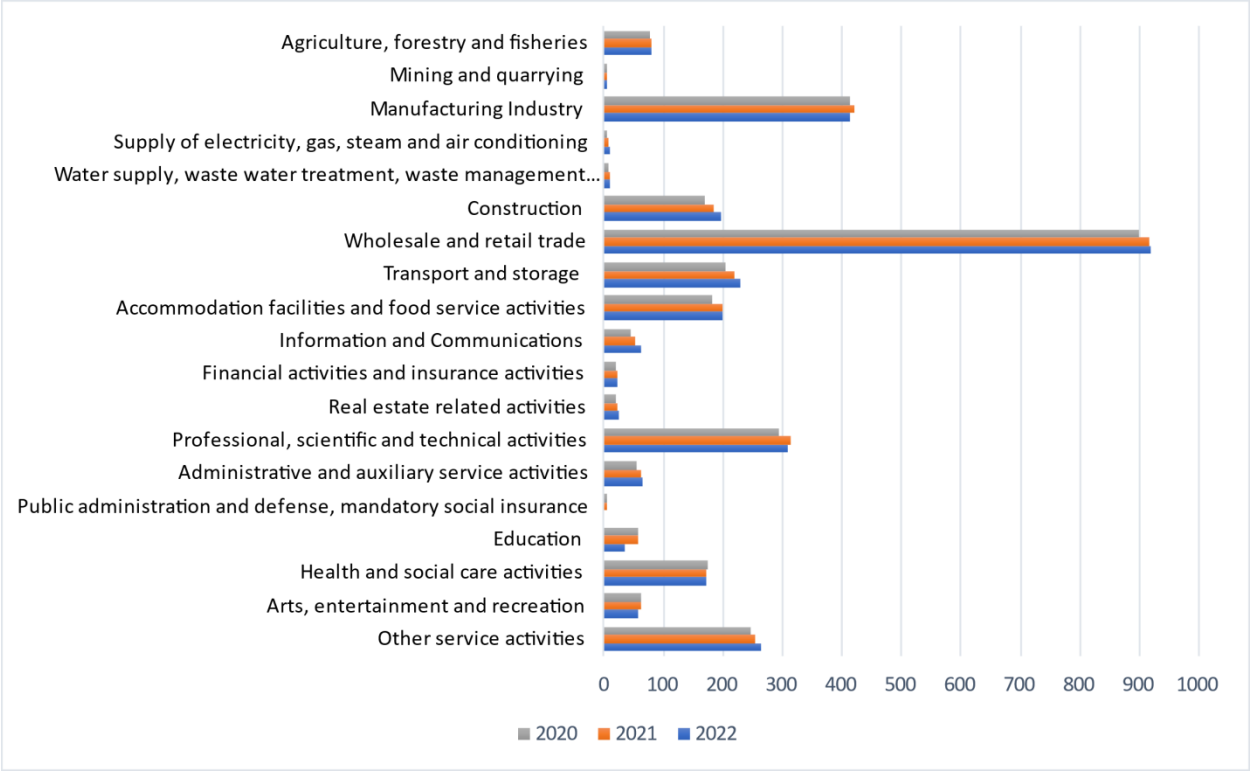


Figure 2 Number of entities in the Municipality of Kumanovo by sectors

3.3.2 Labor market in the Municipality of Kumanovo

The municipality of Kumanovo is the largest municipality in the Republic of N. Macedonia. According to the last census of 2021, Municipality of Kumanovo has 98,104 inhabitants, of which 25,209 are young people aged between 15 and 30 years old. The number of residents who are of working age between 20 and 64 years is 59,104 i.e. 60.2%.

Labor market in Kumanovo is very specific and very different from any other municipality in North Macedonia because there are young people who have gained experience of temporary work in Iraq, Afghanistan and other countries in the East or Africa where they have their skills in logistical support for USA and NATO military troops in these countries, and have had experience in the field of Construction (electricians, carpenters, plumbers and other construction professionals) as well as in service activities (work in the kitchen, cooks, in laundry, etc.). Unofficially, a significant part of them do not enter the labor market, and they remain in the group of idle population. They have invested a good part of their earnings from the foreign missions in the mentioned foreign countries in real estate or in the financial markets and generate alternative incomes for life.

More precisely, the total population with working abilities, that are all people aged over 15 years in 2021 amounts 80,953 (compared to 81,571 in 2002). Of them, 59,194 (60,2% of total population) are in the working age group (20 – 64 years old). But the total active population in 2021 amounts 36,978 (compared to 39,386 in 2002). The difference of 22,216 people that are in a working age still remain idle. That is a large part of the population. Actively employed in 2021 are 28,102 (compared to 21,219 in 2002) and unemployed are 8,876 (compared to 18,167 in 2002).

Another specificity of the labor market in the Municipality of Kumanovo is that more than a third of employed residents do not work in their municipality, but in the surroundings of the Municipality of Kumanovo, mostly in Skopje usually traveling every day. Namely, the Bureau of Statistics, according to the 2021 census, shows that the number of employed residents of Kumanovo Municipality is 28,102. However, according to data from the Central Registry of the Republic of North Macedonia, the number of people who work in Kumanovo Municipality is 17,809. Of course, this figure also includes people who are not residents of Kumanovo, but work here. The difference between this two data is the people who are residents of the Municipality of Kumanovo and who are employed in other cities and in the vicinity of Kumanovo. Most of these residents of Municipality of Kumanovo work in Skopje. In the report for the RVA for the economic sector for the City of Skopje, on the analysis of the labor 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. A significant part of them are residents of Kumanovo Municipality due to the proximity of the two cities.

Table 6 Overview of the structure of the labor market in the Municipality of Kumanovo 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	**80,953**	**36,978**	**28,102**	**8,876**	**41,479**	**2,496**
Men	**39,916**	**20,653**	**15,748**	**4,905**	**18,046**	**1,217**
Women	**41,037**	**16,325**	**12,354**	**3,971**	**23,433**	**1,279**

Furthermore, according to the data from the State Statistics Office, out of the total number of employees 28,102, the largest number of 26,935 is people who are workers, employed by other employers. The structure of the economic status of the employees is presented in more detail in the Figure 3.

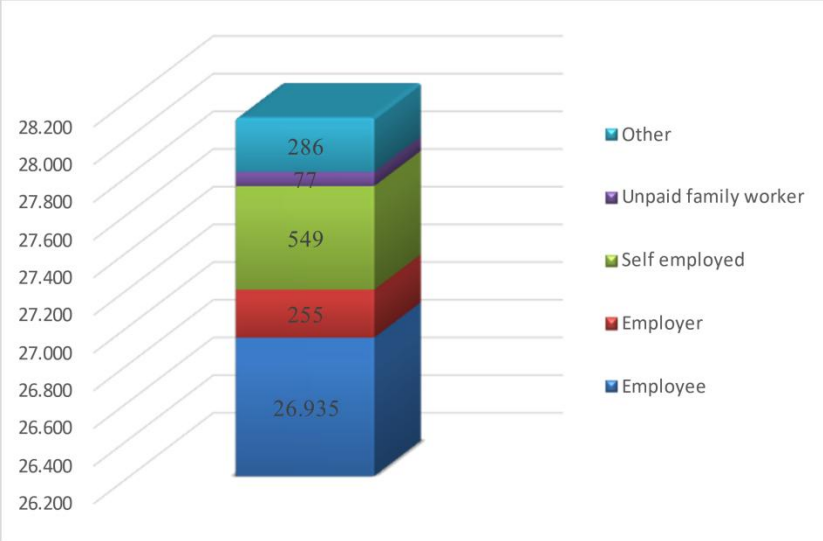


Figure 3 Structure of employees according to economic status in the Municipality of Kumanovo in 2021

Table 7 Employees according to the type of occupations in the Municipality of Kumanovo in 2021

Type of occupations	Number of employees	%
Military occupations	493	1.8%
Members of legislative and executive bodies, state officials, senior civil servants, diplomats and directors	997	3.5%
Experts and scientists	5,534	19.7%
Technicians and related workers	4,395	15.6%
Officials	1,367	4.9%
Workers in service activities and sales	4,932	17.6%
Professional workers in agriculture, forestry, fishing and hunting	110	0.4%
Occupations for non-industrial way of working in production	3,580	12.7%
Operators and assemblers of machinery and plant	2,069	7.4%
Elementary occpations	3,905	13.9%
Unknown occupation	720	2.6%
TOTAL	28,102	100.0%

Table 8 Unemployed persons by level of education

Level of education	Number of unemployed persons
Without an education	189
Incomplete primary education	225
Elementary education	2,329
Secondary Education	4,982
High education	1,058
Master's degree	88
Ph.D	5
Unknown	-
Total	8,876

Number of employees in the Municipality of Kumanovo decreases constantly (Figure 4) in the last three years. Here, the effect of COVID-19 also has an impact. It is evident that number of employees decrease in all sectors, except the transport sector where there is no significant increase.

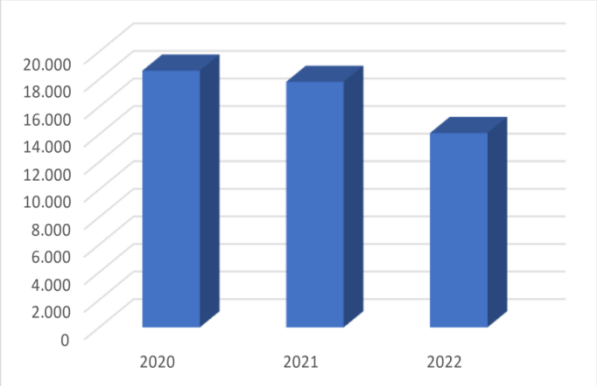


Figure 4 Number of employees in Municipality of Kumanovo

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 Figure 5 gives a clear picture of this aspect. The local economy of the municipality of Kumanovo is dominated by two sectors, with the largest sector being the trade sector, which absorbs 22.5% of the workers in the municipality, and the same number of employees is absorbed by the processing industry sector with 22.3% of the employees, together with the third largest sector in terms of number of employees absorb 55.7% of the total employees.

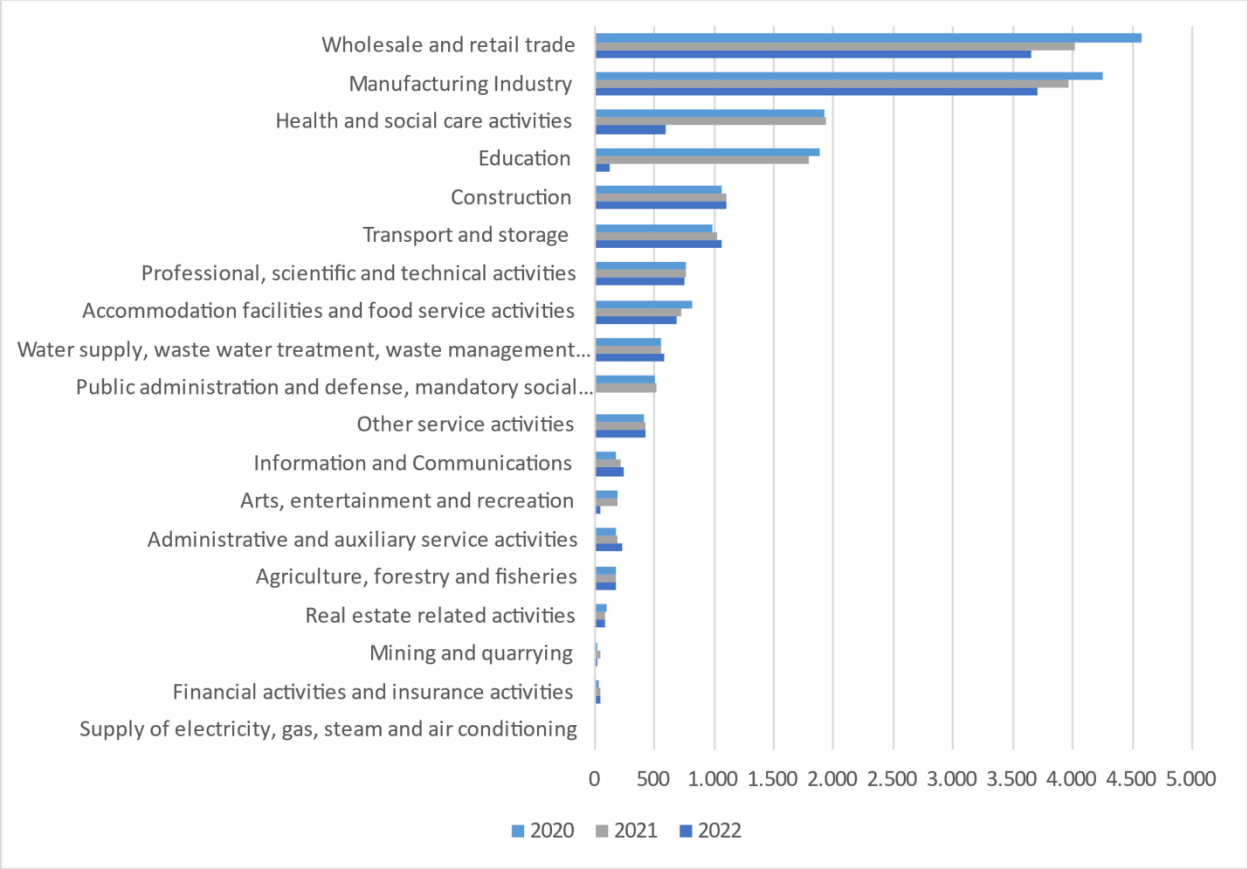


Figure 5 Number of employees by sector in Municipality of Kumanovo

Kumanovo has a developed industry and is the center of industrial production in northeast North Macedonia. The shoe industry in this city has a huge tradition and has survived for decades. More than 60 shoe production companies are operating in the city today, making this city center for the shoe industry in North Macedonia and beyond. Production is intended for North Macedonia, the former Yugoslav states, as well as Bulgaria, Greece, Albania and Italy. A smaller portion is exported to the Czech Republic, Slovakia and Germany.

Also, in Kumanovo is located a big factory FZC 11 October Ltd., operating in the field of welded pipe and profiles industry that employs more than 250 workers and has a large participation in the city's economy. The food industry is mostly represented by the mill and bakery, while Quattro operates from the beverage industry.

Climate-sensitive sectors absorb a small relative share of employees, such as Construction 6.22%, Transport 5.8%, and Agriculture is marginal with 1% of employment.

3.3.3 Revenues, profit and loss generated in the Municipality of Kumanovo by sectors

The number of employees by sector gives one perspective of measuring 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, Kumanovo belongs to the North-Eastern planning region, but there

are also other cities and municipalities within it. Although Kumanovo may dominate, the use of regional GDP and GDP per capita figures will not be a reliable measure.

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 Figure 6 gives a clear picture that the Trade sector is the largest and extremely dominant sector according to this criterion. This sector generates half of the total revenues in the local economy, or more precisely 49.8%. Next according to the size is the Manufacturing Industry sector where 16.7% of the local revenues are generated and Construction with 7.1%. Taken together, the first three sectors generate as much as 73.6% of the total revenues in the local economy.

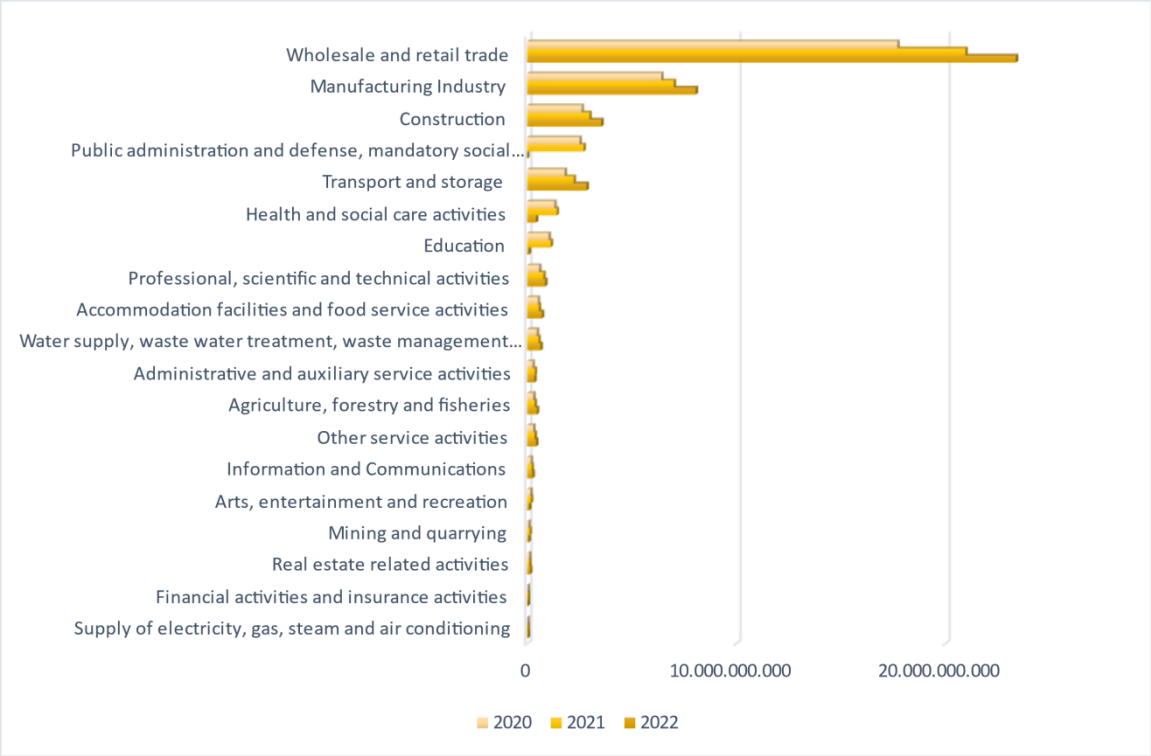


Figure 6 Revenues generated in the Municipality of Kumanovo by sectors

Almost identical conclusions can be reached if the realized profits in individual sectors are analyzed. The Trade sector generates 41.7% of the total profit (Figure 7) at the municipal level, followed by the Processing Industry sector with 15%, and the third is Construction with 11.6%. Synthetically, the three together generate 68.2% of the entire realized profit in the municipality. However, not all entities were profitable. The loss is six times less than the gain. Of the total loss (Figure 8), Industry covers 36.3%, Trade 18.1%, and Transport 7%.

