Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

SKOPJE

RISK AND VULNERABILITY ASSESSMENT TO CLIMATE CHANGE

CENTER FOR CLIMATE CHANGE

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ORGANIZATION RESPONSIBLE FOR DEVELOPING THE REPORT	**Center for Climate Change**
CLIENT	**The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) – North Macedonia**
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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 City of Skopje.

The risk assessment include 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 was taken the relevant local level assessment reports and policy documents, as for instance the Climate Adaptation Strategy of the City of Skopje which has been published and adopted in 2017.

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 SKOPJE

The City of Skopje is located in the central part of the Skopje Valley, covering an area of 571 km^2 . The city is surrounded by high mountains: Skopska Crna Gora to the north; Zeden and Osoj to the west; Jakupica to the south; and Katlanovski Rid to the east. The basic orientation of the valley is from northwest to southeast, shaped by the flow of the River Vardar.

The wider area of the Skopje basin consists of Neogene-Pliocene sediments and Quaternary–alluvial deposits. Most of the soil in the Skopje Valley is a mixture of clay and alluvium with a high content of organic substances. The soil in the lower parts of the valley is fertile and of high agricultural value.

The climate of the Skopje Valley is influenced by the continental and Mediterranean climate, as well as the mountain climate in the areas at higher altitudes. The lower parts of the valley have warm and dry summer periods and averagely cold and wet winters. The average annual temperature for the period 1978–2015 was 12.9^{o}C. The highest average monthly temperatures have been recorded in July and August, while the lowest temperatures have been recorded in January. Precipitation is not equally distributed either in time or in area. This is true whether we analyse precipitation in multi-year periods or on an annual basis.

3.1 Geographical and climatic (and hydrographical) characteristics

As a separate unit of the local self-government, the City of Skopje consists of the following municipalities: Aerodrom, Butel, Gazi Baba, Gorce Petrov, Karposh, Kisela Voda, Saraj, Centar, Chair and Shuto Orizari, within the limits established by the Law on the City of Skopje. The City of Skopje is the most important administrative, economic, cultural and educational center of the Republic of North Macedonia.

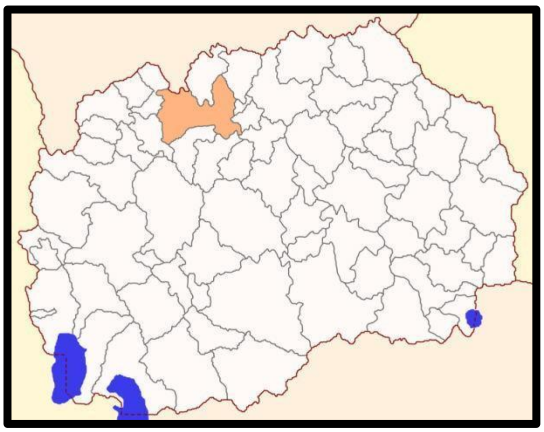

Figure 1. Skopje Planning Region

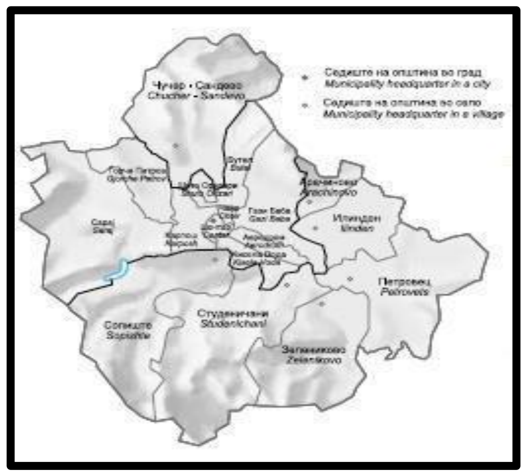

Figure 2. Location of the City of Skopje

Figure 3. Municipalities in the City of Skopje

The City of Skopje is the base of the Skopje region, which occupies the extreme northern part of the Republic of North Macedonia and extends into the Skopje Valley. The Skopje region consists of 17 municipalities, 10 of which belong to the area of the City of Skopje. The Skopje region is the smallest in terms of area and occupies only 7.3%1 of the total territory, but according to the data for 2014, it is the most populated: 29.8% of the total population and is also the most densely populated region with 339.7 inhabitants per km2. The Skopje region is the main crossroads of the Republic of North Macedonia, with the most favorable traffic infrastructure. The region is where most of the industrial, commercial and service facilities are concentrated. In 2012, GDP per inhabitant was the highest and amounted to 327,989 denars. Also, the region had the largest share of 42.8% in the total GDP. Because of all these characteristics, and primarily because of the City of Skopje, the Skopje region represents the largest immigration area in the Republic of North Macedonia.

The city of Skopje is located in the central part of the Skopje valley, at 21°26' east longitude and 42° north latitude. The altitude in the center of the city is 245m. It covers 1818 km2, 9 km wide (Vodno-Radishani) and 23 km long. (Dracevo - Gjorche Petrov). The city area covers an area of 225 km2.

The Skopje Valley, in which the City of Skopje is located, stretches in the upper part of the Vardar River. The Skopje valley is surrounded by the mountains: Vodno (with the peak Krstovar, with a height of 1,066 m), the massif Jakupica-Karadžica, with the peak Solunska Glava-Mokro (2,450 m) and Ubava (2,533 m), Osoj, with the highest peak of 1,506 m, Žeden (peak of 1,260m) and Skopska Crna Goras with the peak of Ramno (1,561m). The basin stretches from north-west to south-east direction. The Vardar River flows through the Skopje valley with its tributaries: Tresca, Pčinja, Markova Reka, Lepenec and Kadina Reka.

The climate in Skopje is characterized by an average annual temperature of about 12.8°C. Summers are long, dry and hot, and winters are cold with many foggy days, on average, 74.1 days. Skopje has an average of 478 mm of rain per year, or 11 days per year.