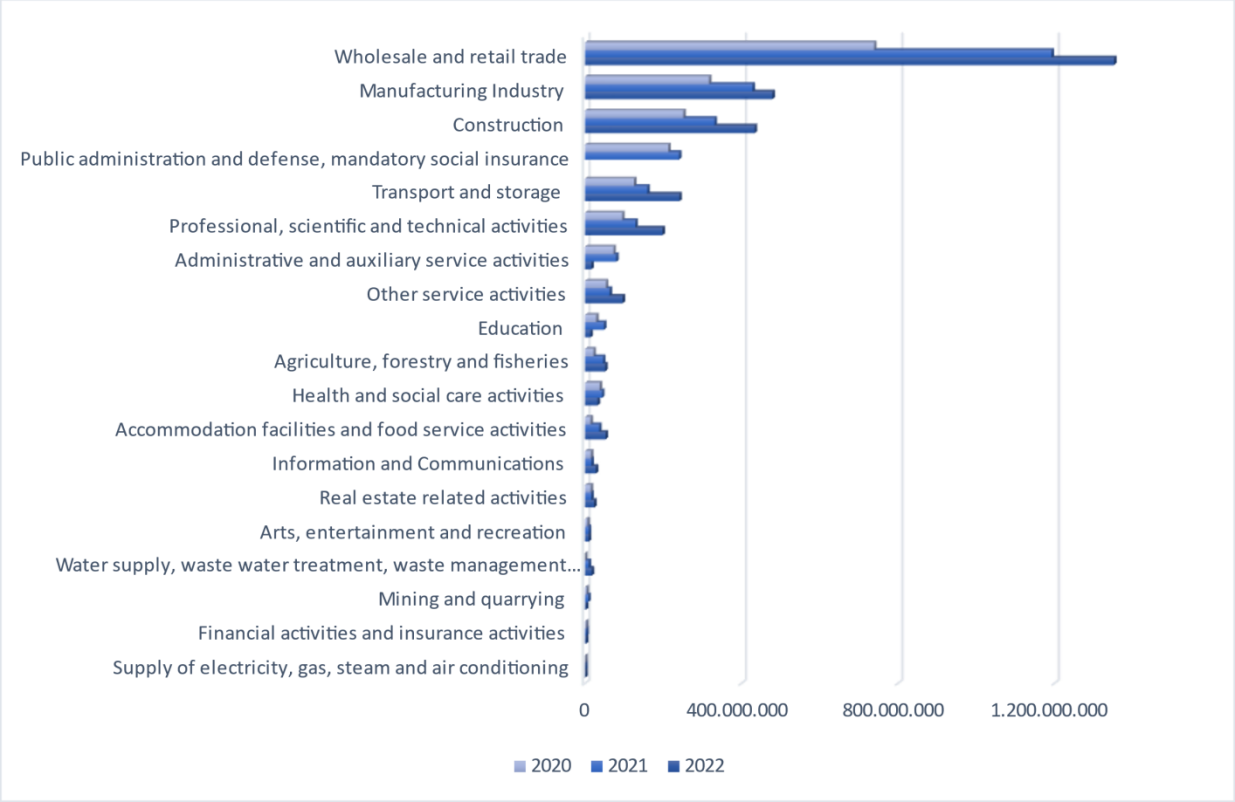


Figure 7 Profit generated in the Municipality of Kumanovo by sectors

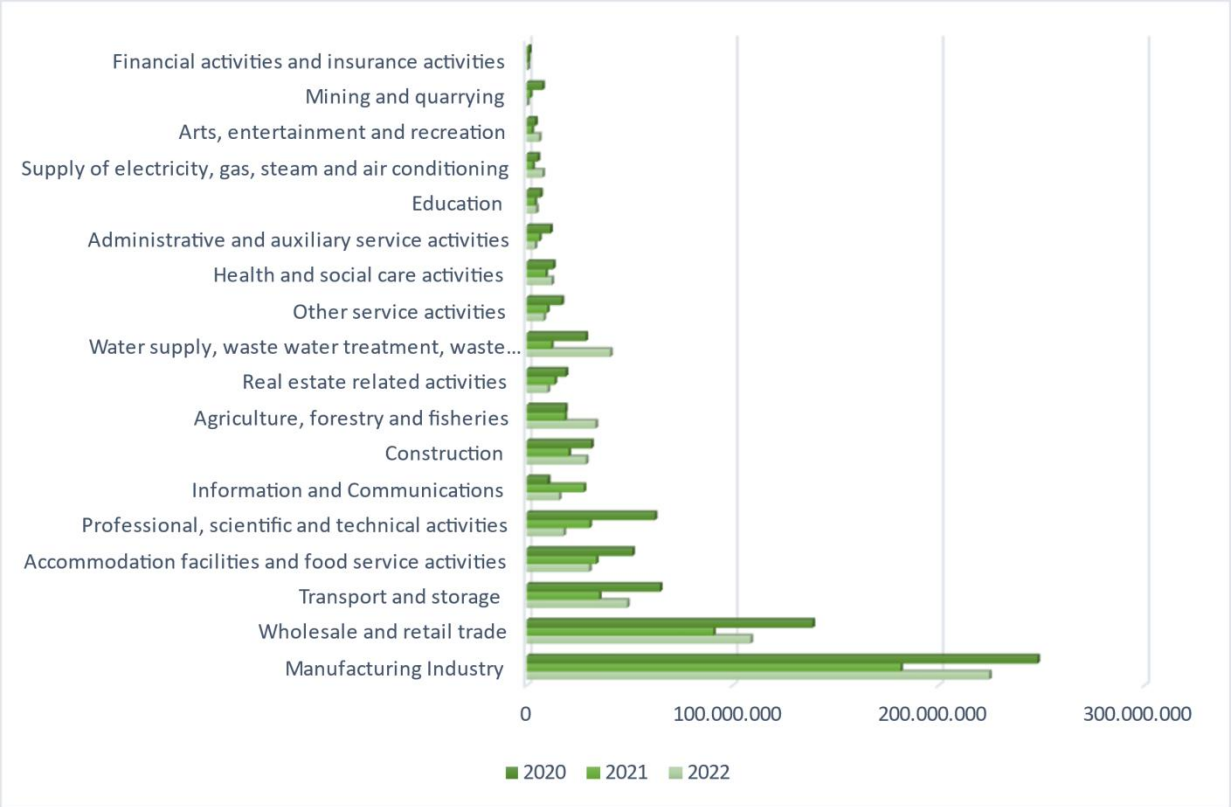


Figure 8 Loss generated in the Municipality of Kumanovo by sectors

3.3.4 Advantages and weaknesses of the local economy

The comparative advantages of the local economy of the Municipality of Kumanovo can be synthesized in the following key points:

- Good transport connection, for potential investors the possibility of transport - land, rail and air (due to the proximity to the airport Aleksandar Veliki);
- Opportunity for transit tourism - part of the territory of the Municipality of Kumanovo is characterized as border, ie. in the immediate vicinity are border crossings with the Republic of Serbia, Kosovo and Bulgaria;
- Own local airport (sports);
- Proximity to the capital and to the airport in Skopje;
- Largest municipality in North Macedonia;
- Highly qualified and trained workforce;
- The municipality of Kumanovo is also the first gasified municipality in R. N. Macedonia;
- Favorable climate and prerequisites for the development of agriculture;
- Excellent institutional infrastructure;

The industrial zone in the area of the village of Gorno Konjare place called "Novine" and place called "Rechica", for which there is an urban plan outside the town of Gorno Konjare intended for an economic complex, in an attractive location at the intersection of two important corridors, the E-75 Skopje-Belgrade and the E-871 that connects Kumanovo with the Republic of Bulgaria, only 7 km away from the city of Kumanovo and only 8 km away from the Tabanovce border crossing. The location is particularly attractive considering the fact that the frequency of passengers crossing the Tabanovce border crossing is very high. Urban documentation provides the opportunity for large investments in light industry, for hotels, large catering and commercial facilities.

Weaknesses of the local economy of the Municipality of Kumanovo can be synthesized in the following key points:

1. Continuous population reduction, especially in the vicinity of Kumanovo
2. Insufficient personnel, technical and information staffing of the LED department
3. Insufficiently qualified workforce according to the needs of the local labor market
4. Inconsistency between the educational system and the current needs of the local labor market
5. Insufficiently developed mechanism for encouraging social responsibility of local companies
6. Absence of a one-stop shop system
7. Outflow of human resources
8. Low standard of living
9. High percentage of unemployment, especially among young people
10. Political changes
11. Absence of a system or plan for subsidizing the growth and development of the SME sector, social enterprises and innovative start-up businesses

4 ASSESSMENT OF THE PAST CLIMATE RISKS AND HAZARDS IN THE KUMANOVO

A trend of air **temperature growth** in the second half of the 20th and beginning of 21 centuries was observed in the Kumanovo region as same as on the whole territory of the country. Besides raising the annual and summer mean temperature.

In the last 60 years in the Kumnano, two major floods were registered and recorded. In 1962 when the water flow was estimated 320 m^3/s, when the lower part of the municipality was flooded with a total of over 3,500ha. The flood of November 1979, where the flow of the river Pčinja was estimated 205 m^3/s. The flood covered an area of over 2,390 ha.

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

4.1.1 FLOODS

Average annual sums of precipitation

Average annual sums of precipitation in the past are low, and referring to annual average discharges, rivers in the region didn't have special vulnerability to climate changes and don't indicate large hazards or risks. But, it should be emphasized that investigated data are average annual data for the period 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.Lipkovska, r.Slupcanska, r.Konjarka, r.Kumanovska) causing inundation and flooded areas.

According to the graphic of the precipitations (Figure 9 the precipitations have an increasing trend. Based on this trend continuous is expected to have more precipitation in the next period (years), which may affect more water in rivers, sources, wells and groundwater's.

The average precipitation for the period from 1961 till 2015 is 517,1 mm. The driest year according to the precipitation is the year 2000 with participation of 257,4mm and the years 1990 (P=337,4 mm) and 1977(P=319,9 mm). The wittiest year with precipitation is 2014 (P=875,3mm), 1976 (P=798,4 mm) and 1995 (P=761,5 mm).

Opposite of the precipitations, the general trend for the average annual temperatures is rapidly increasing. If this trend continues is excepting to have higher temperatures in the next period (years).

The averaged temperature for the period is 12,7°C, the smallest temperature appeared in 1995 and 2005 (11,6°C) and the highest temperature is in 2019 (14,1°C). So the temperatures for the period 1991-2020 varies for 2,5°C in the amplitude from 11,6 °C to 14,1°C .

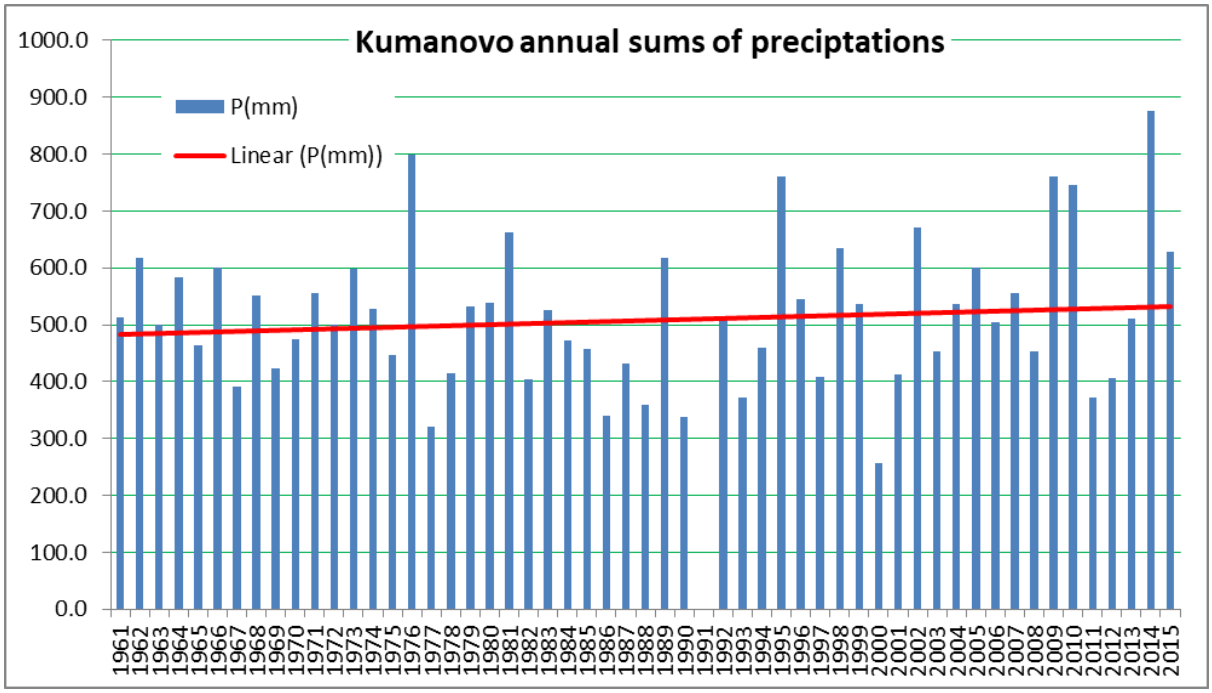


Figure 9 Kumanovo annual sums of precipitations

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 torrents with high slopes in the region that are potential danger of appearing of the flash floods. The region was very vulnerable to flash floods in the past due to the very frequent occurring this heavy precipitation.

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

Annual average daily temperatures

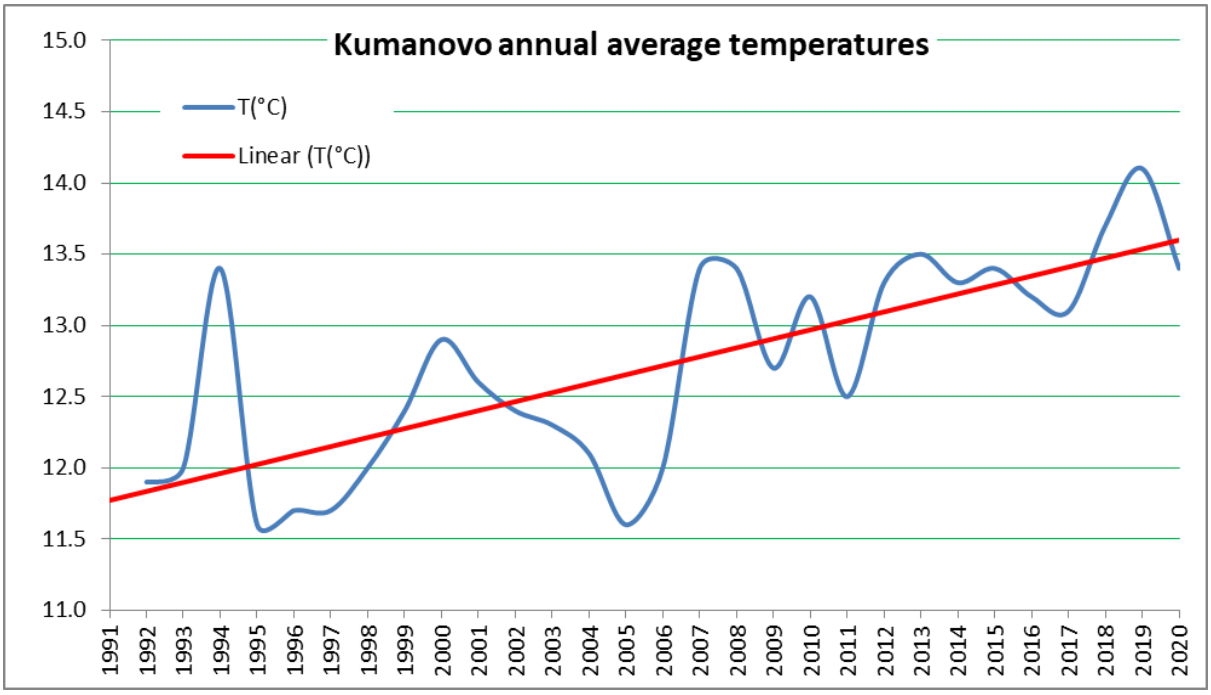


Figure 10 Kumanovo annual average temperatures

In the past in the municipality of Kumanovo are registrired floods in januar 2003 on r.Lipkovska and r. Konjarka, in May 2010 on r. Pcinja, in fevruar 2013 on r.Konjarka,in januar 2014 on r.Lipkovska, r. Kumanovska, r.Konjarka and r. Kriva, in november2014 on r.Lipkovska, r.Kumanovska and r,Konjarkain januar 2015 on r. Lipkovska, r.Kumanovska, r.Pcinja and r.Konjarka in mart 2015 on r.Lipkovska and r.Kumanovska and urban floods in June 2019. The most prone areas of floods are areas around Bashkimi stadium, some parts before and after the village Bedinje, and in the area of vllage of Lopate. Because of the configuration of the terrain and flat slopes of the river during the flood events there are large inundated areas, especially in the catchment of r. Lipkovska
The most flooded area in the region of Kumanovo are presented in Figure 11.

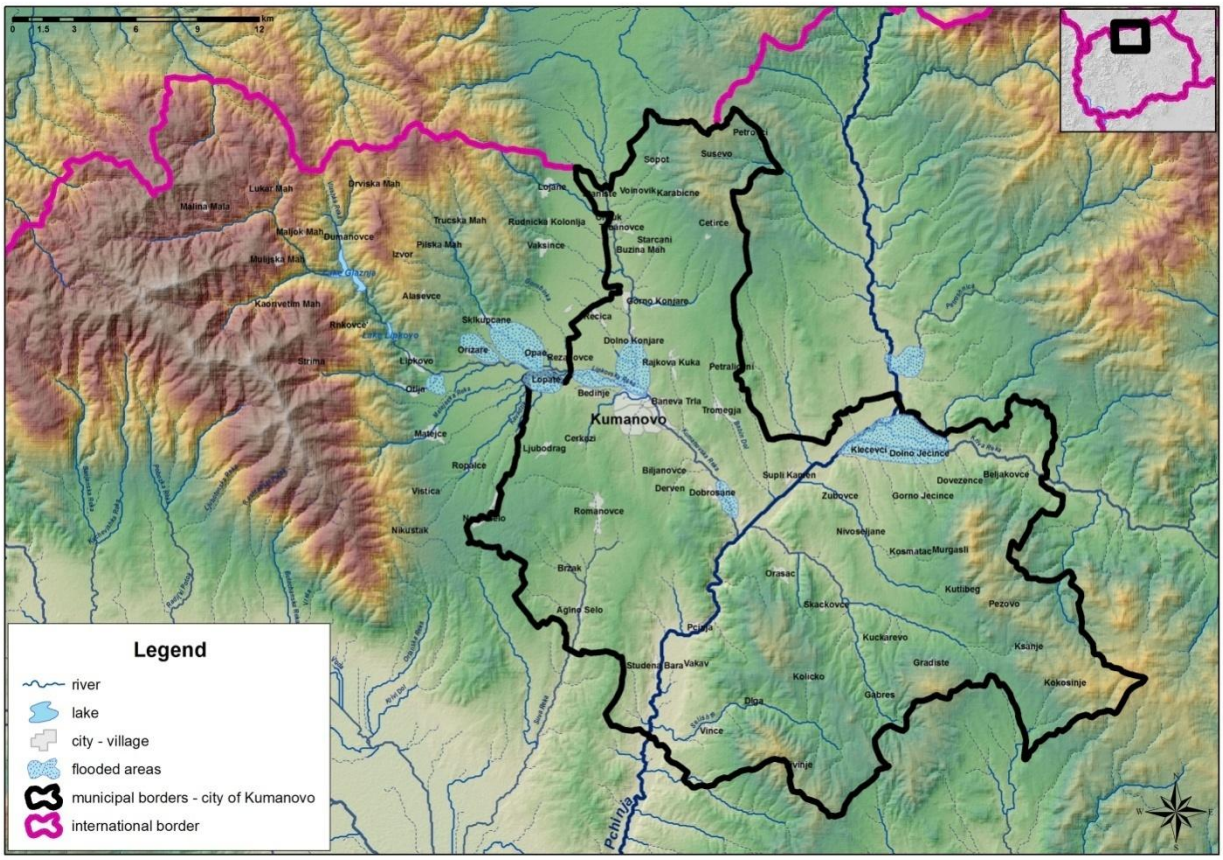


Figure 11 Most flooded area in the region of Kumanovo

Because of the absence of high mountains and rivers with steep beds there are not many dangerous torrential in the area of the municipality. However on the map below are presented some of the torrentials that are potention danger for floods in case of intensive precipitation in their catchments (Figure 12).

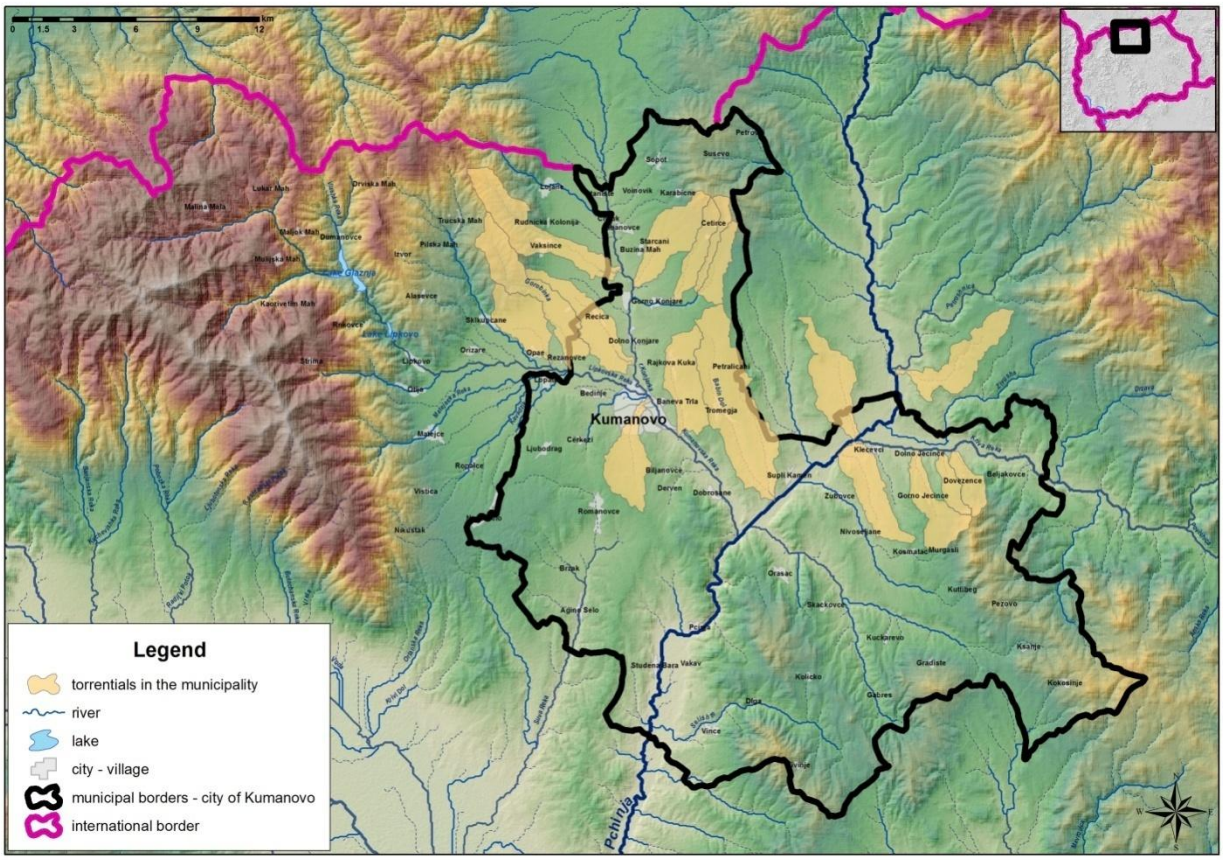


Figure 12 Torrential in the municipality of Kumanovo

The critical points of urban floods in the city usually are subways or overpasses or any road in the city with configuration to capture (detain) water during the intensive rains. In the Figure 13 are presented the most critical points in the city prone to urban floods.

Figure 13 Most critical points in the city pron

Below in the Table 9 are given the extreme weather events (floods), the date of occurrence and caused damage.

Table 9 Extreme weather events (floods) in Kumanovo

Event	Date	Damage
Flood	**DECEMBER 1935**	**a part of the city and the villages along the river Pčinja and Kriva Reka from Beljakovce to Klečovce and from Shupli Kamen to the village of Studena Bara were flooded**
Flood	**DECEMBER 1937**	**only smaller parts around the riverbeds of the rivers in the municipality of Staro Nagoricane, Lipkovo and Kumanovo were flooded.**
Flood	**NOVEMBER 1962**	**only the lower part of the municipality was flooded, with a total area of over 3,500 ha**
Flood	**NOVEMBER 1979**	**The flood covered an area of over 2,390 ha**
Flood	**NOVEMBER 2014**	**spilling of the Lipkovka, Kriva Reka, Koynarka and Kumanovka rivers along the entire course to the confluence with the Pčinja river, both in urban and suburban and rural areas, where material damage was caused to residential,**

		basement, auxiliary facilities of legal entities and individuals and also on agricultural land, agricultural crops, livestock and other livestock.
Flood	**JANUARY 2015**	**The river Kriva reka, after heavy rains in the mountainous parts of Kriva Palanka and Kratovo, poured into the atar of the villages of Beljakovce, Dovezence, Jachince and Klečovce. The spill caused damage to around 250 ha of arable agricultural land and several buildings**

4.1.2 Frost days

There are not identified special vulnerabilities of frost days in the region, so the possibility to happen winter minimum on some of the rivers (mostly the smaller ones) in case of prolonged dry summer and autumn periods and occurring of frost days in November and December in the region was very low. River Kumanovska because of the artificial influence dictated from the upper artificial dams and accumulations has less probability of appearance the winter minimum.

4.1.3 Droughts

Kumanovo region in the past was rather vulnerable on climate changes and drought periods according to occurred drought days especially in some parts of the region. The biggest part of the city is seriously influenced by droughts that can cause deficiency for water for drinking, irrigation, technological water and water for power plants. This affected also the artificial accumulations with decreased runoff inflow in them, and decreasing the discharges in the rivers, groundwater levels and capacities of the springs in the region. This was especially expressed in the summer periods.

On the map (

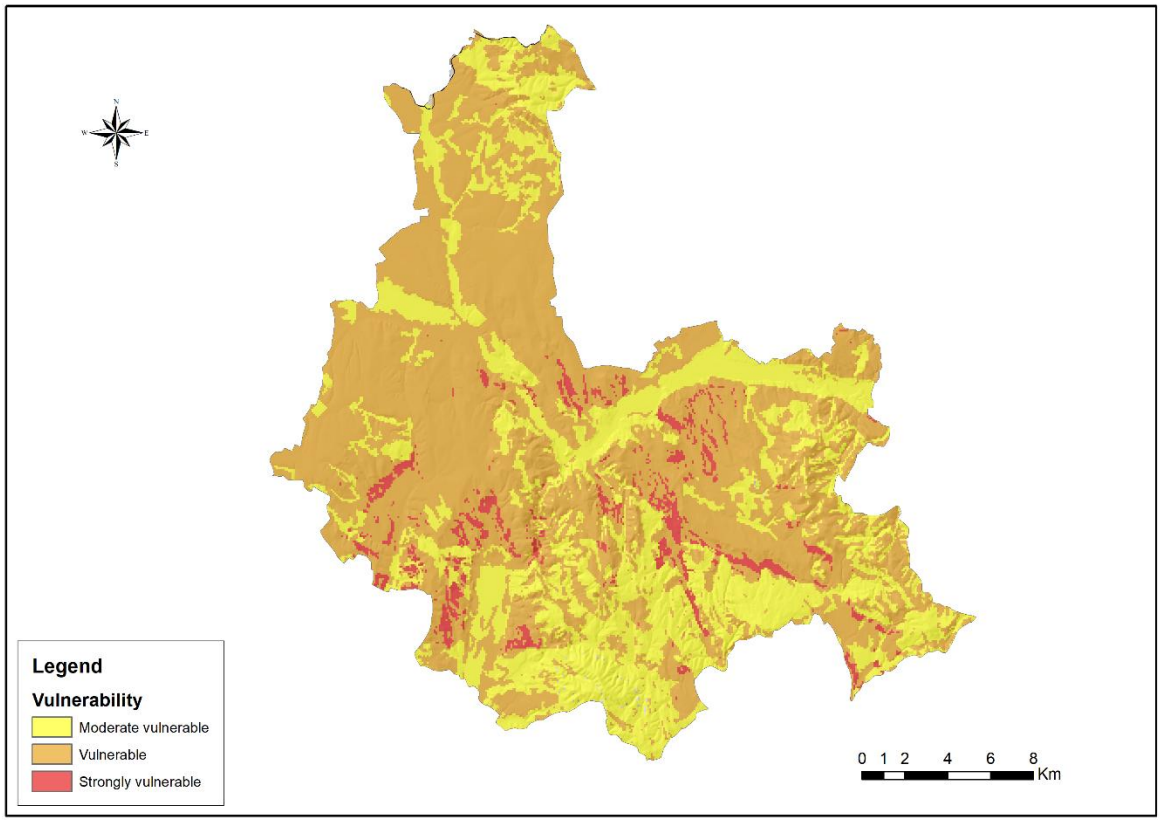


Figure 14) it can be seen that the Kumanovo municipality is affected by drought in some way. The most dominant classes are Vulnerable and strongly vulnerable to drought. Also in the lower parts there are regions which are strongly vulnerable to drought. The climatic data used for this analysis are for the period from 1981 to 2010. The vulnerability map of the country was developed for the project: Achieving Biodiversity Conservation through Creation and Effective Management of Protected Areas and Mainstreaming Biodiversity into Land Use Planning" Activity 3.1.1.1 Preparation of national erosion and drought sensitivity map, and identification of high risk zones and their impact to biodiversity.

The drought vulnerability is the best indicator for assessing the vulnerability to forest fires. So it can be surmised that the whole municipality is vulnerable to forest fires in smaller or larger extent.

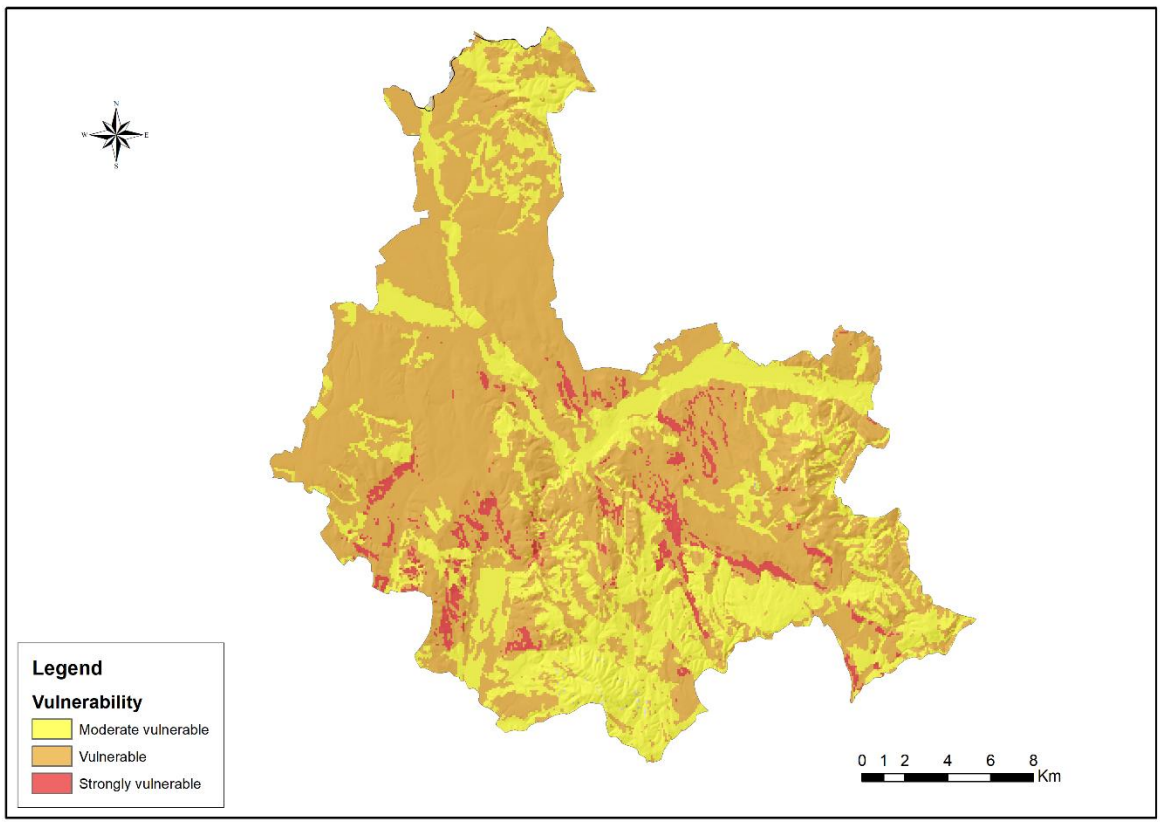


Figure 14 Drought vulnerability of Kumanovo municipality

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

5.1 Water sector

Kumanovo region before the regulation of the river bed in the city had serious problems with river flooding from river Lipkovska, river Slupcanska, river Konjarka, and also the downstream part of the river Kumanovska, around village Dobrosane and inflow to river Pcinja. After the partial regulation of the river Kumanovska, these possibilities are decreased and the city is safer from river flooding. Also, in the upper part of the river basin of r. Lipkovska presents artificial accumulations Glaznja and Lipkovo that can attenuate the propagation of flood waves from the upper part of the catchment and mitigate the flood effects in the city of Kumanovo.

The identification of future climate threats was done based on the assessment of the past climate hazards and events and based 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 Kumanovo Region and the Report on climate change projections and changes in the extremes events in RN Macedonia. In addition to the desk work, it was performed detailed and extensive consultations with the authorities and other relevant actors to make a good and informed prediction of the future climate threats for Kumanovo.