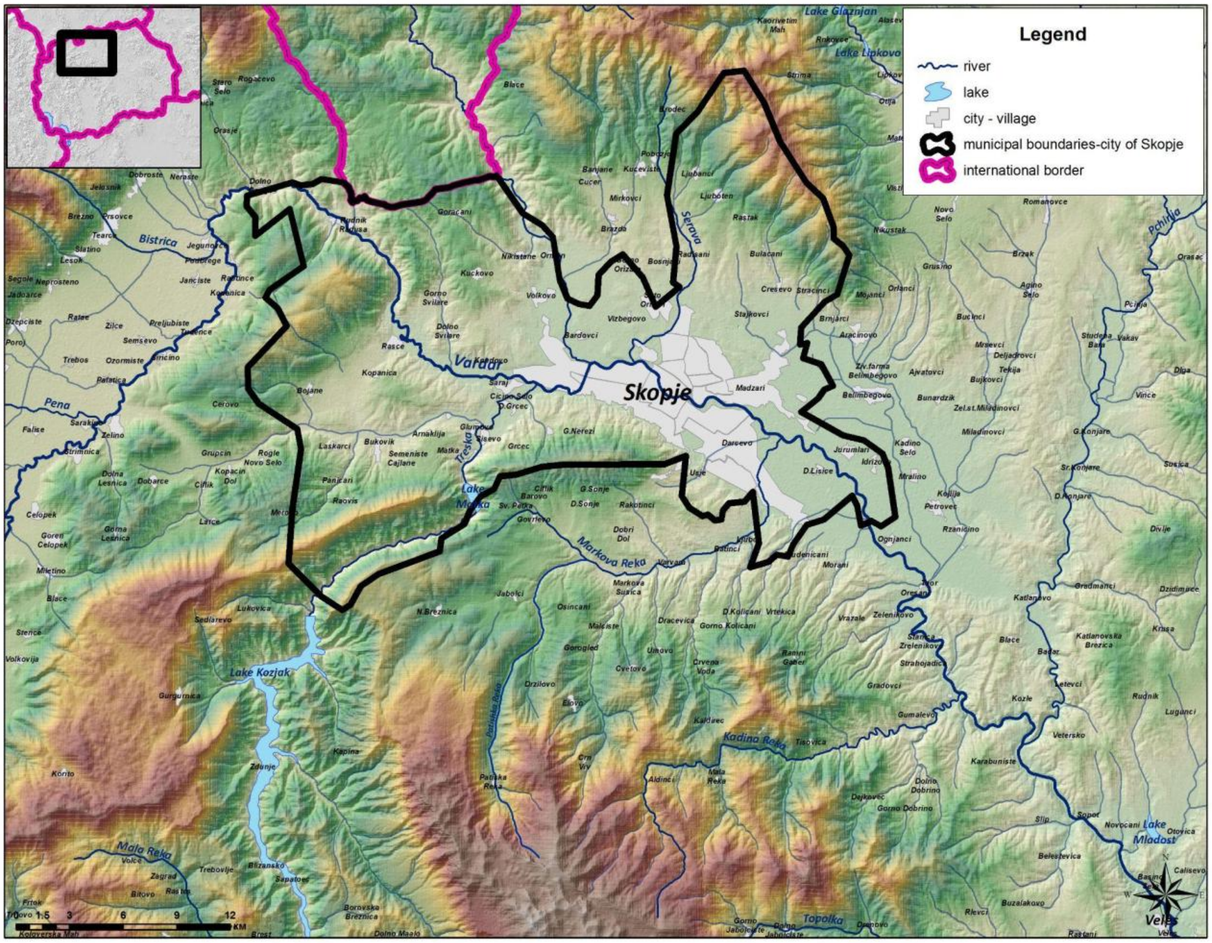

Figure 4. Topographic and hydrographic characteristics of the area of city of Skopje

3.2 Demographic and social data

According to the data from the last 2021 census, a total of 526,502 inhabitants live in the City of Skopje, which represents as much as 28.7% of the total population in the Republic of North Macedonia. Among the ten municipalities in the City of Skopje, the municipality of Aerodrom is the most populated, where 14.8% of the total population of the City of Skopje live, Gazi Baba is second in number of inhabitants with 13.2%, and Karposh, Kisela Voda and Chair have approximately the same number of inhabitants in third place. While the total population in the Republic of North Macedonia decreased by -9.2%, the total population in the City of Skopje has increased by 3.9% compared to the previous census from 2002. Municipalities that recorded population growth are Aerodrom (+8%), Butel (+5), Karpos (+6,9%), Kisela Voda (+8,3%) Gorce Petrov (+7,7%), Saraj (+8,4%) and Suto Orizari (+16,8%), and municipalities with a population decrease are Gazi Baba (-4,1%), Centar (-3,3%) and Cair (-3,4%).

Table 1. Total residential population according to the 2021 census

	Total population	Men	Women
Republic of North Macedonia	1,836,713	911,087	925,626
City of Skopje	526,502	256,247	270,255
Aerodrom	77,735	37,153	40,582
Butel	37,968	18,738	19,230
Gazi Baba	69,626	34,465	35,161
Gjorche Petrov	44,844	22,005	22,839
Karposh	63,760	30,127	33,633
Kisela Voda	61,965	29,961	32,004
Saraj	38,399	19,419	18,980
Centar	43,893	20,389	23,504
Chair	62,586	31,032	31,554
Shuto Orizari	25,726	12,958	12,768

Table 2. Number of families, census 2021

	Total		Urban		Rural	
	Number of families	Number of persons	Number of families	Number of persons	Number of families	Number of persons
City of Skopje	150,813	526,502	121,670	422,540	29,143	103,962
Aerodrom	23,407	77,735	22,610	75,108	797	2,627
Butel	10,744	37,968	7,001	24,391	3,743	13,577
Gazi Baba	20,108	69,626	11,323	38,426	8,785	31,200
Gjorche Petrov	13,218	44,844	10,042	34,040	3,176	10,804
Karposh	18,475	63,760	17,733	61,288	742	2,472
Kisela Voda	18,226	61,965	15,119	51,357	3,107	10,608
Saraj	10,338	38,399	1,704	6,265	8,634	32,134
Centar	12,740	43,893	12,740	43,893	-	-
Chair	16,700	62,586	16,700	62,586	-	-
Shuto Orizari	6,857	25,726	6,698	25,186	159	540

Table 3. Number of dwellings by type of dwelling, 2021 census

	Residential building	Non-residential building	Institutional Housing Building	Other	TOTAL
City of Skopje	88,534	999	29	7	89,569
Aerodrom	6,425	168	1	2	6,596
Butel	8,393	175	5	-	8,573
Gazi Baba	15,970	120	1	-	16,091
Gjorche Petrov	10,211	95	5	-	10,311

Karposh	7,854	123	5	2	7,984
Kisela Voda	12,732	120	8	1	12,861
Saraj	9,250	75	1	-	9,326
Centar	4,545	72	1	2	4,620
Chair	7,111	19	1	-	7,131
Shuto Orizari	6,043	32	1	-	6,076

3.3 Economic characteristics of the City of Skopje

The City of Skopje is part of the Skopje region. It is the administrative, cultural and economic center of the Republic of North Macedonia and it contributes the most to the social and economic capacity of the Republic of North Macedonia. The statistics have richer data for the Skopje region than for the City of Skopje and its municipalities, and therefore they are presented in the preparation of this study for the RVA of the City of Skopje. When talking about the Skopje region, it is clear that the biggest contribution to the region comes from the City of Skopje. The Skopje region includes the ten municipalities in the City of Skopje that we have listed above and seven other surrounding municipalities that have a small relative share. The Skopje region is to the greatest extent identified with the City of Skopje, considering that the majority of the inhabitants of the Skopje region live in the City of Skopje, the City of Skopje generates the largest part of GDP, etc. Considering that there is no measurement of some of the key economic measures at the municipal level, but they exist at the regional level, we will present them at the regional level. More specifically, at the level of the Skopje region, GDP, gross value added and investments in fixed assets will be shown. We will present the other measures that we are working on in the points below, related to the labor market, etc., at the municipal level. However, let us repeat that it is not a mistake to look at some of the measures at the regional level, given that the Skopje region is represented by the City of Skopje with more than 90%. In addition, although the surroundings of the City of Skopje are not administratively part of it, it is still considered a wider part of the City.

Table 4. GDP, in millions of denars

	2017	2018	2019	2020	2021
Republic of N. Macedonia	618,106	660,878	692,683	669,280	720,414
Skopje region	264,559	284,394	300,398	292,799	316,412

Table 5. GDP per capita, in denars

	2017	2018	2019	2020	2021
Republic of N. Macedonia	297,954	318,309	333,551	322,929	392,230
Skopje region	422,571	451,983	475,257	461,999	521,266

Table 6. Gross value added in Skopje region, by sectors of activity, in millions of denars

	2017	2018	2019	2020	2021
Agriculture, forestry; fishing	4,115	4,916	5,183	5,692	5,183
Manufacturing industry; Supply of electricity, gas, steam, and air conditioning; Mining and quarrying	35,820	43,800	44,287	40,588	41,641
Construction	22,423	18,133	19,009	16,188	17,740
Wholesale and retail trade; Repair of motor vehicles and motorcycles; Transport and storage; Accommodation facilities and food service activities	55,137	60,645	64,642	59,338	62,848
Information and Communications	17,981	18,737	20,361	22,152	25,304
Financial activities and insurance activities	14,575	13,819	14,119	15,243	16,184
Activities related to real estate	18,582	20,295	19,112	26,096	26,660
Professional, scientific, and technical activities; Administrative and auxiliary service activities	16,592	17,191	19,502	17,833	20,676
Public Administration and Defense; mandatory social insurance; Education; Health and social care activities	34,133	39,085	43,033	43,150	44,517
Art, entertainment and recreation, Other service activities	9,942	10,354	11,590	10,994	12,812
Total	229,299	246,975	260,838	257,275	273,565