Risk for the separate climate extremes are obtained by taking into account their vulnerability, exposure, and hazard. The risk derived by multiplying the vulnerability, exposure, and hazard for each of the climate extremes that is expressed below:

Risk = Vulnerability x Exposure x Hazard

That is done for each of the relevant climate extremes and different periods - for past, short future, and medium future. It can be seen that some identified risks in the past are no longer risks for the short and medium future and opposite, some smaller risks in the past are big dangers for the future, which is a result of climate changes happening over the years.

Identically (In the same way) that was done with the water categories and subcategories. The risk was obtained separately for each of the water categories and subcategories taking into account their vulnerability, exposure, and hazard. This analysis is presented in Table 10 and Table 11.

Table 10 Assessment of climate extremes in water sector

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

Table 11 Assessment of water category

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	high	high
Urban Floods	medium	high	high	low	medium	medium	medium	high	high	medium	high	high
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	medium	medium	medium	low	low	low	medium	medium	medium	medium	medium	medium
Water for irigation	medium	medium	medium	low	low	low	medium	medium	nedium	medium	medium	medium
Water for electricity	medium	medium	medium	low	medium	medium	low	medium	medium	medium	medium	medium
Polution of water	low	medium	medium	low	medium	medium	low	medium	medium	low	medium	medium

5.2 Health sector

The list of sensitivity indicators of importance for the vulnerability and health risks assessment in the Kumanovo region shows the following: in the demography of the area of Kumanovo the density of inhabitants per km^2 is 119 which is lower than the national average, the aging index (80-90) and percentage of the population over 65 (12.8%) are also lower. Though still negative the natural growth is higher than in the country and the mortality rate is on the level of the national average.[1] Drinking water quality is at a satisfactory level except in rural areas and public taps and individual water supply facilities where there is no proper maintenance and regular disinfection.[2] Air quality is not regularly followed. The current health profile of the Kumanovo population is similar to the national one. The main cause of death among the older population is circulatory and malignant diseases, and the main morbidity causes are circulatory and respiratory diseases[3]. The medical staff is insufficient though the number of inhabitants per doctor (316) is similar to the national one (343)[4]. All these sensitive indicators make the population in the Kumanovo region moderately vulnerable to some of the predicted climate extremes.
No vector transmissive disease had been registered so far and among other infectious diseases, a higher trend is among enterocolitis, similar to the whole country and could be an indicator for drinking water quality and food safety problems, especially in the rural areas.

Although sufficient quality health data 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 Kumanovo 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) floods (on the short) , droughts (on the medium and long term) and forest fires (this the forest areas is not huge in the municipality) on the medium to long term period)will be the priority climate change risks for the population in Kumanovo (with high and moderate probability to happen).

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. (Annex 2). 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, analyze the data and advise the adaptation measures and monitoring.
Among the various population groups the most vulnerable on the Climate change impacts are:

[1] State Statistical office 2021
[2] Drinking water quality in Kumanovo region, Center for public Health Kumanovo, 2022
[3] Report on population health in North Macedonia, Institute of public health (IPH) 2021
[4] Health Map of the regions in North Macedonia, IPH 2020

- 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 12)

Table 12 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, Heat islands in the central urban areas , Tropical nights, 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)**

List of abbreviations

- CPH – Center of Public Health
- EMS- Emergency medical services
- SSO- State Statistical Office
- IPH – Institute of Public Health
- SCC – Social Care Centers
- LSG – Local self-Government
- MoH – Ministry of Health

5.2.1 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. (Annex 2).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 source of the indicators is various local and national agencies or in some cases directs research and estimations. The local self-government should establish a working group (committee) that will process, analyze the data and advise the adaptation measures and monitoring.

Among the various **population groups 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

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 Kumanovo, 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 were then summarized 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).

Average annual air temperatures and precipitation sums

Annual average air temperatures and the sum of annual precipitation are of particular importance for agricultural production, since these two parameters give an initial estimation in the process of designing of the cropping pattern in certain areas and selection of agricultural crops and varieties. Moreover, several very important climate extremes and indices are directly dependent on the air temperatures and precipitation such as evapotranspiration, dater deficit, humidity aridity index etc.

The dynamics of the average annual air temperatures was estimated on the basis of the available spatial data for the monthly averages for the periods: 1980-2020 (WCRP CORDEX). Out of the data presented in Graph 1 most of the territory of Kumanovo is with average annual air temperatures in the ranges from 12.2-13.5 C^{o}, only the northern parts and some areas on the south-west of the municipality are with lower annual air temperatures (11.2-12.2 C^{o}). Most of the agricultural land is in the zone with a lower air temperature

The yearly sums of precipitation are rather lower than in the adjacent areas and vary in the ranges of 310-360 mm on the-west and southern parts, up to 365-428 mm, which is still a rather low sum of precipitation. The most part of the agricultural land is in areas identified as more humid. However, it should be emphasized that these sums refer to the vegetation period and are somewhat lower than the yearly sums. In general, on the base of these two key meteorological parameters it can be concluded that the climatic conditions are not in favor to agricultural production,

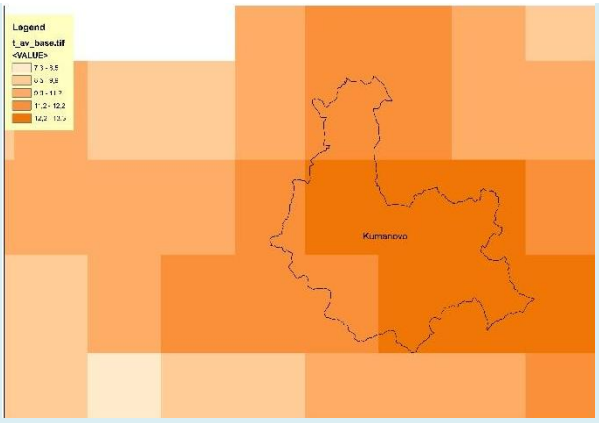


Figure 15 Average annual air temperatures (1990-2020)

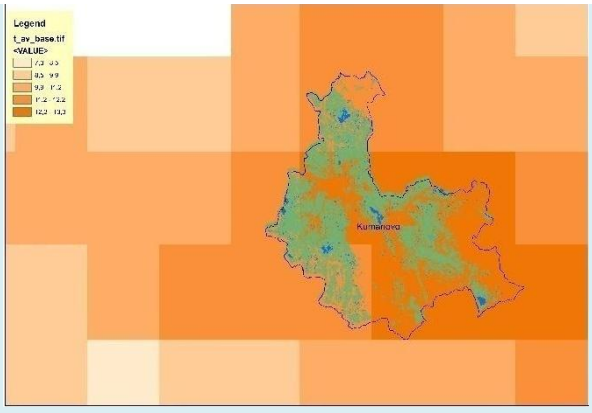


Figure 16 Agricultural areas vs. temeprature (1990-2020)

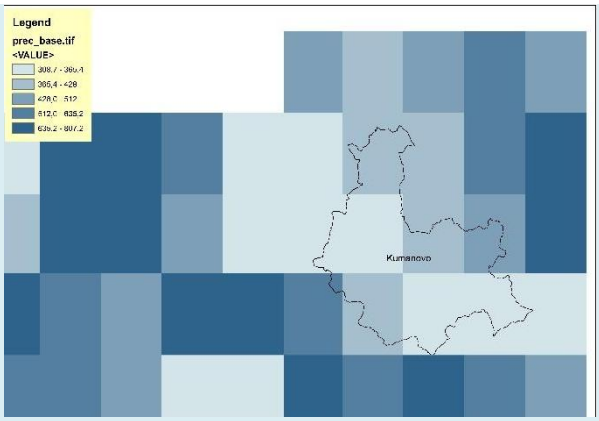


Figure 17 Average annual sums of rpecipitations (1990-2020)

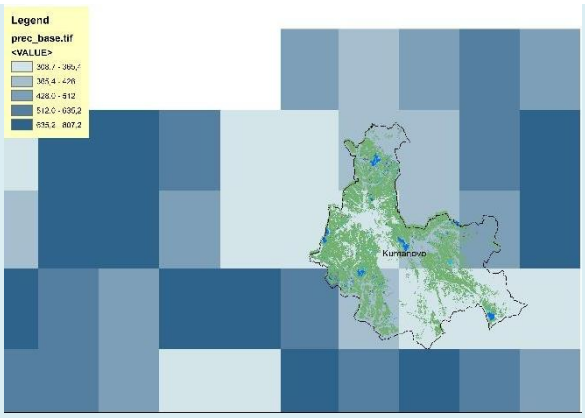


Figure 18 Agricultural areas vs. precipitation (1990-2020)

Frost days and last spring frosts

The number of frosty days and its appearance during the winter period and spring defines the length of vegetation season since as a start of vegetation for autumn crops is consider the period with three consecutive days above 5 C^{o} . However, another weather extreme "late frosts" at 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 damage and compromising the whole season.

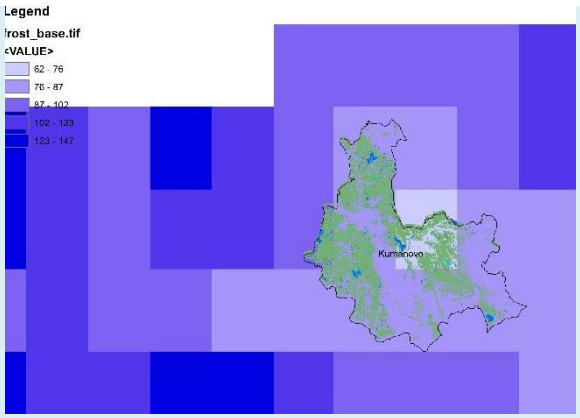


Figure 19 Frost days

Year	Month	Day	Region	T, C^{o}
1994	4	23	Kumanovo	-2.51
2007	4	15	Kumanovo	-2.65
2018	3	30	Kumanovo	-4.51

Table 13 Date of extreme events of last frosts

On Figure 19 are presented the spatial distribution of the sums of frost days in the municipality of Kumanovo for the period of 30 years (1990-2020). The overall number of frosty days is rather low and for the most part of the municipality is from 76-87 days. And only a small part of the central part of the municipality has a lower number of frosty days varying from 62-76 days.

As mentioned before, of particular importance for agricultural plants, especially for fruits, is the date of the last frosts in spring, when they are in the very sensitive phase of flowering and bud formation. In Table 13 are presented the several examples of late frost in the analyzed period which taking into consideration the period of their appearance and the temperatures, it can be expected that these events caused certain damages to agricultural crops. The latest appearances of temperatures below -2 C^{o} were detected on 24th April 1994 when the air temperature was -2.51. In 2007 the latest spring

frost was on 15th2007 with temperature below -2,6C, while in 2018 temperatures of -4.51 C° were detected on 30 of April.

Heat waves

Heat waves usually appear in the hottest months of the year usually coupled with drought events, which have a harmful effect for the agricultural crops, putting them under stress conditions with reduction of photosynthetic activities, water deficiency even on the irrigated crops, sun burns on vegetables and fruits etc. Heat waves are usually joined with hot winds which additionally increases the evapotranspiration which is the key mechanism for cooling down the overheated plants. Having in mind all these facts it can be concluded that most of the agricultural plants are highly sensitive to heat waves.

For the purpose of evaluation of the exposure of agricultural crops to hot waves, two parameters were analyzed: the average duration of the longest hot waves events and the average number of events per year. From the data presented in Figure 20and Figure 21it can be concluded that the area of the municipality of Kumanovo is seriously affected by heat waves. The most part of the territory falls in the category with the longest duration of heat waves ranging from 13-15 days. Certain small parts of the municipality on north and west are somewhat less affected, but still the estimated duration is 11-13 days.

Out of the data presented for the analyzed period 1990-2020 it can be concluded that the average number of heat events increases toward the east (Figure 21). The highest number of heat waves are determined in the central and the south-eastern part of the municipality, with average number of events of 2.15-2.57 and 2,57-3,12, respectively. Of utmost importance is that in these areas the most part of agricultural areas are located, making them significantly exposed to the negative effects of this climate extreme.

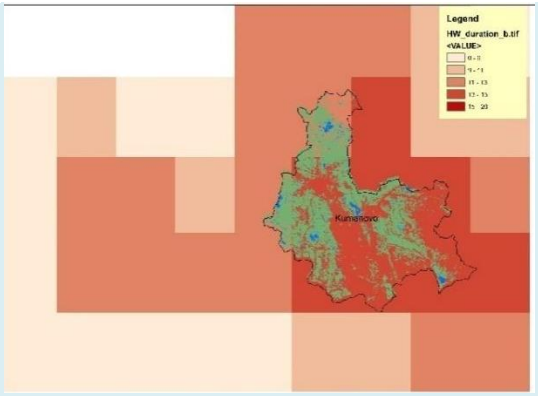


Figure 20 Average duration of longest HW events

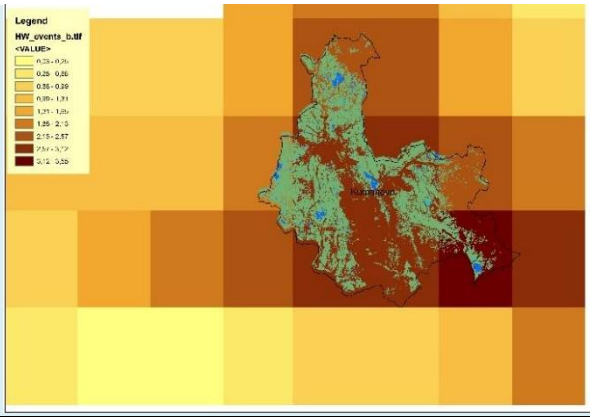


Figure 21 Average number of HW events/year

Drought events

The disturbed rainfall regime with more frequent drought events and prolonging of its duration, together with net reduction of yearly sums of precipitations are the main outcomes of the negative impact of climate change on rainfall regime. 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. Drought events during the vegetation seasons represent a serious risk for agricultural crops, especially in particular phases of plant development.

With regards to the length and appearance of the drought events, it can be concluded that most of the drought events appear during the months of the vegetation season. The average duration of drought events is especially important because extended periods with no rain can have a serious negative effect even on irrigated crops. Out of the data presented on Figure 22 it can be concluded that with regards to the duration of dry periods the municipality of Kumanovo is seriously affected. In the north, east and south-east the duration of dry events is at its peak of 16.3-17.9 days on average for the analyzed period, while the western parts and west-north with big agricultural land is less affected with average duration of 14.5-15.5 C^{o}. However, 2 weeks periods with no precipitation, during the vegetative period are a serious risk for the agricultural plants. In general, the whole municipality is under serious threat of dryness, with higher exposure towards the east. Similar pattern can be noticed with the number of events (Figure 23). The number of dry events has its highest values in the central and southeast part of the municipality with an average number of 9.7-10.1 events. Some parts on north and south of the municipality are less affected, but still the number of events is still high (8.5-9.7 events) mining that overall, the territory of the municipality is seriously affects with drought events,

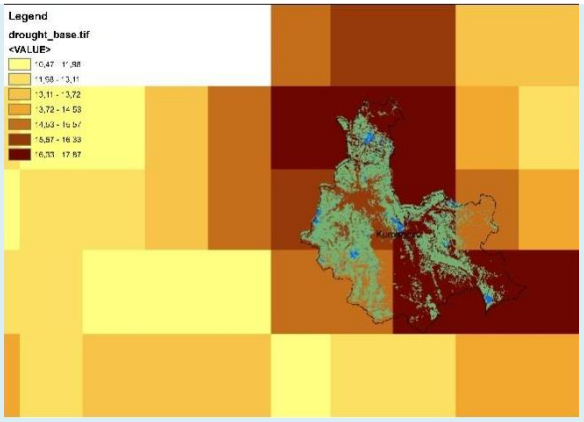


Figure 22 Maximum duration of dry periods

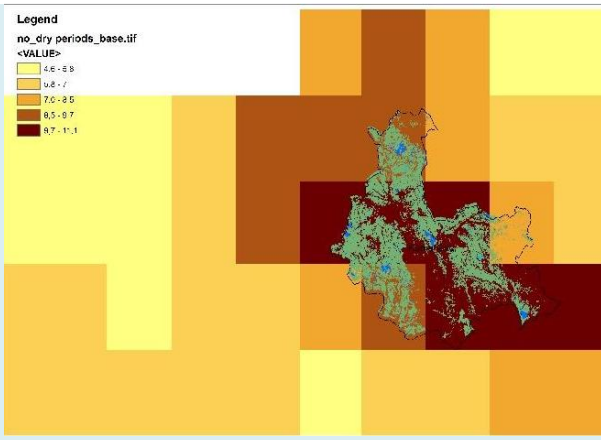


Figure 23 Average yearly number of dry periods

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. Such stormy events which usually happen during the summer period over a small area, usually generate torrential flows and serious damages to the agricultural crops and the overall infrastructure (houses, roads, channels etc.) in affected areas. Huge amounts of excessive surface water which cannot be infiltrated into the topsoil, causes serious run-offs downstream on a sloped terrain. The average number of events with rainfalls bigger than 40 mm. that appear every year, for the period 1990-2020 are presented on Figure 24.

Most of the area of the municipality of Kumanovo as well as the majority of agricultural land is located in areas with average of 1.6-1.8 stormy events with precipitation over 40 mm. This is a

rather high exposure to this weather extreme. However a small part of the south of the municipality is less affected with an average number of 0-1.3 events/year, which is significantly less exposure in comparison to the other parts of the municipality.

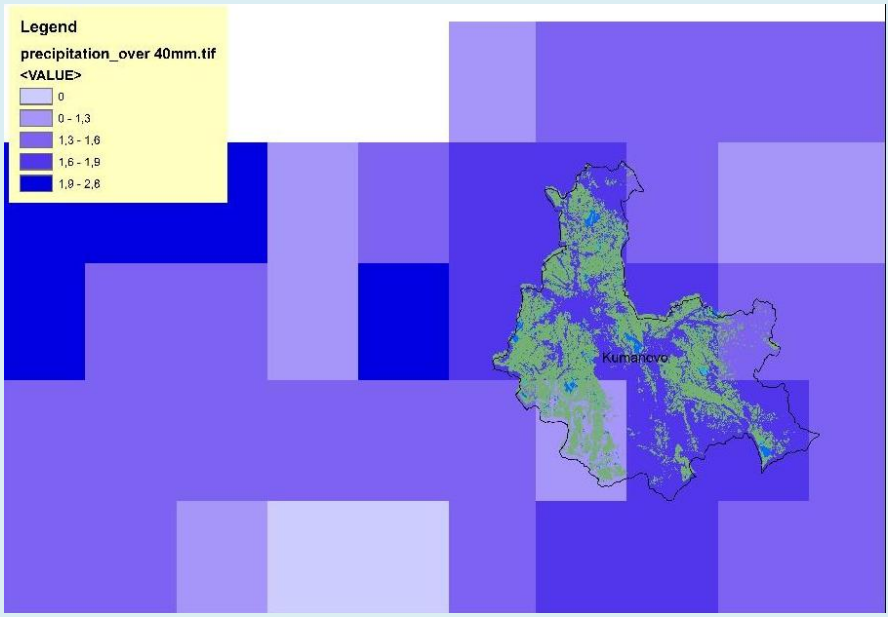


Figure 24 Events with precipitation >40 mm/year

Length of vegetation season

When selecting the suitable crops for a certain area and designing the cropping pattern the length of the vegetation season is a very important parameter that should be taken into consideration. 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. Length of vegetation season is closely related to the air temperatures, mining that with projected rising of air temperatures due to global warming, once would expect prolonging of the vegetation season, or shifting of its start/end dates. Such shifting of vegetation season most likely influences the phases of plant development (phenophases). For these reasons, phenological observations of the plants are very important for timely application of certain agro-technical operations (irrigation, plant protection, fertilization, cultivation, etc.). 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 damage to the orchard plantations. Such risks are even higher with the 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 for the Municipality of Kumanovo area, is presented in Figure 25. The results show that the length of the vegetation season in the Municipality of Kumanovo is very diverse. The most part of Municipality has a length of vegetation season which vary in the ranges from 272.8-283.7 days, and only a small part on west has a bit shorter season with 257.8-272.8 days . In general, the urban areas of the territory have longer seasons, compared to the adjacent rural areas.

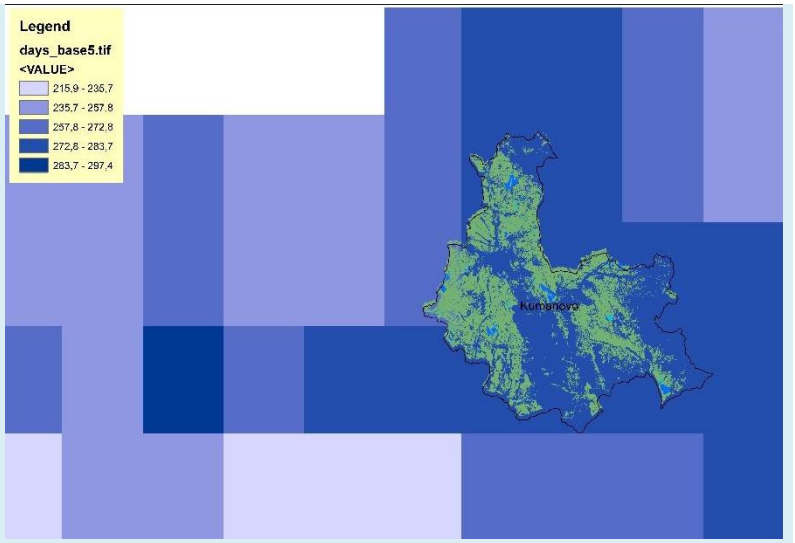


Figure 25 Length of vegetation season, (>5 C^0)

Yearly sums of effective temperatures (>5 C^0)

Yearly sums of temperatures are 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.

Agricultural plants have certain thresholds for the optimum sum of temperatures during the vegetative season. The temperature sums for the Municipality of Kumanovo, are significantly variable as presented in Figure 26. There is a high uniformity of this index over the whole territory of the municipality. The yearly sums for the almost whole area of the municipality including the agricultural land are high, varying in the ranges of 4090-4430 C^0. Only a small part of the agricultural land is less exposed to this index with still high yearly sums of 3700-4090 C^0. The general conclusion is that the agricultural land is significantly exposed to a high temperature sum. This should be taken into consideration when selecting the plants and plant varieties for agricultural production.

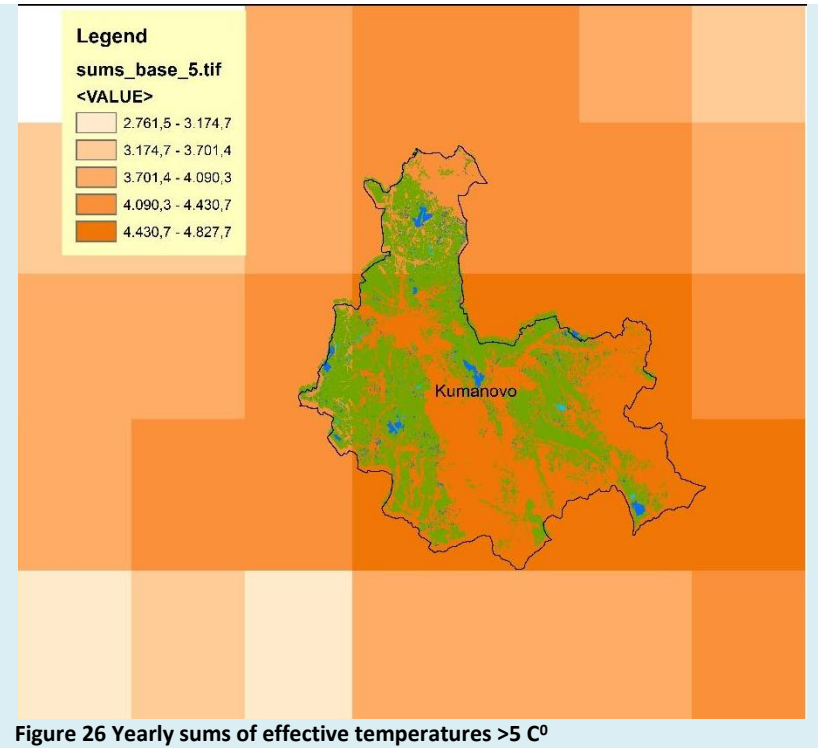


Figure 26 Yearly sums of effective temperatures >5 C⁰

Thermal Humidity Index for livestock

Livestock production in Kumanovo accounts for all main species. Only a relatively small part of the municipality is urban, but even in peri-urban areas, there is organized livestock production. In Kumanovo, there are also a lot of animal processing operators that depend on the local livestock farms with significant contributions to the municipality's economy. 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 Kumanovo 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 Kumanovo

	Cattle	Sheep	Goat	Swine	Poultry	Honey bee hives
Kumanovo	7324	20626	3078	19921	86515	3859

*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 favorable conditions for the occurrence of many parasites and diseases. The most common proxy of heat stress is the Thermal Humidity Index (THI). We considered that the most representative and applicable model is the one developed for ruminants (cattle, sheep and goats). Ruminants are also the most vulnerable to climate change.

The climate risks and hazards in the municipality of Kumanovo were done in 24 points. In the past, the livestock was under pre-heat stress conditions for almost 70 days during the summer period. However, the alert THI phase lasted 40 days, the emergency phase 23 days and the phase of emergency lasted for more than 4 days.

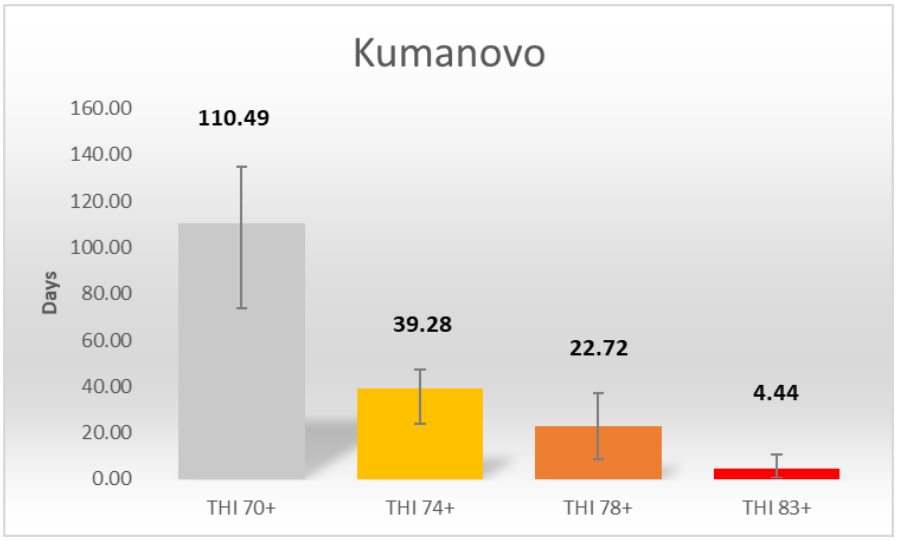


Figure 27 The average number of days for the period from 1990 to 2020 under different THI loads in the municipality of Kumanovo.

The current vulnerability of the agriculture in the Municipality of Kumanovo to the extreme weather conditions is estimated takin 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 categorized as low, medium, and high.

The adaptive capacity of agriculture was also categorized 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 agricultural sectors

Vulnerability				
	Adaptive capamunicipality			
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	Medium	High	High	Low	Medium	Medium
Vineyards	Low	Medium	Medium	Low	Low	Low
Vegetables	Low	High	Medium	Medium	Low	Medium
Livestock	Low	High	High	Medium	N/A	Low

5.4 Assessment of the vulnerability risks to forestry sector

In the past, a large number of fires in open space were registered on the territory of the Municipality of Kumanovo, which affected large areas of forests. For example, in the period 1998-2007, a total of 32 fires occurred on the territory of the municipality, with a total of 2,465 ha of burnt area.

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

The municipality of Kumanovo in the recent years is under intense pressure of urbanization. The city itself is built up intensively, removing green areas and diminishing the permeable surfaces, consecutively converting it to impervious surfaces in a process called soil sealing. This effects into less permeable surfaces and diminishing the ability of the surface to absorb the rainfalls and in turn after every rain event the streets are covered with water layer and if the rains are more intensive to larger flooding. On the other hand the city is expanding its borders and on the way it is ingesting surrounding natural areas.

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 provided by the municipality, the total number of fires registered in the period 2019-2022 is 1375 fires, the total burned area is 3079 ha. Most of the burnt area is agriculture area and 522 ha are forests. This is a large area but fortunately most of the forest fires are happening far from the inhabited areas and they do not pose a large risk for the infrastructure. The highest risk of forest fires are the forest close to the inhabited areas, ex. Park forest Biljanovce.

Table 17 Occurrences of forest and open fires in the municipality of Kumanovo

Year	No. Forest fires	Area (ha) Forest fires	No. Open fires	Area (ha) Open fires
2019	34	206,5	379	899,7
2020			229	157,5
2021	17	259,5	353	817,2
2022	5	56	358	682,8
Total	56	522	1319	2557,2

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. The municipality of Kumanovo is faced with the situation of transference of risk. This means that activities are happening in other municipalities and the risk is transferred trough the river system to the municipality of Kumanovo.

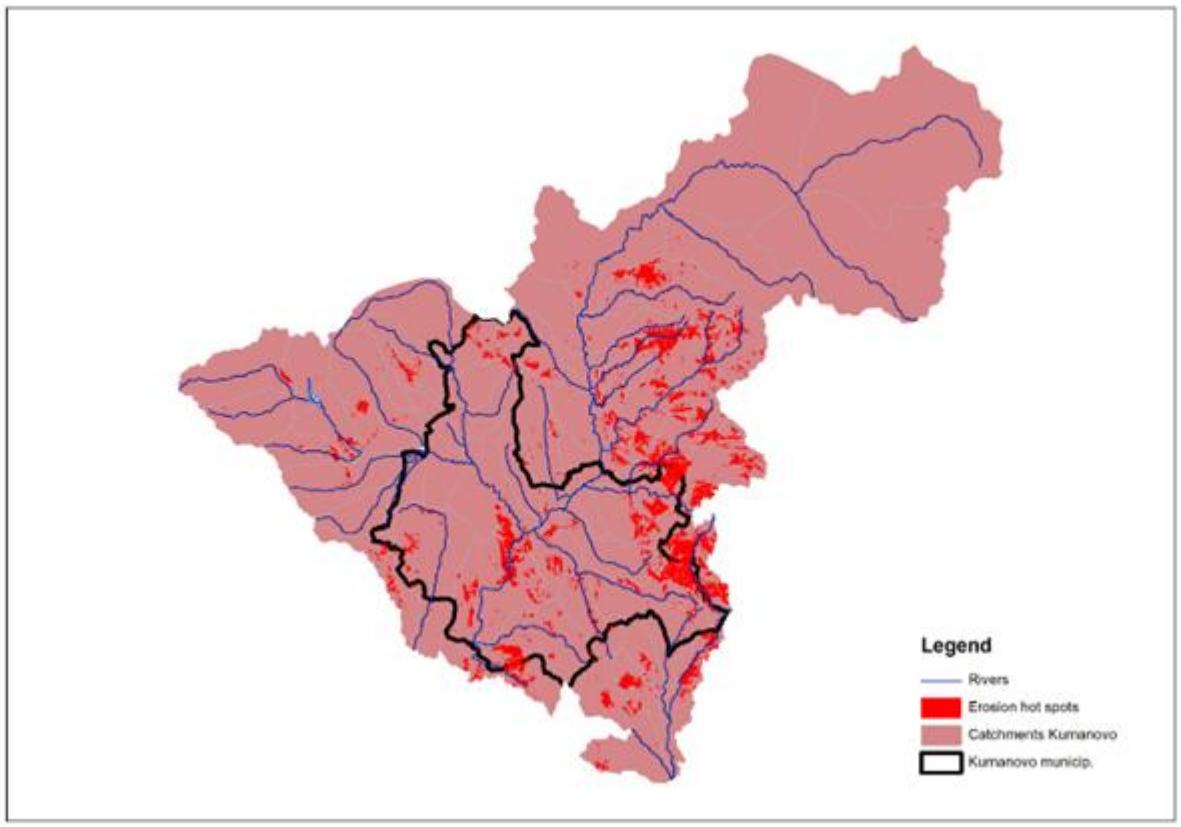


Figure 28 Transfer of risk of other municipalities to the municipality of Kumanovo

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 Kumanovo:

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

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^{o} C and the tendency for rainfall increase is 30 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 climate station taken into account is in the city 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 Kumanovo valley is with low average precipitation of around 520 mm. The aridity index of the lower parts show sub humid climate.

5.5 Assessment of the past and current risk and vulnerability of the local economy of the Municipality of Kumanovo

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 photovoltaics 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 the home market, caused by the global inflation. A number of businesses have opened for electricity production with photovoltaics, 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.

Apart from these events described above, another frequent extreme event is the heat waves that usually affect the City every year in the summer. It exposes a large number of people to health risk and reduced productivity due to the need for cooling, but also the need for absence from work for chronically ill, elderly and pregnant women. Heat waves have a negative impact on outdoor activities such as construction and agriculture. There, in particular, business process interruptions, business discontinuities and reduced output occur.

In the municipalities of Kumanovo, there are occasional floods from local rivers, which are the result of heavy rainfall. The result is damage to bridges and other infrastructure that prevents the normal movement of people and livestock. However, the direct and indirect economic consequences are not huge. E.g: Due to heavy rain on March 29, 2015, the bridge over the Lipkovka River was damaged. This direct damage is estimated at 1,200,000 denars (19,500 euros).

Heavy rains from the rains on November 18th and 19th, 2014 caused the Lipkovka, Kriva Reka, Kojnarka and Kumanovka rivers to overflow along the entire course to the confluence with the Pčinja river, both in urban areas and in suburban and rural areas, where material it damages residential, basement, auxiliary buildings on legal entities and natural persons, as well as non-agricultural land, agricultural culture, livestock and other livestock. The estimated value of direct damages is 1,336,904 denars (21,730 euros).

There are no relevant records on forest fires and caused direct and indirect damage.

The local economy of Kumanovo Municipality is dominated by two sectors, namely the trade sector and the manufacturing industry sector. The largest number of entities, up to 30% of the total number, is registered in the trade sector. However, the manufacturing industry absorbs 23% of the total number of employees, the same amount are in the trade sector. Almost half of the total labor force works in these two sectors. The trade sector generates 50% of the total revenues in the local economy, and 42% of the total profit. The manufacturing industry generates 16.7% of total revenues and 15% of total profits. The trade sector is generally not very vulnerable to climate change, although to a large extent the increase in temperatures can lead to greater vulnerability of industry.

Sectors that are extremely vulnerable to extreme weather conditions have a small relative share in the overall local economy. Construction employs 6% of the total workforce, generates 7% of revenue and 11.5% of profit. In the Agriculture, forestry and fisheries sector, 1% of the total number of employees work, generating only 0.8% of the total revenues and 1.6% of the profit.