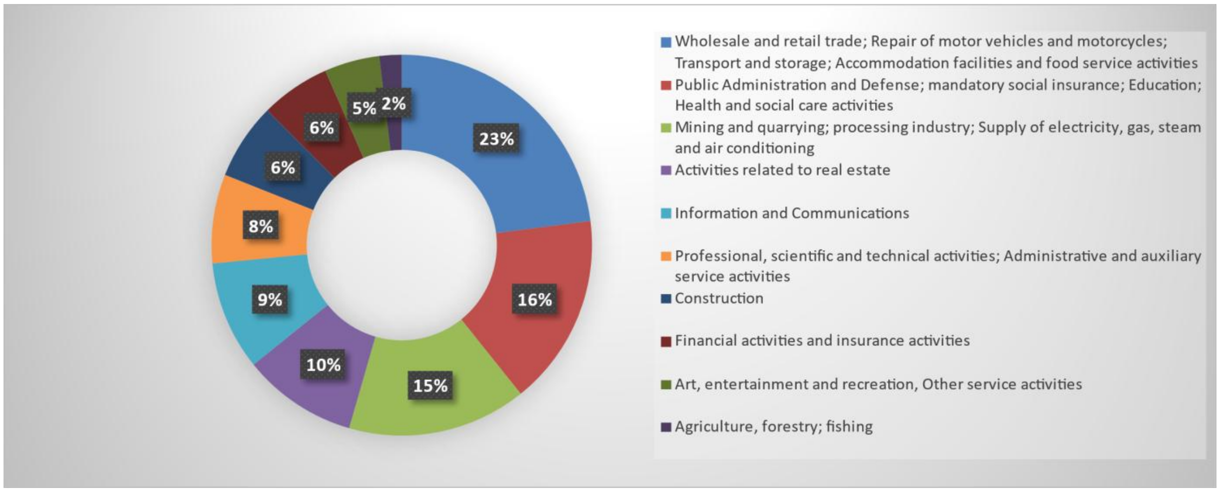

Figure 5. Gross value added in Skopje region in 2021, by sectors of activity

Table 7. Investments in fixed assets in Skopje region, by sectors of activity, in millions of denars

	2017	2018	2019	2020	2021
Agriculture, forestry; fishing	693	60	1,798	1,385	1,758
Mining and quarrying; processing industry; Supply of electricity, gas, steam and air conditioning	14,253	12,639	15,452	16,534	14,568
Construction	20,650	16,433	16,733	18,732	21,043
Wholesale and retail trade; Repair of motor vehicles and motorcycles; Transport and storage; Accommodation facilities and food service activities	15,725	14,311	17,915	16,655	16,529

Information and Communications	**7,188**	**6,907**	**6,674**	**7,334**	**9,936**
Financial activities and insurance activities	**1,593**	**1,587**	**1,516**	**3,472**	**2,037**
Activities related to real estate	**1,658**	**2,201**	**498**	**2,282**	**7,623**
Professional, scientific and technical activities; Administrative and auxiliary service activities	**3,817**	**3,470**	**2,320**	**2,565**	**3,552**
Public Administration and Defense; mandatory social insurance; Education; Health and social care activities	**7,498**	**8,159**	**8,839**	**12,033**	**11,477**
Art, entertainment and recreation, Other service activities	**3,736**	**3,485**	**2,339**	**4,834**	**2,323**
Total	**76,811**	**69,250**	**74,084**	**85,827**	**90,846**

From the presented data on GDP by years, it can be seen that the Skopje region participates in the formation of GDP in the Republic of Macedonia with an average of about 43%, or in a rounded way it would be said that half of the state GDP is formed in Skopje. The analysis of GDP per capita reveals that GDP per capita in Skopje is higher than the average GDP per capita at the state level, on average it is about 40% higher. These data give a picture of the strength of the economy of Skopje, which is the engine of the overall national economy.

The Trade sector (wholesale and retail) has the biggest contribution to the Gross value added with an average of 23% per year, and the public administration with an average of 16% per year. The relative share of agriculture is the smallest with only 1.9%.

The construction sector has the largest contribution to gross investments in fixed assets with 23.2%, followed by wholesale and retail trade with an average annual contribution of 20%, and again, the smallest contribution has agriculture with 1.9%.

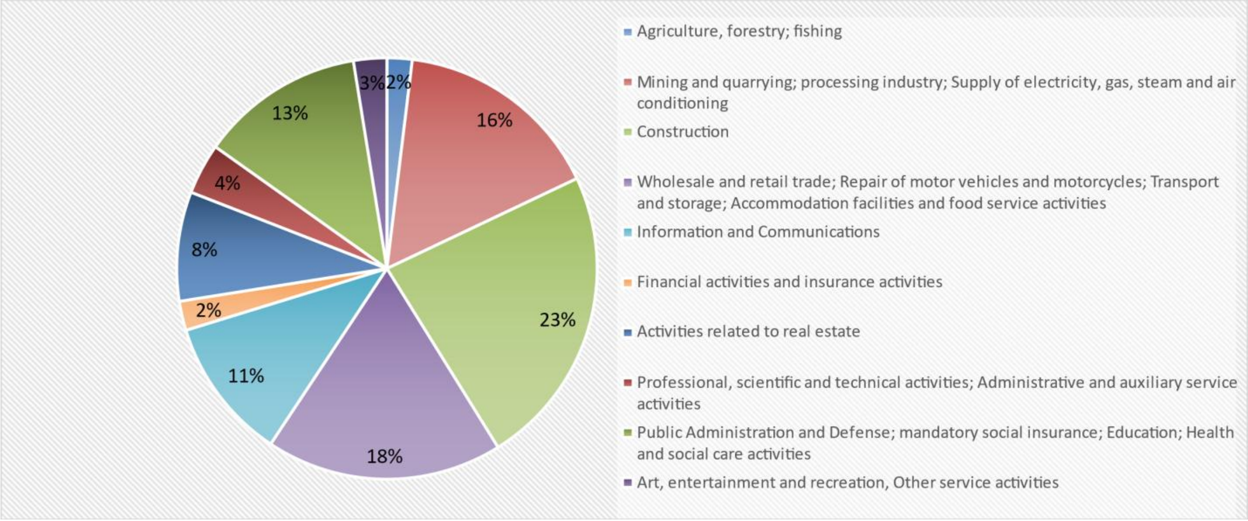

Figure 6. Investments in fixed assets in Skopje region in 2021, by sectors of activity

4 ASSESSMENT OF THE PAST CLIMATE RISKS AND HAZARDS IN THE CITY OF SKOPJE

A trend of air **temperature growth** in the second half of the 20th and beginning of 21 centuries was observed in the Skopje region as same as on the whole territory of the country. Besides raising the annual and summer mean temperature. In the past period, there were usually short periods of **heat waves** in Skopje[1]. 2012 was the year with the biggest number of heat waves but the longest heat wave was registered in 2003 (from 29 April to 15 May).

The last year with a significant number of **cold waves** in Skopje was 1991, but the years with the longest occurrence of cold waves were 2001 and 2002 (22 days). Most frequently the cold waves in Skopje occur in January and February. Significant differences in the temperature are registered between the central area (around Macedonia square) and other parts of the city (significant **urban heat islands**).[2]

In the last 60 years in the Skopje region, three major **floods** were registered and recorded. In 1962 when the water level of the Vardar River was at its highest more than 6000 ha in the region were affected and the economic loss was estimated to be about 7 % of the GDP. [3] High effects were registered during the flood in 1979. The most prone area to the appearance of stormy events is the north parts of Butel and Gazi baba municipalities, in the vicinity of the villages Stajkovci, Strachinci, Brnjarci and Viniche. In summer 2016, a very strong storm event in this region totally destroyed the infrastructure, and crops on several thousand hectares, infrastructure and caused 22 human casualties. Several neighboring communities were seriously damaged with more than 4500 households affected and the economic loss was estimated at 30 million Euros.