In the trade sector, no high vulnerabilities have been detected, but they are medium or low. High vulnerability is assessed in the construction sector to heat waves and extreme precipitation. Agriculture is a marginal economic activity in the Municipality of Kumanovo. Therefore, focusing on the vulnerabilities of the dominant branches, **the general assessment is that the local economy of the Municipality of Kumanovo is moderately to low vulnerable to extreme weather events.**

Table 18 Assessment of past and current climate risk and vulnerability of local economy of the Municipality of Kumanovo

ECONOMIC SECTOR	EXTREME WEATHER EVENT	CURRENT VULNERABILITY
HOUSING	Heat wave	High
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	High
	Storms	Low
	Landslides	Low
	Forest Fires	Medium

INDUSTRY	Heat wave	High
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Low
	Droughts	High
	Storms	Low
	Landslides	Low
	Forest Fires	Medium
TRADE (WHOLESALE AND RETAIL)	Heat wave	Medium
	Extreme Cold	Low
	Extreme Precipitation	Medium
	Floods	Low
	Droughts	Medium
	Storms	Low
	Landslides	Low
	Forest Fires	Medium
CONSTRUCTION AND CIVIL ENGINEERING	Heat wave	High
	Extreme Cold	Medium
	Extreme Precipitation	Medium

	Floods	Medium
	Droughts	High
	Storms	Medium
	Landslides	Low
	Forest Fires	Medium
TRANSPORT AND STORAGE	Heat wave	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Low
	Landslides	Low
	Forest Fires	Low
TOURISM AND HOSPITALITY	Heat wave	High
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	High
	Storms	Low

	Landslides	Medium
	Forest Fires	Medium

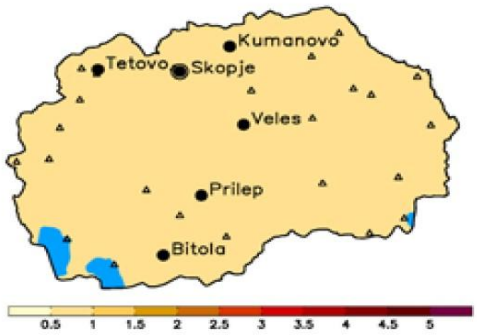
6 IDENTIFICATION OF FUTURE CLIMATE THREATS FOR KUMANOVO (SHORT, MEDIUM, AND LONG-TERM)

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 Kumanovo Municipality.

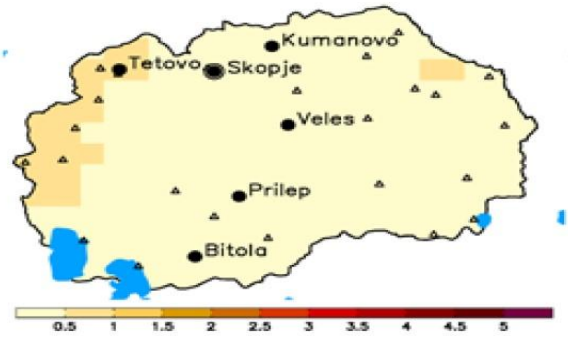
6.1 Water Sector

In this chapter are identified and presented the future climate threats for the Kumanovo region are identified in a short term, for the period 2016-2035 according to Gurgevic scenarios. Here were analysed the climate extremes that mostly affect the water resources and that have large impact of them.

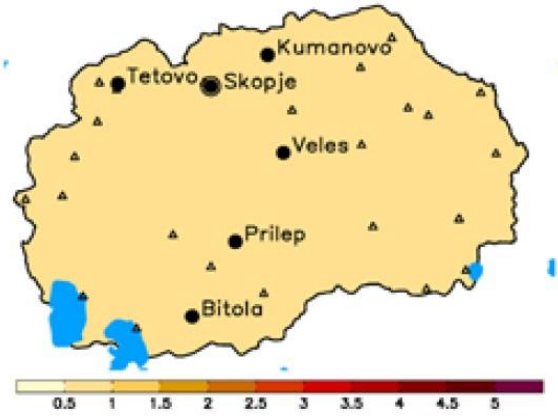
Temperatures and precipitation for period 2016 – 2035, scenario RCP 4.5



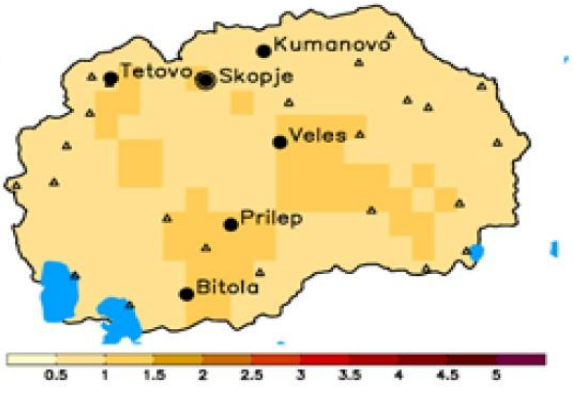
Average annual temperatures



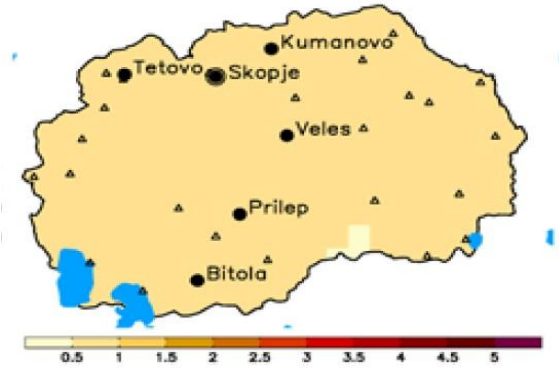
Average winter temperatures



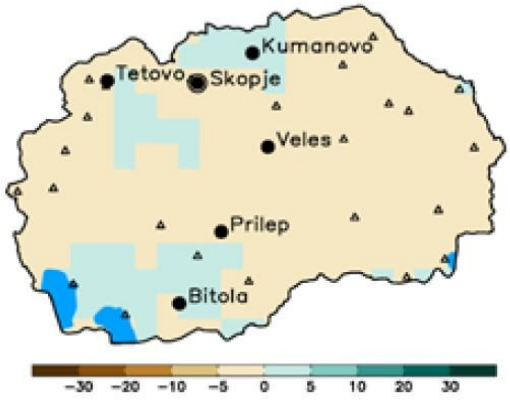
Average spring temperatures



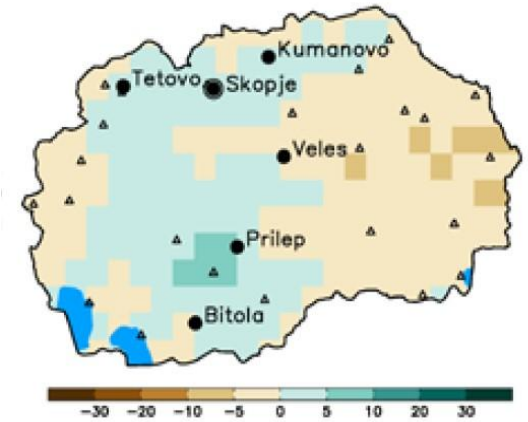
Average summer temperatures



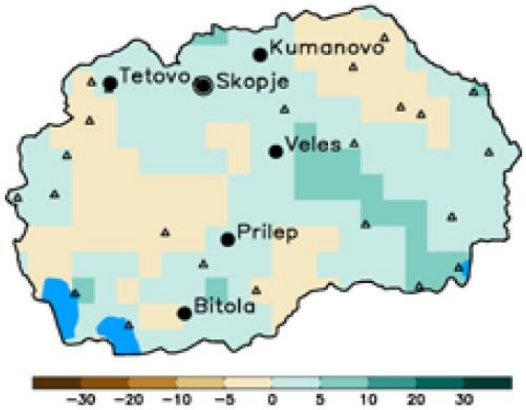
Average autumn temperatures



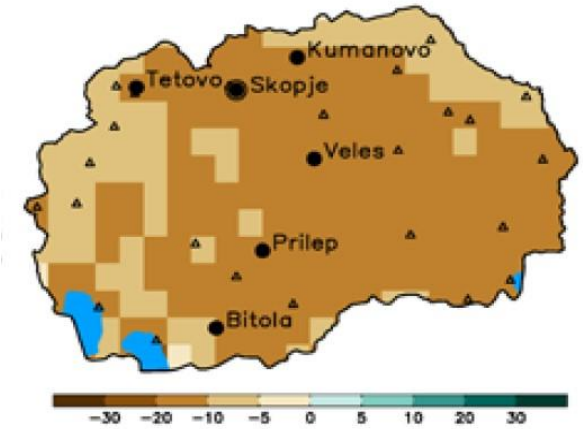
Average annual precipitation



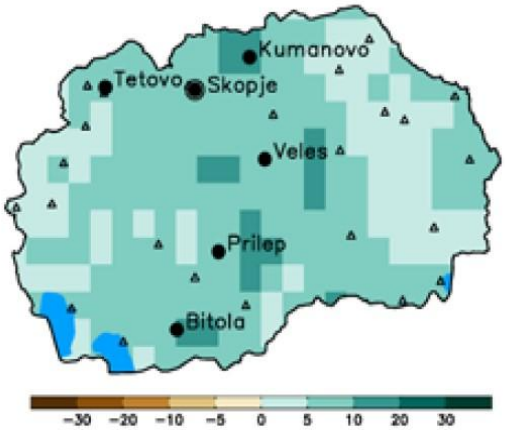
Average winter precipitation



Average spring precipitation



Average summer precipitation



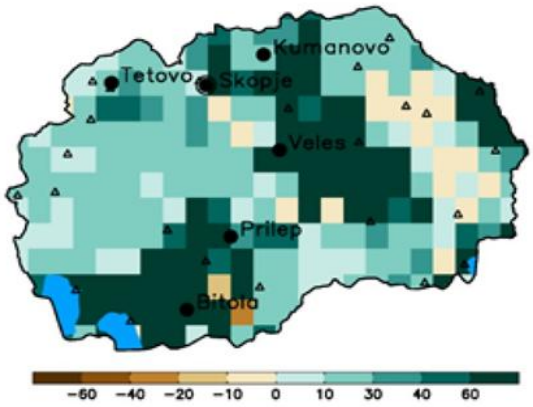
Average autumn precipitation

According to maps on the future climate extremes like temperatures and precipitation, in the future it is expecting increasing of the air temperatures and average sums of precipitations to remain the same. This predictions will affect the water resources through occurring short and middle term droughts periods and decreasing of the average discharges in the r. Lipkovska, r. Slupcanska, r. Konjarka and r. Kumanovska, which with part of their catchment areas belongs in the Kumanovo region, then decreasing of groundwater levels, possible decreasing of the capacity of springs, as well

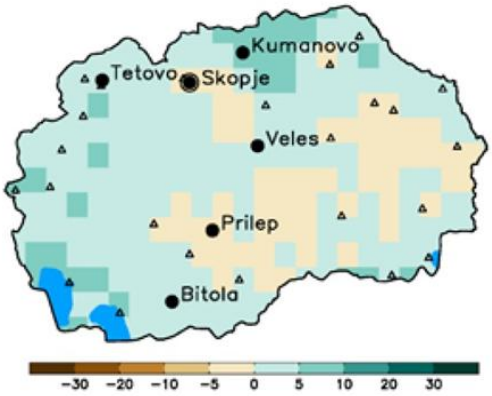
as decreasing of the water inflow in the artificial accumulations on r. Lipkovska (Glaznja and Lipkovo).

But we must mention that the maps are prepared with 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.

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



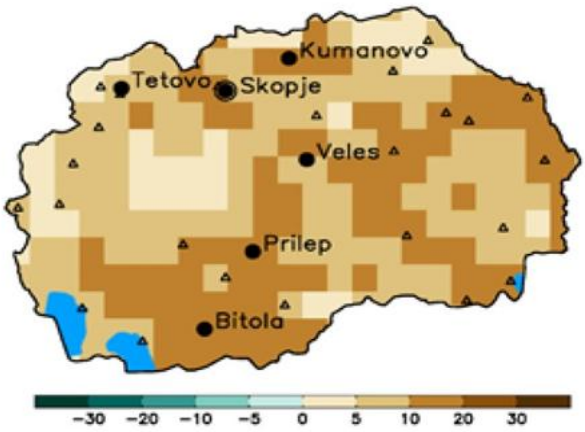
Number of events with extreme precipitation



Max daily precipitation

According to map of the days with precipitation above 40 mm and map of the number of events with extreme precipitation, they are indications that region of Kumanovo has serious possibility of occurring intensive precipitation in the future causing flash floods on the small rivers and torrential in the region, as well as appearances of urban floods in the city of Kumanovo. Although in the future period are expecting decreasing of the average sums of precipitation or to remain the same, 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.

Drought days for period 2016 – 2035, scenario RCP 4.5



Consecutive drought days

Kumanovo 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 dough days.
It could cause problems with the water supply of the region and providing (supplying) drinking water in future. Also, during the summer periods the capacity of the springs will decrease, and groundwater levels of wells are expected to decrease. So, in the future maybe it will be needed to investigate new ways for additional replenishment of water from other sources and other river basins.

Seasonal oscillation of the extremes
Regarding 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 Forestry

Identification of future climate threats is at the heart of the process of identification of future risks, priorities and designing and implementing of effective adaptation strategy. Climate change trend is 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 two future periods: Short term (2015-2035) and Mid-term (2046-2065), to assess the future climate.

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. From the data presented a slight increase of 1 to 1.5 degrees is expected in the short term and on mid-term it is expected an increase of 1.5-2 degrees.

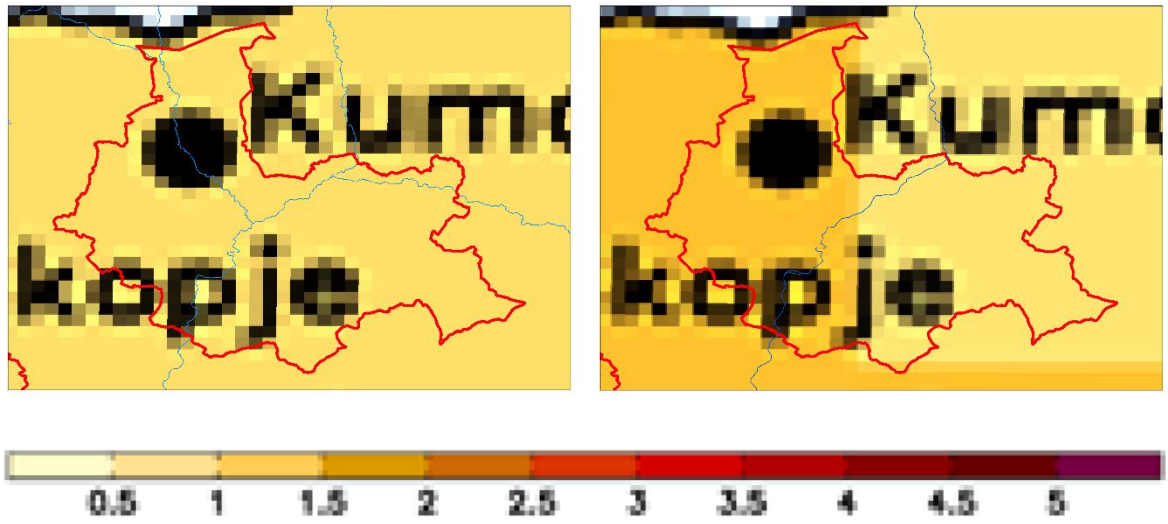


Figure 29 Projected change of average air temperatures 2015-2035 related to 1986-2005

Figure 30 Projected change of average air temperatures 2046-2065 related to 1986-2005

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 increase in the northern parts of the municipality and small decrease of precipitation in the other parts (+/- 5%). In comparison of the current available data, the status quo of the precipitation will go on in short-term period. On medium-term it can be seen a decrease of annual precipitation up to 5 %.

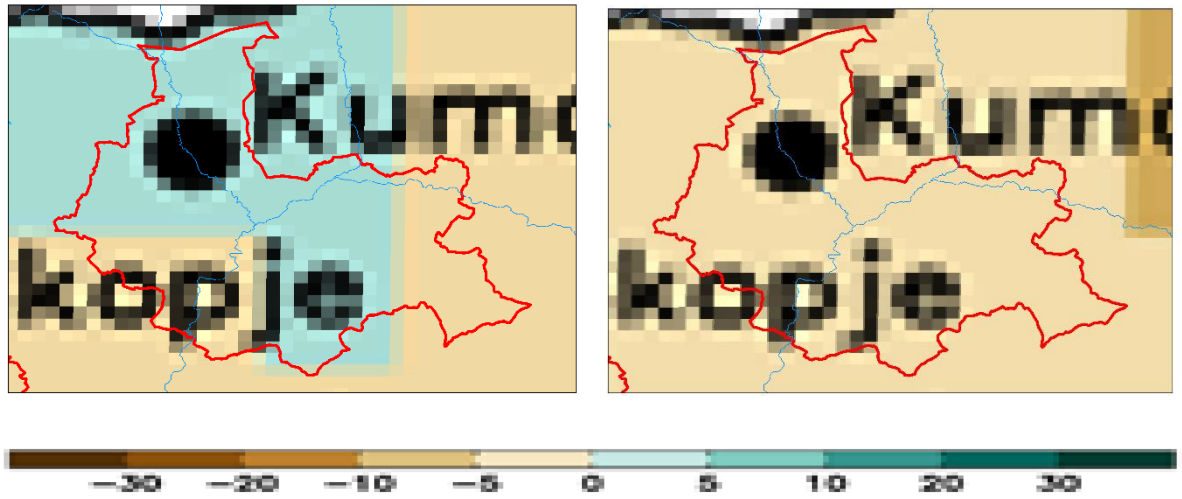


Figure 31 Projected change (%)of annual precipitation 2015-2035 related to 1986-2005

Figure 32 Projected change (%)of annual precipitation 2046-2065 related to 1986-2005

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, the situation stays the same with a mild re-composition of the spatial distribution.