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

According to the central weather station of Zajcev Rid in Skopje the average annual precipitation quantity for the period 1981–2010 was 478.6 mm. The average monthly variations of precipitation reach maximum values in May and November/December, while the lowest are in January/February and August. The dry period lasts from July until September, often continuously for more than 60 days. The occurrence of intensive rainfall is frequent in the valley, especially during the warmer period of the year.

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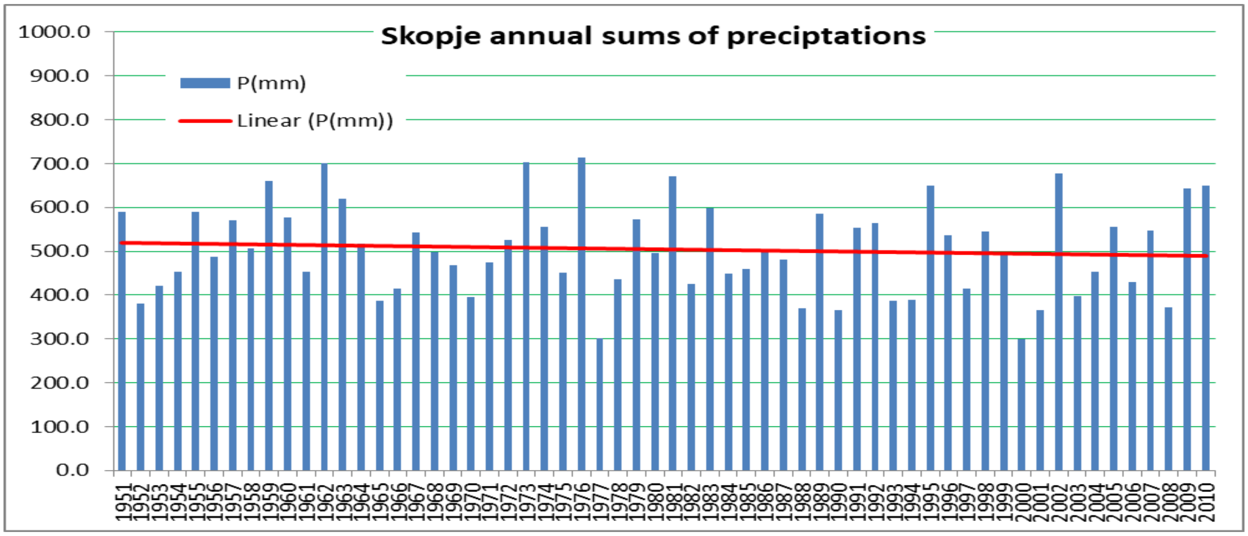
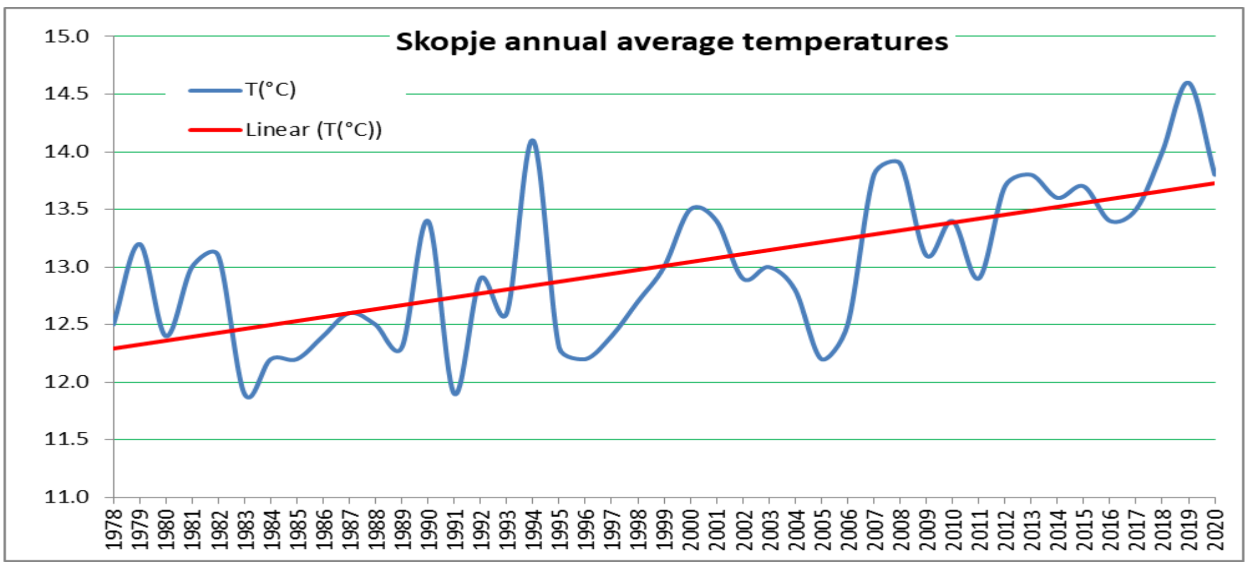
1 City of Skopje : Resilient Skopje – Climate Change Strategy , 2017

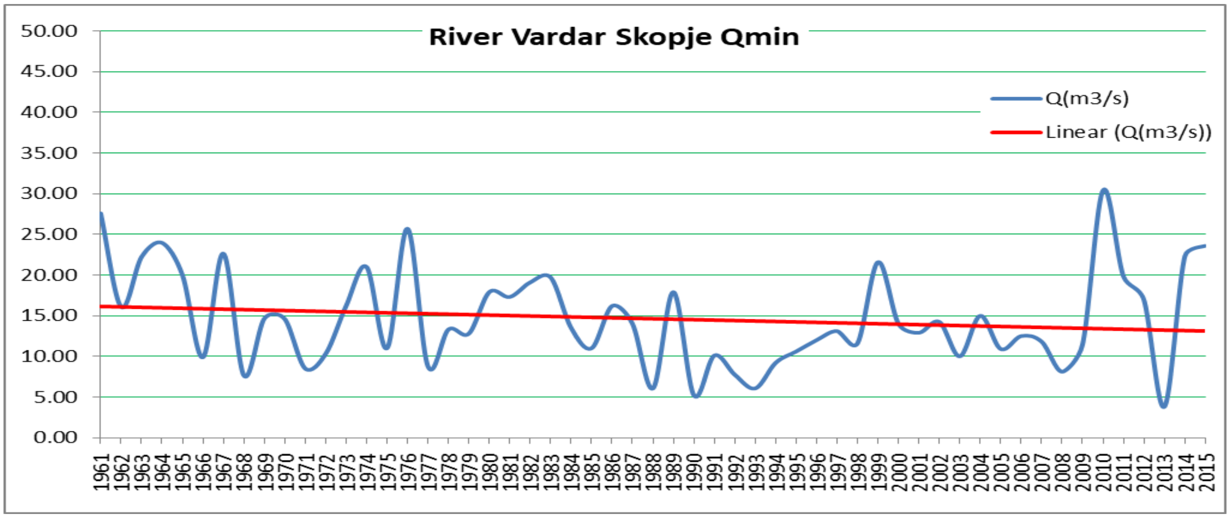
2 Trajanov. D. Urbani toplinski ostrovi vo Skopje, 2018

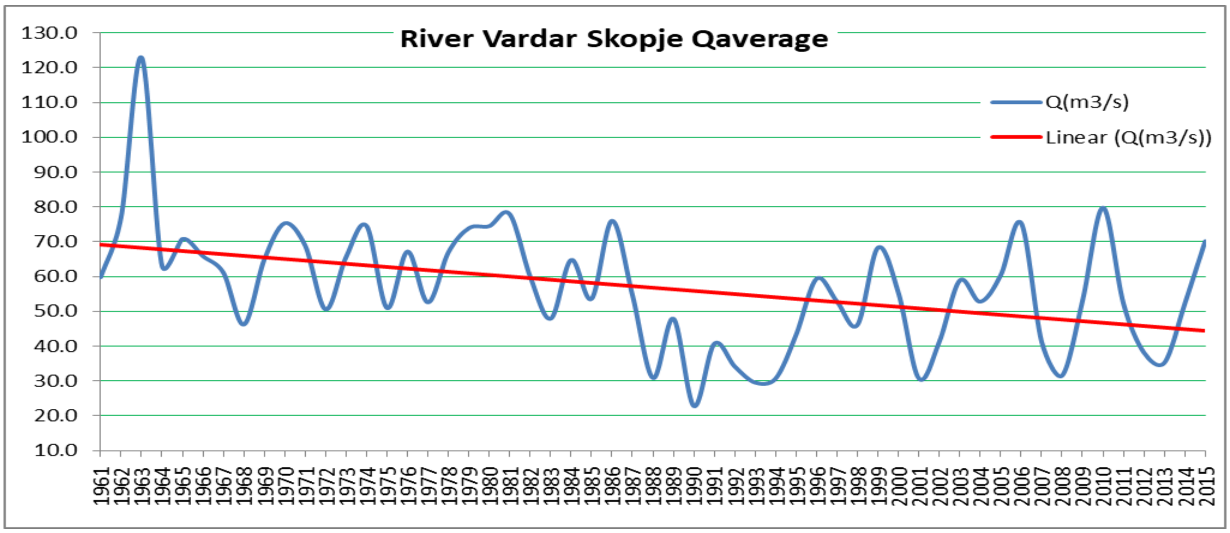
3 City of Skopje-UNDP: Studija za modeliranje na poplavite vo gradot Skopje, 2016

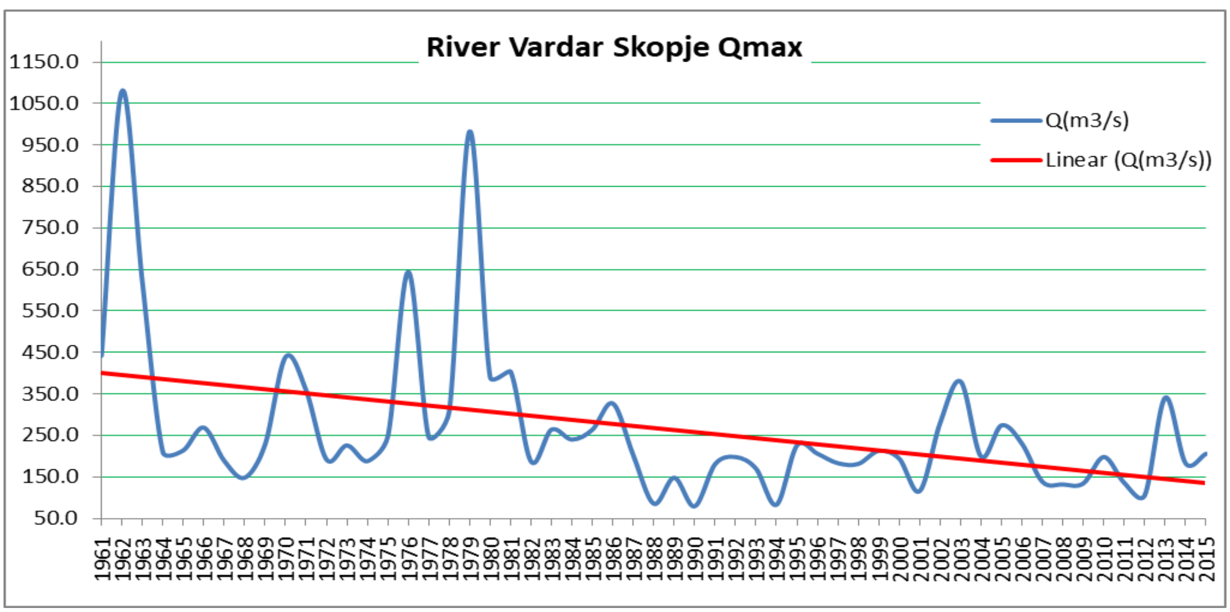
The year with the highest level of precipitation was 2014, with 782.9 mm, while the driest year was 2000, with 296.4 mm. The volume of precipitation is lower during the warmer period of the year (vegetation period), when the water consumption of the sectors identified as the major water consumers is at its highest. According to the drought index proposed by De Martonne, most of the years could be categorised as dry and semi-dry climate. In addition, the drop in the annual values of the De Martonne Index is also very important, showing a trend of increasing dryness in the region.






River Vardar Skopje Qmin
Q(m3/s)
Linear (Q(m3/s))


River Vardar Skopje Qaverage
Q(m3/s)
Linear (Q(m3/s))


River Vardar Skopje Qmax
Q(m3/s)
Linear (Q(m3/s))

4.1.1 Floods

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

EVENT	DATE	DAMAGE
Flood	**DECEMBER 1935**	**a small area of the city was flooded.**
Flood	**DECEMBER 1937**	**the downstream areas were flooded, while the city was protected with embankments.**
Flood	**NOVEMBER 1962**	**with economic losses amounting to about 7% of GDP. The water level of the Vardar River was at its highest, at 1.310 m3/s. Some 6,752 ha of land were flooded**
Flood	**NOVEMBER 1979**	**economic losses amounting to about 7% of GDP. The water level of the Vardar River was 980 m3/s. 7,550 ha were flooded.**
Flood	**AUGUST 2016**	**An intense flash flood in flooded the north-eastern area of the city, claiming 23 lives, destroying several settlements and causing economic losses of about 30 million Euros**

The picture below shows the hydrology characteristic of the City of Skopje, and the most important the area that are mostly flooded. It is evident that the central part of the city, i.e. Centar, Chair, Keramidnica, but also areas in the north part of the city are those that are mostly flooded urban areas caused by flash floods.