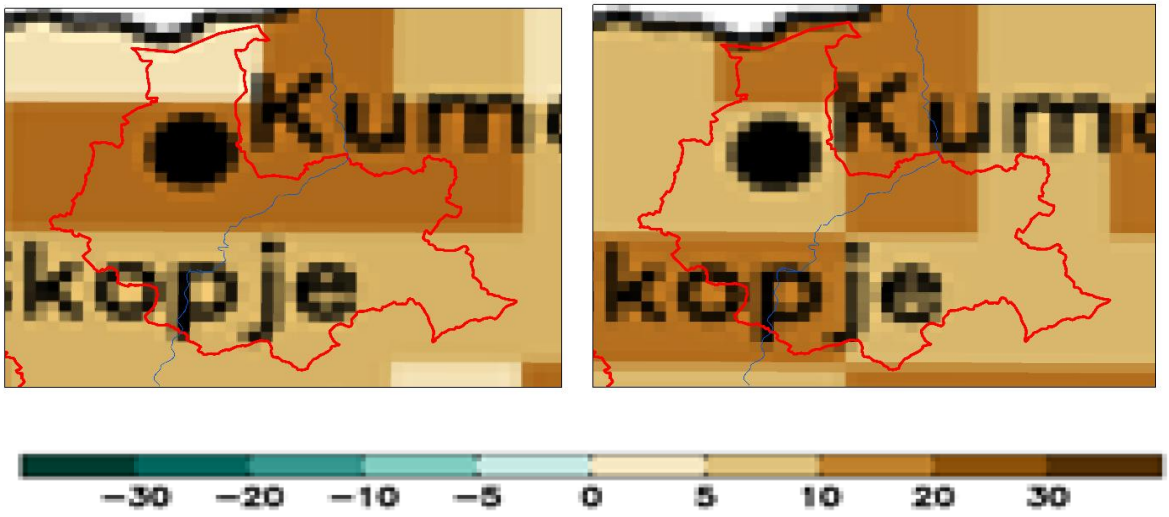


Figure 33 Projected change of consecutive dry days 2015-2035 related to 1986-2005

Figure 34 Projected change of consecutive dry days 2046-2065 related to 1986-2005

Intensive rainfall

From the maps below it can be seen that on short and mid-term the projected daily accumulated rainfall is increasing. On short term part of the territory is covered with increase of extreme rainfall events of 10 to 30 %. On mid-term, the results are similar as the first period.

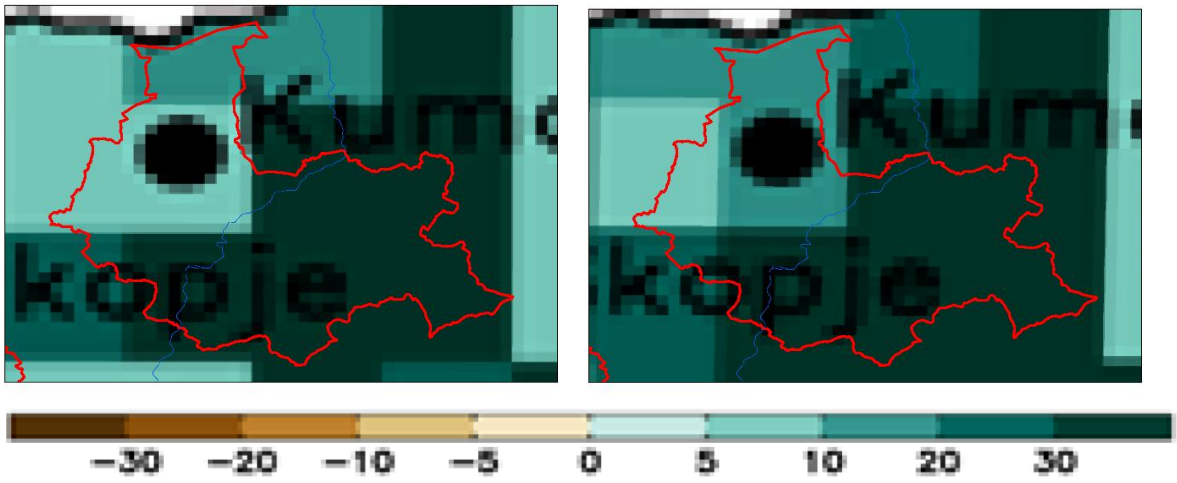


Figure 35 Projected change of extreme rainfall events (%) 2015-2035 related to 1986-2005

Figure 36 Projected change of extreme rainfall events (%) 2046-2065 related to 1986-2005

6.3 Health sector

According to the projected RCP4.5 climate scenario, in the Kumanovo region, an increase in future temperature is expected to be in the range of 1-1.5C (especially during the summer). Like 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 Kumanovo region in the RCP4.5 scenario, it will decrease by 20% on average during the summer 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. As same as with floods the risk of droughts will be moderate to high.[5]

6.4 Agricultural sector

Identification of the future climate trends is at the heart of the process of identification of future risks, priorities and designing and implementing of effective adaptation strategy. Climate change trends are one of the most effective tools 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 provided during the preparation of the Fourth communication of climate change, developed by WCRP CORDEX. Meteorological data were organized 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 tern 2016-2035 and a mid-term - 2045-2065 For this analysis the RCP 4.5 scenario was used for modeling 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.

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 Kumanovo it can be concluded that the average air temperatures are expected to increase over a short and a mid-term for about 1-1,5 C°. Unlike some parts of the country (central region) the differences between the compared two periods for Kumanvo municipality are expected to be somewhat higher. All agricultural areas will be affected by this increase in air temperatures.

[5] DjurdjevicV. Report on Climate Change Projections and Changes in Extreme Climate Events in North MacedoniaUNDP/GEF 2020

With regards to the trends of increase of air temperatures in vegetative session, the trend is similar as with the annual air temperatures. Air temperatures in the vegetation season will equally increase for about 1 C° which can seriously affect the agricultural crops. Such increases of air temperatures indicate an increase in evapotranspiration, plant water demands and water deficit. Plants during the vegetation period will be under stress because of insufficient water and high temperatures.

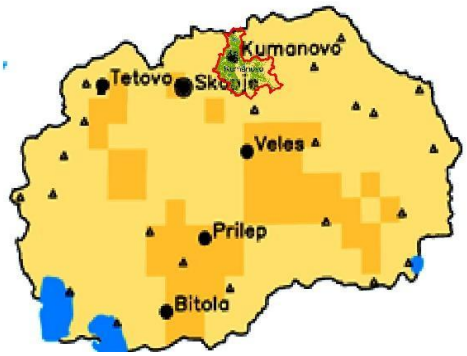


Figure 37 Annual air temperatures 2016-2035

Figure 38 Annual air temperatures 2046-2065

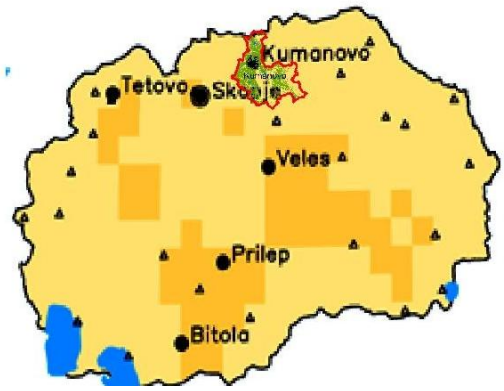


Figure 39 Air temperatures in vegetation 2016-2035

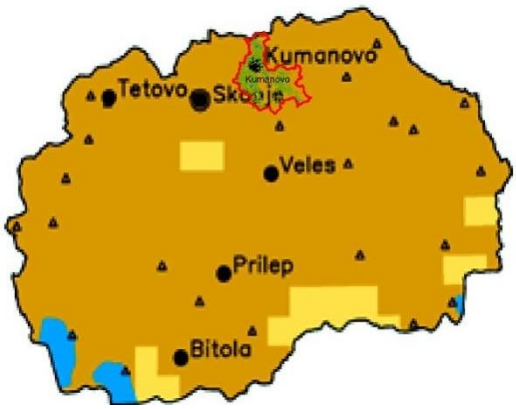


Figure 40 Air temperatures in vegetation 2016-2035

Heat waves

With regards to the future trends of heat waves, out of the data presented in Figure 38and Figure 40 it can be seen that no significant changes are expected. The expected changes on a short term-period (2016-2035) are evenly distributed over the whole municipality and the increase of the number of heat waves in this period compared with the base period 1985-2005, is expected to be only one additional event (period of 20 years). In the mid-term period the trend remains the same compared with the period 2016-35, with an increase of only one additional event compared to baseline period. This means that the agricultural crops in Kumanovo Municipality are not expected

to be significantly affected with this climate hazard, due to what the risk for the agricultural crops should remain on the same level. However, the negative influence of heat waves should not be neglected having in mind the relatively higher mean annual temperatures in the Municipality and higher evapotranspiration, due to what the heat waves are an additional burden to the already unfavorable climate conditions.

Figure 41 Heat waves 2016-2035

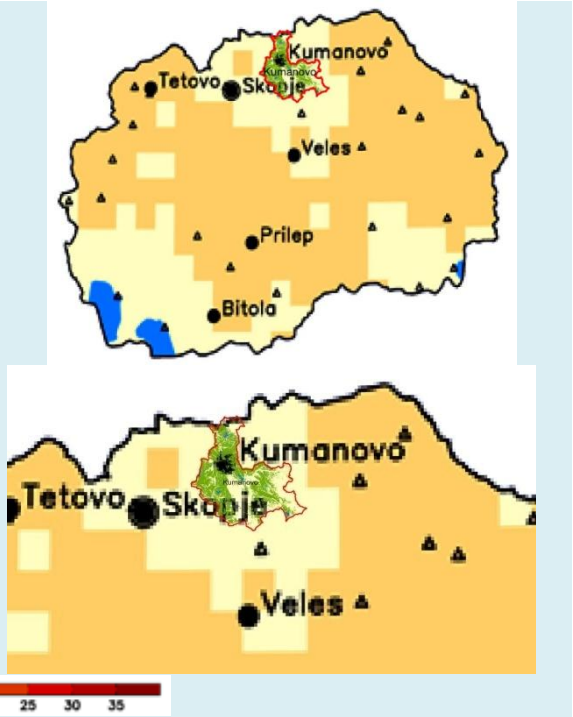


Figure 42 Heat waves 2046-2065

Extreme precipitations

Projected trends of the extreme rainfall's events for the municipality of Kumanovo indicate significant increase in the short-term period compared with the base period. The expected increases are for 60 days in the eastern part of the Municipality, while in the western part the expected increase is projected to be 10-30 days and in the north part to about 30 days. In the medium term period (2045-65) there are no significant changes compared to the short term period. However, such a high increase of extreme precipitation is a serious threat for the agricultural crops due to the overloading and flooding of certain areas, and the appearance of torrential floods which can damage certain areas with agricultural crops and plantations.

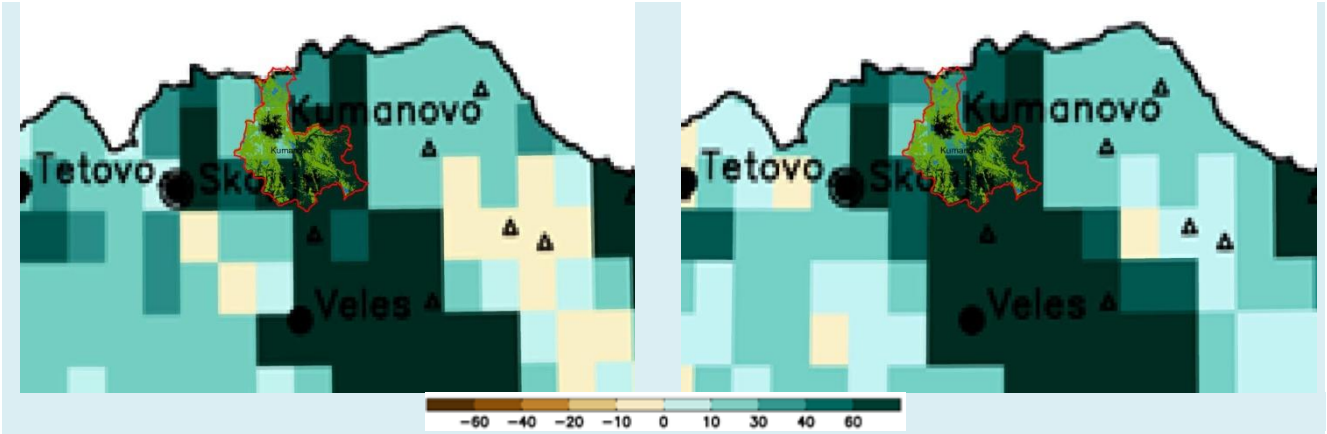


Figure 43 Intensive rainfalls 2016-2035

Figure 44 Intensive rainfalls 2046-2065

Frosts

As presented in the Maps Figure 45 and Figure 46, the number of frost days is expected to decrease for about 5 days on a short-term period 2016-2035 and for about 10 days on an especially on a medium term (2046-2065). The decrease of the number of frost days will be evenly distributed over the whole area of the municipality of Kumanovo. This means that the overall agricultural areas will evenly be affected with this decrease of frost days.

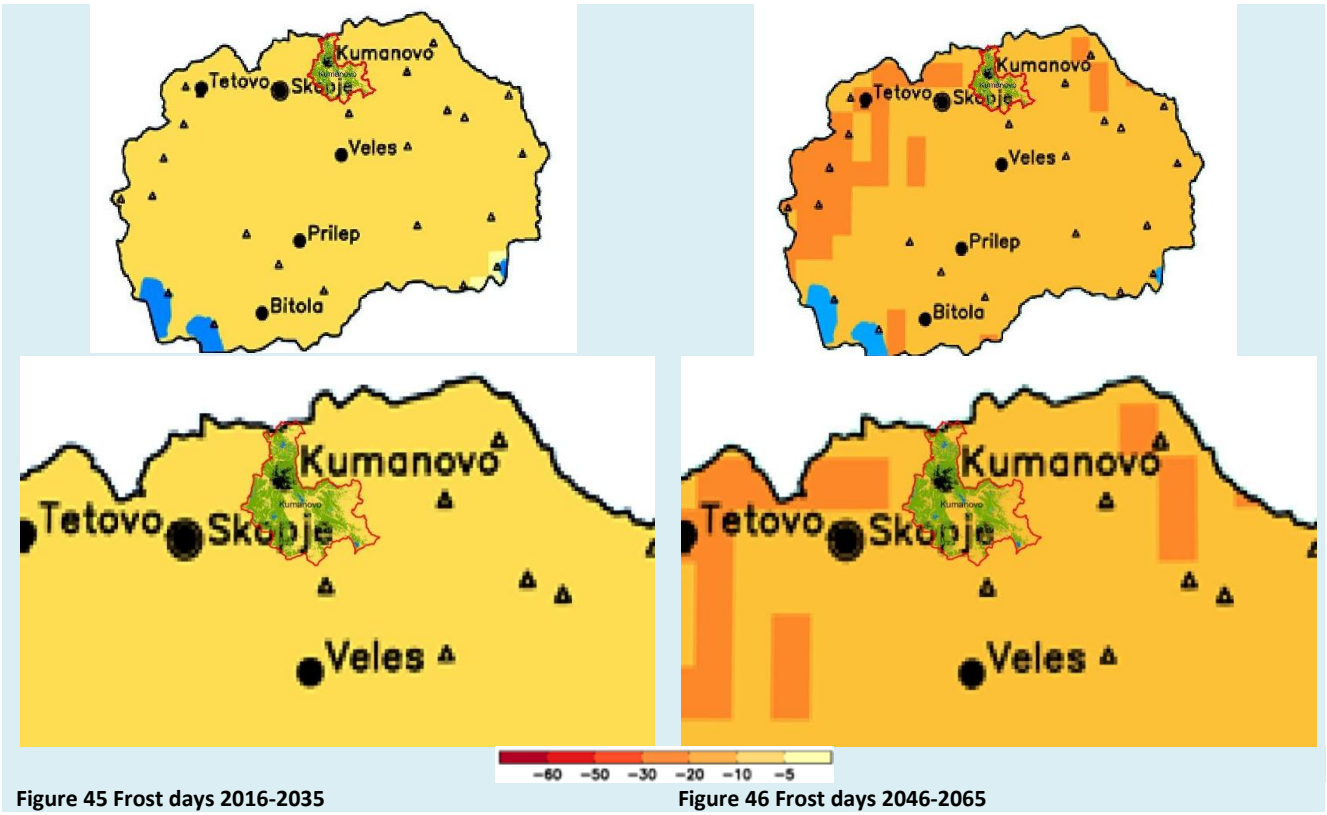


Figure 45 Frost days 2016-2035

Figure 46 Frost days 2046-2065

Drought

Drought is one of the common threats for most of the agricultural plants. The drought period in Kumanovo Municipality is expected to increase in the short term period for about 10-20 days which

is a significant increase which significantly increases the risk for agriculture. Especially affected areas in a short period are the central and the eastern parts of the municipality of Kumanovo, while the southern parts of the municipality according to the projections is expected to be less affected, with a 10 days increase of drought periods. In the mid-term period, the drought periods are expected to remain the same, except a certain decrease in the eastern parts of the municipality from additional 10 days. Increased dry periods, increases the water deficit which should be overcome with intensive irrigation. In a rain fed area a serious reduction of yields can be expected due to a water stress. In order to reduce the risks for the agricultural crops, modern and properly organized irrigation systems are of particular importance.