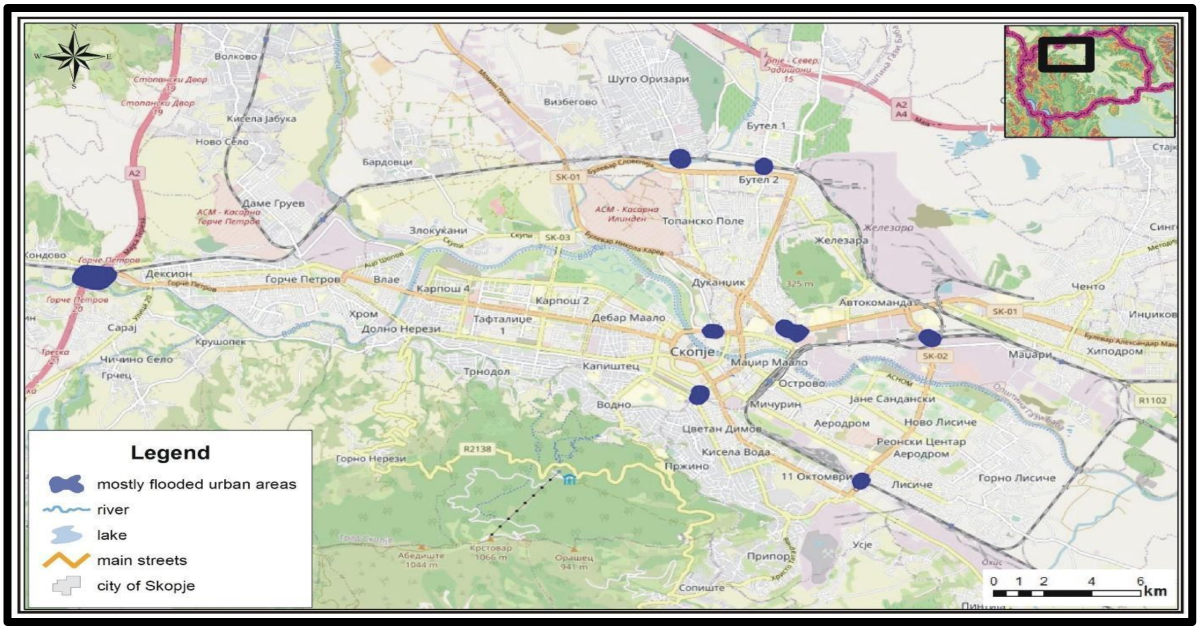


Figure 7. Locations in the city most prone on urban flood

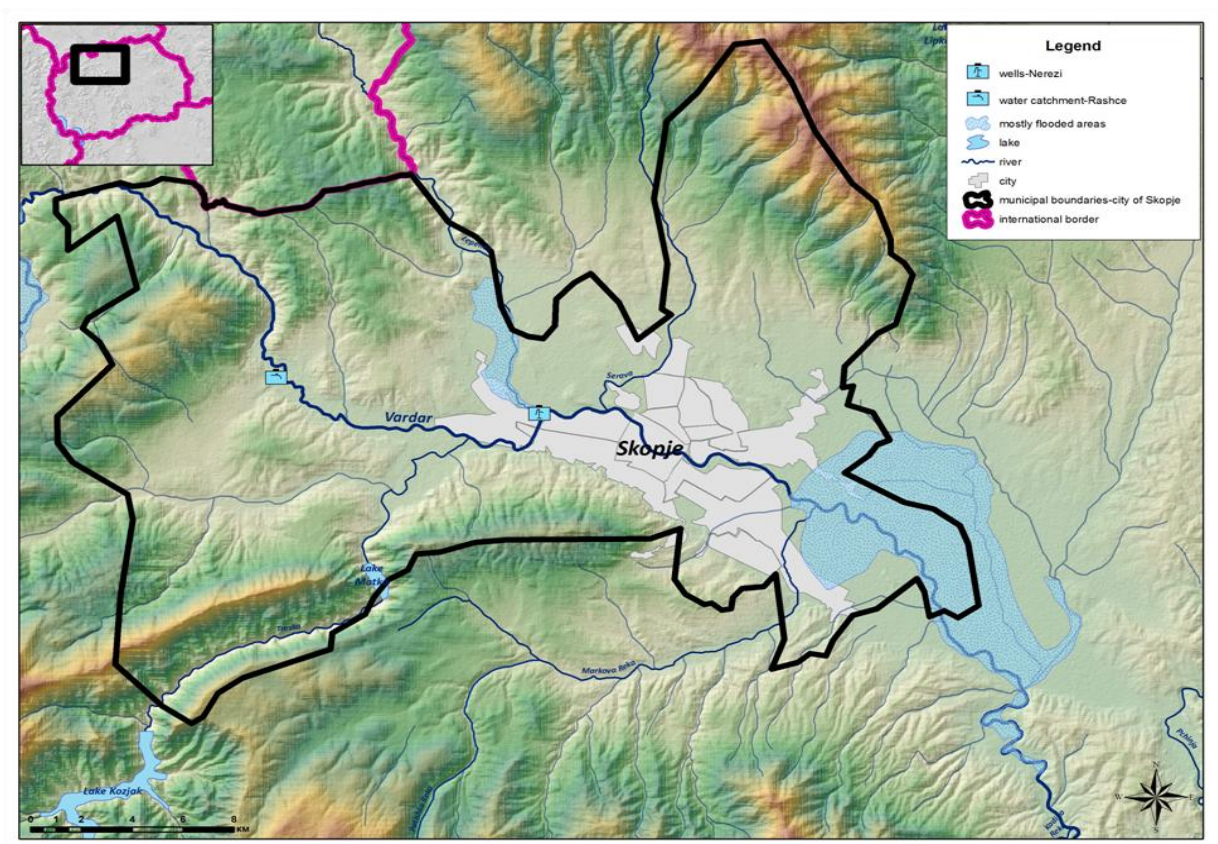


Figure 8. Mostly flooded areas in Skopje

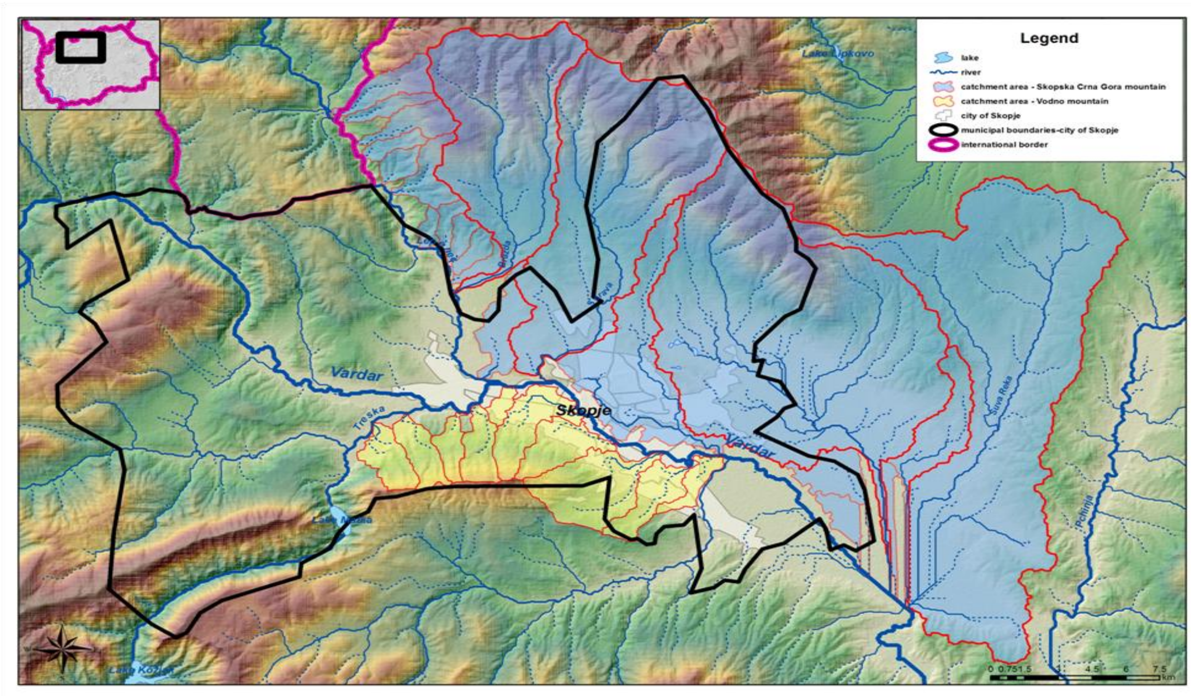
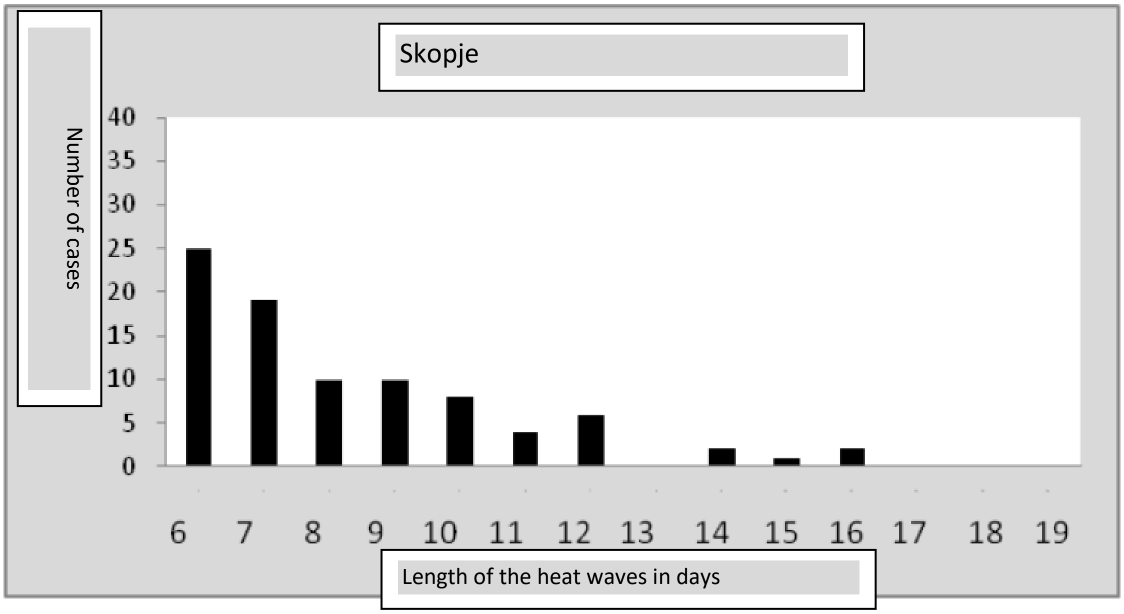


Figure 9. Vodno and Skopska Crna Gora torential catchments

4.1.2 Heat waves

Based on the analysis conducted by the Hydromet service, and the statistical analysis it can be noted that most frequently occur short heat waves (those with duration of up to 6 days), and the longer their duration is the lower are the chance to occur. In the period between 1961-2012 in the City of Skopje are noted 25 occurrences of heat waves[4].

[4] Hydromet analysis of extreme weather events



Up to the moment there are 25 cases in Skopje with a heat wave of 6 days. Heat waves have been most frequent in the last ten years. 2012 was the year with the biggest number of heat waves. Heat waves have been more frequent during the cold period of the year (November – April) than during the warm period of the year (May – October). In addition, heat waves are not equally distributed throughout the year. The largest number of heat waves have been recorded in the month of March (22 cases in Skopje), while the least number in April. The years with the highest occurrence of heat waves per year were as follows: May 2003, July 2003, July 2007 and October 2012.[5]

The picture below shows the annual frequency of occurrence of heat waves. The graph is for the City of Skopje and for the period 1961-2012. It is evident that the frequency of the heat waves are increasing especially after 1989 and then in the period between 1989 to 2007 there is no increase. The significant increase of heat waves is evident in the year 2012, when the number of heat waves significantly increase.

[5] Hydromet analysis of extreme weather events

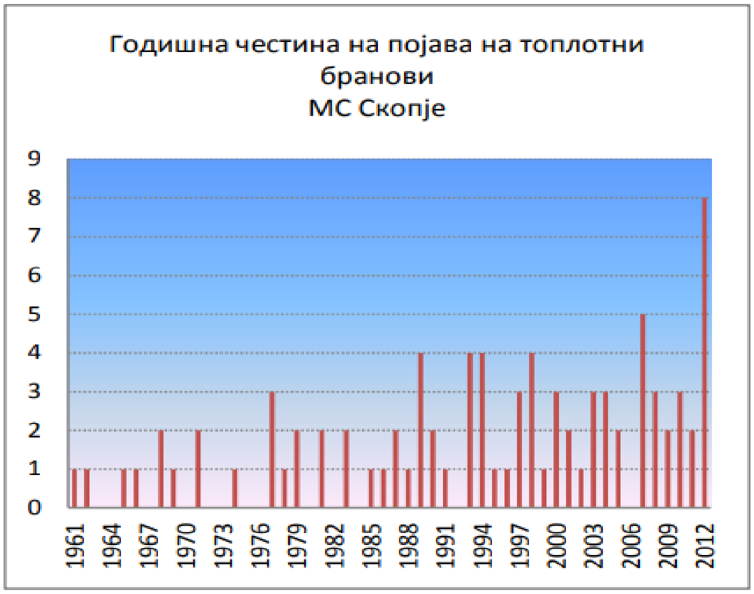


Figure 10. Annual frequency of heat waves

The graph below clearly shows the distribution of heat waves through the whole year. Heat waves occurred in March, April, June, July, August, September and October 2012. The longest duration of the heat waves is in July, but also in March and September. There is also extended duration in October but with lower temperatures.

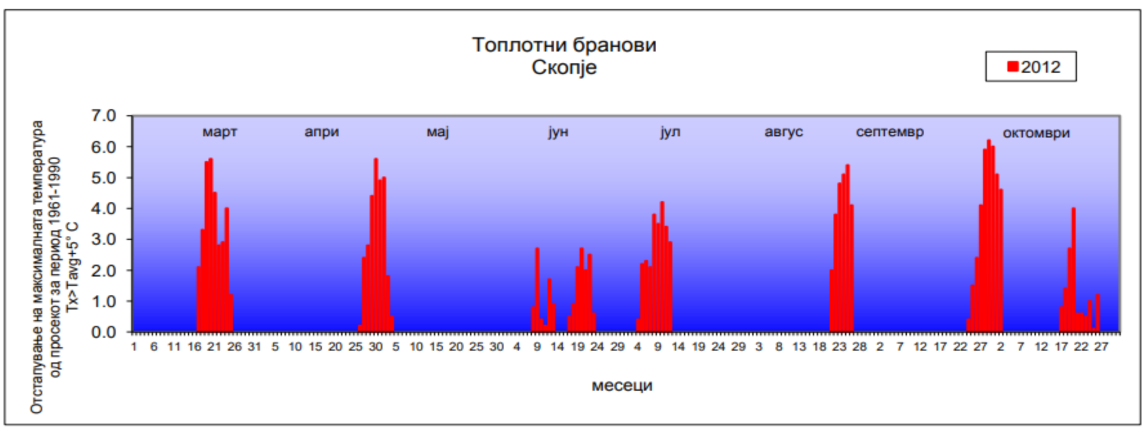


Figure 11. Heat waves

4.1.3 Cold waves

Unlike heat waves, the occurrence of cold waves in Skopje is falling. The total number of recorded cases of cold waves for the entire period 1961-2012 was 27, while the total number of recorded cases of heat waves for the same period was 87. Cold waves occur most frequently in January and February. The years with highest occurrence of cold waves per year (4 cases) were 1991 and 1967. The longest cold wave in Skopje was of 22 days between 17 December 2001 and 7 January 2002.[6]

The analysis held by Hydromet Service for cold waves is based on the statistical analysis of the daily maximum temperatures where main conclusion is that highest frequency has the cold waves with duration of 6 days. For Skopje are evident 7 cases of cold waves with duration of 6 days.

Figure 12. Frequency of cold waves

4.1.4 Droughts

The drought vulnerability is the best indicator for assessing the vulnerability to forest fires, agriculture activities as well as the hydrology potential and some economic activities within the region. So it can be summarised that the whole municipality is vulnerable to droughts in smaller or larger extent.

The drought vulnerability for the country where projections for the City of Skopje is also done indicate that City of Skopje is affected by drought in some way. The most dominant classes are "vulnerable" and "strongly vulnerable" to drought. The climatic data used for this analysis was 1981 to 2010.[7]

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[6] Resilient Skopje Strategy

[7] developed within the project: Achieving Biodiversity Conservation through Creation and Effective Management of Protected Areas and Mainstreaming Biodiversity into Land Use Planning, i.e. within the activity on Preparation of national erosion and drought sensitivity map, and identification of high risk zones and their impact to biodiversity