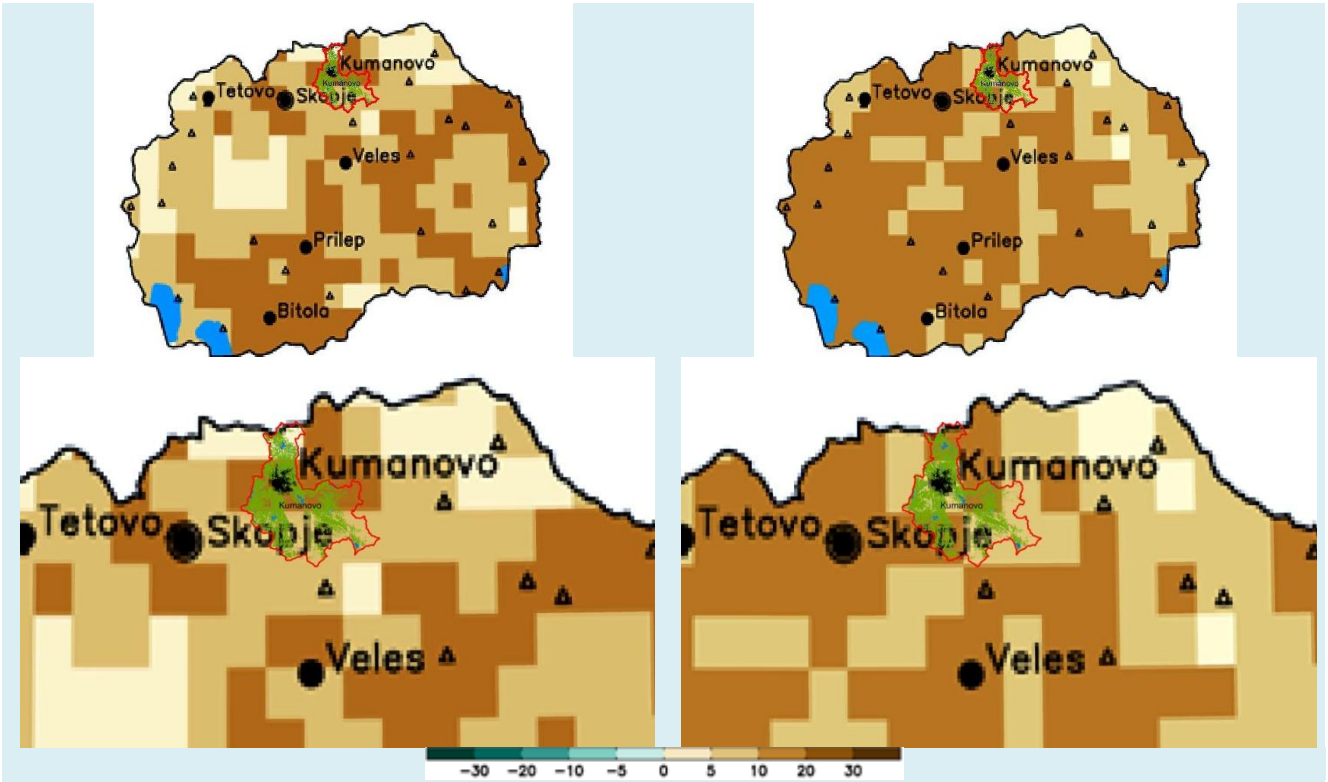


Figure 47 Drought 2016-2035

Figure 48 Drought 2046-2065

Livestock

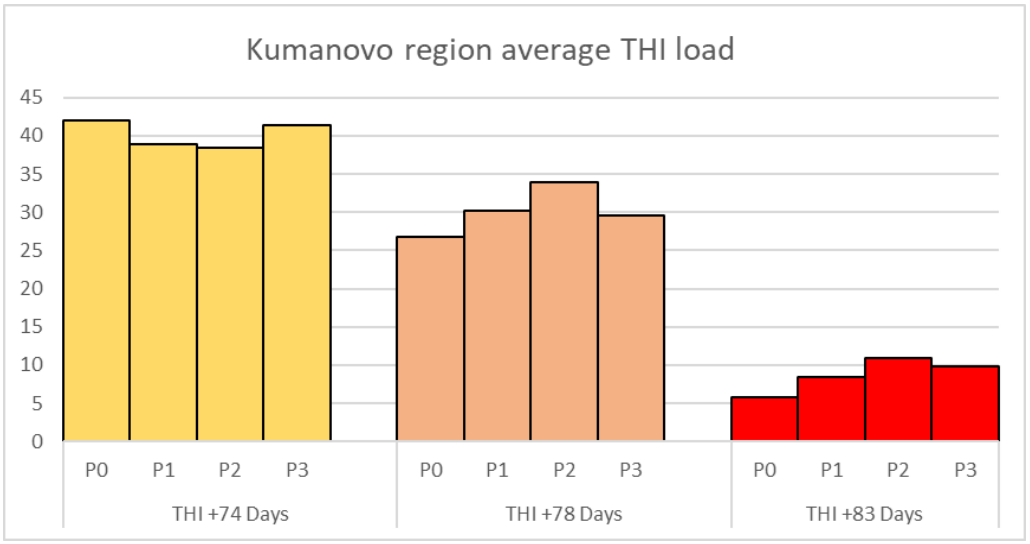
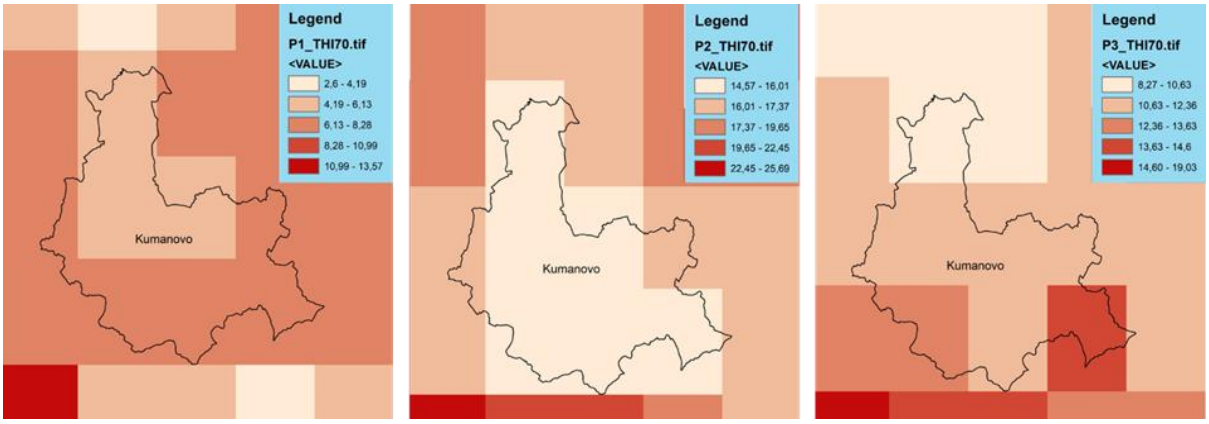


Figure 49 Kumanovo region average THI load

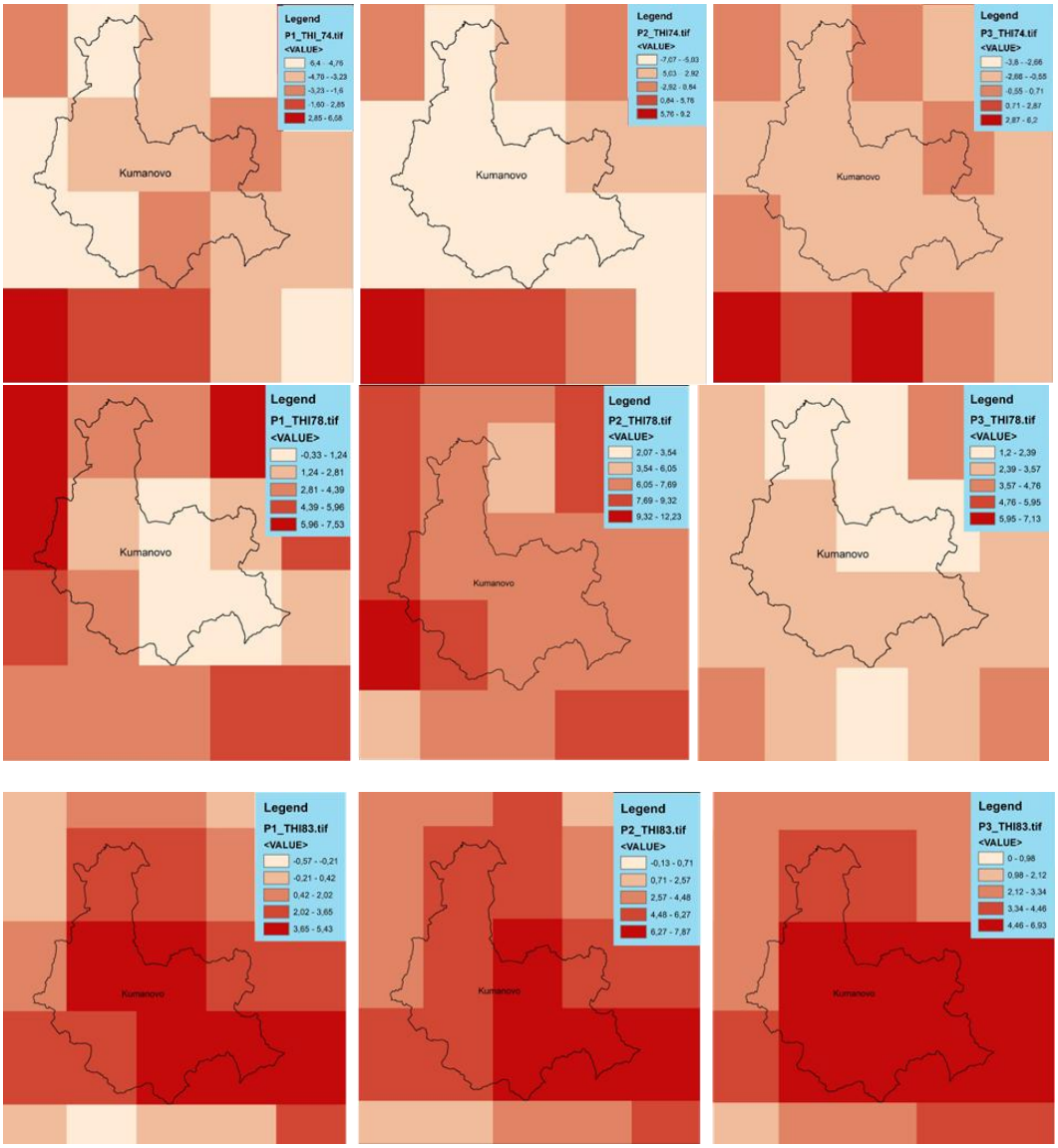
The average THI loads in ruminants in the area of the municipality of Kumanovo, for the reference period (P0: 1990-2020), short (P1: 2021-2030), medium (P2: 2031-2040) and long (P3: 2041-2050)

The estimated average annual alert THI load over time will be stable for about 40 days annually. However, higher THI loads (emergency and dangerous) would be increased over time reaching maximum in P2. On average annually, the emergency phases will last 35 days, while the dangerous phase will last for more than 20 days. The increase for THI 78+ and THI 83+ would be 27% and 88%, respectively, in P2 compared to P0. However, the spatial distribution is not even.



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)

The largest increase of preheat THI load would happen in the southern and southwestern parts of the municipality, when the increase can reach over 15 days annually, compared to the reference period.



Spatial distribution of 3 THI loads in alert (yellow THI 74+), emergency (orange THI 78+) and dangerous (red THI83+) municipality of Kumanovo expressed as the difference from the reference period (P0: 1990-2020) and short (P1: 2021-2030), medium (P2: 2031-2040) and long term (P3: 2041-2050)

During these periods there will be an increased area where the THI will be higher, than in the others. In the municipality of Kumanovo could be expected an increase of the THI 74+ load for up to 6 days in the north and northeast areas, compared to the reference period. It is also expected that for THI 78+ load the increase of 5-7 days annually would happen in the western part of the municipality, compared to the reference period. However, the central part of the municipality of Kumanovo would expect a significant increase in dangerous heat load of THI 83+. The increase would be in 4-7 days annually compared to P0, reaching maximum in P2 and P3.

	P1	P2	P3
THI +70	3.14	**7.96**	5.39
THI +74	-2.91	-2.32	**-0.18**
THI +78	4.10	**7.65**	2.92
THI +83	1.63	**4.00**	3.25

Figure 50 Change in THI load in the municipality of Kumanovo from the reference point

The trend observed in the average annual THI load is that the maximum can be expected in P2 for preheating, 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.

6.5 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 preexisting 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, labor, 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: labor productivity and total factor productivity. Labor productivity measures the amount of hours worked relative to the amount of

output in an economy, while total factor productivity considers not only labor but also other factors of production such as land and capital.

Labor is a major channel through which climate change might affect the workforce and thus economic output. Warming directly affects labor supply (working hours) by changing the allocation of time to labor beyond certain thresholds, especially in working conditions that are highly exposed to the climate—e.g., 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 (labor 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 labor 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 labor 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 un mitigated 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, no 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.

6.5.2 Assessment of the future climate risk of the local economy of the Municipality of Kumanovo

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 Kumanovo, as we point out in more detail above.

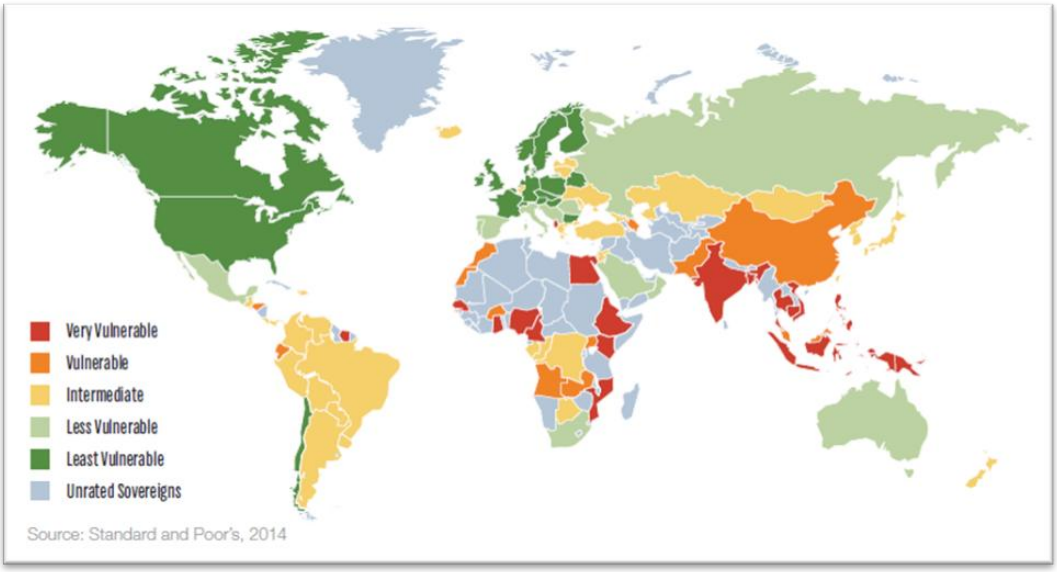


Figure 51 The impact of climate change on the global

At this moment there is great uncertainty and we cannot predict with great precision in which direction the local economy of the Municipality of Kumanovo 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 Kumanovo in relation to the current vulnerability. However, the general assessment is that the economy of the Municipality of Kumanovo will be moderately vulnerable to future climate risks in the future. 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 behavior.

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, these two sectors have a small relative contribution to the overall economy, especially agriculture, which is a marginal branch in the Municipality of Kumanovo.

Excessive temperatures can have a negative impact on the incentive of tourists to visit the Municipality of Kumanovo. It will also lead to potentially increased operating costs of the tourism sector, hotels, accommodation facilities and restaurants.

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.

Table 19 Assessment of the future climate risk of the local economy of the Municipality of Kumanovo

ECONOMIC SECTOR	EXTREME WEATHER EVENT	FUTURE CLIMATE RISK
HOUSING	Heat wave	Very High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	High
	Droughts	Very High

	Storms	Medium
	Landslides	Low
	Forest Fires	High
INDUSTRY	Heat wave	High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	Medium
	Droughts	Very High
	Storms	Medium
	Landslides	Low
	Forest Fires	Medium
TRADE (WHOLESALE AND RETAIL)	Heat wave	High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	Medium
	Droughts	High
	Storms	Medium
	Landslides	Low

	Forest Fires	Medium
CONSTRUCTION AND CIVIL ENGINEERING	Heat wave	Very High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	Medium
	Droughts	Very High
	Storms	High
	Landslides	Low
	Forest Fires	Medium
TRANSPORT AND STORAGE	Heat wave	High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	High
	Droughts	High
	Storms	Medium
	Landslides	Low
	Forest Fires	Medium
TOURISM AND	Heat wave	High

HOSPITALITY	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	Medium
	Droughts	Very High
	Storms	Medium
	Landslides	Low
	Forest Fires	Medium

7 CLIMATE CHANGE ADAPTATION MEASURES

7.1 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[6].
- 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

- 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;

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

- 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