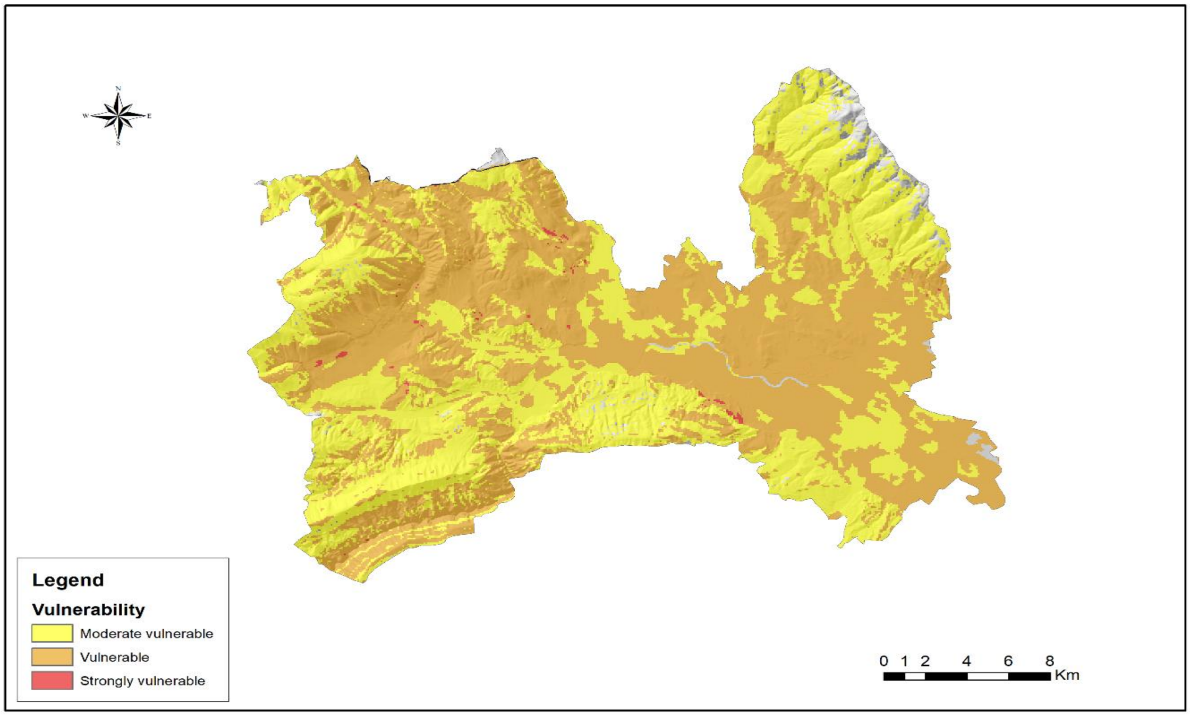

Figure 13. Drought vulnerability of Skopje municipality

4.2 Forest fires and open fires

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

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

5.1 Water Sector

Skopje region is very characteristic because is a region where most of the economic activities are happening and is main administrative center where is concentrated all the administration, and because of its importance is specific for understanding and identification of its vulnerability to climate changes.

Skopje Region has specific exposure and terrain configuration and in the past was very vulnerable and sensitive to climate changes with huge hazards and risks. The vulnerability is mainly due to that the City is a place where 3 rivers have junction, upper Vardar, r.Treska and r.Lepenec with possibility of superimposing the peaks of the 3 flood waves. Vulnerabilities of climate changes and their reflection on water resources was dominantly visible through appearances of extremes like floods and droughts. In the past there are several big river floods in this region like floods from 1935, 1937 and especially the floods from 1961 and 1979 causing damages and large flooded areas. With regulation of the river Vardar and with construction of the dams and accumulations on r.Treska, the possibility of appearances of this type of floods in this region is very diminished which shows that human activities can affect on climate changes and to decrease or mitigate the negative (adverse, harmful) effects.

- **Average annual sums of precipitation**

According to average annual sums of precipitation in the past, it is evident that referring to annual average discharges, rivers in the region didn't had special vulnerability to climate changes and don't indicate large hazards or risks. But, it should be emphasised 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 possible 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.Serava, r.Markova, r,Kadina) causing inundations and flooded areas.

- **Days with precipitation above 40 mm**

Except huge river floods, the region in the past was also prone (susceptible) to flash floods caused by havy intensive precipitation. According to the days with precipitation above 40 mm, the most vulnerable are north-west parts of the region where are present this types of days that varied in the range of 1,9-2,8. There are many torentials in the region of Skopska Crna Gora mountain where the danger of appearing of the flash floods is big. The classic example of this is the big flood in 2016 when were registered 22 casualties. Also, in the region of Vodno mountain are identified torrents with potential danger and vulnerability of possible flash floods.

- **Number of events with extreme precipitations**

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

- **Consecutive drought days**

Skopje region in the past was not so vulnerable on climate changes and drought periods according to appeared (occurred) drought days and generally there were not problems with water supplying of the city. Referring the consecutive drought days, it can be seen that the biggest part of the city don't have long duration of drought days and the same can be seen from the map that shows the average days of drought periods, with exception of the north-west part of the region where can be seen longer duration of drought days and more numbers of drought days or drought periods.

It is a positive circumstance that Skopje has spring like Rasche with quite constant capacity during the years and able to satisfy the needs of the drinking water in the region in the past. But, there were still some exceptions when during the summer periods the capacity of the spring decreases and for its replenishment were used the waters from the Nerezi-Lepenec wells system.

In the past, especially in the recent past in the region have occurred problems with filling of the artificial accumulations of r.Treska (Kozjak, st.Petka and Matka), and also Mavrovo Lake which waters indirectly through power plants Vrutok and Raven goes to the Vardar river basin and flows through the city of Skopje. That was caused by the drought periods and decreased inflow in the accumulations, especially expressed in the summer and winter months. The lack of water in the accumulations can cause some instability at power supply from the power plants.

- **Frost days**

From the analyses of frost days it is evidently wide range of spatial uneven distribution in the region, that can drive us to the conclusion that in case of prolonged dry summer and autumn periods and occurring of frost days in November and December it is possible to happen winter minimum at some of the rivers (mostly the smaller ones) in the region. River Vardar because of the artificial influence and the specific runoff regime of flowing is exempted from this possibility.

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

Assesment of risk of climate extremes according to their vulnerability, exposure and hazard

Climate extremes	Vulnerability			Exposure			Hazard			Risk		
Days with P>40 mm	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	low	medium	high	medium	medium	medium	low	medium	high	low	medium	high
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	high	medium	medium	medium	low	medium	high	low	medium	high
Annual and sesonal amount of precipitation	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium
Consecutive Drought Days	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	low	low	low	low	low	low	medium	medium	medium	medium	medium	medium
Annual and sesonal average daily temperatures	past	short future	medium future	past	short future	medium future	past	short future	medium future	past	short future	medium future
	medium	high	high	medium	medium	medium	medium	high	high	medium	high	high

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

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5.2 Health sector

As health consequences of **extremely high temperatures** and heat waves will lead to increased rates of deaths, heat stress, and diseases, they can, especially affect sensitive population groups like children elderly, physically and economically disadvantaged groups, people working outside, and the homeless. They can also worsen chronic conditions such as cardiovascular disease and respiratory and cerebrovascular diseases. People over 65 are the most vulnerable to heat-related illnesses. During the heatwave period in July 2007, an increase in temperature of 1°C above the heat cut-point (30.8°C) in Skopje, led to an increase in the population's total mortality of 4.8%. Further analysis showed a positive correlation between the time series of maximum temperature and daily mortality in Skopje for the variable 'warm' (May September for the period 1996-2000). Urban heat islands in Skopje is, unfortunately, a usual phenomenon during the summer. The decrease in green areas and increase in the use of fossil fuel energy are among the main reasons together with the increased city population density. Among others, the heat island is also contributing to the summer air pollution in Skopje, with the evident *raising of the ozone concentrations* (also due to the heavy city traffic). Among others, this kind of air pollution significantly contributes to the increased cardiorespiratory morbidity and mortality during heat waves periods. One of the few existing estimations related to climate change focused on morbidity and mortality from heat waves in Skopje over a 5-year period from 2006 to 2010, estimated an annual average of 316 additional cases of cardiovascular disease and 344 additional cases of respiratory disease attributable to climate change, with 13 and 1 deaths resulting, respectively. The estimated average cost resulting over the 5-year period was €1.2 million per year or €2.5 per inhabitant of Skopje.

The studies on foodborne diseases showed that disease episodes of heat wave *Salmonella* bacteria increase by 5-10% per each degree Celsius rise in temperature. *Salmonella* cases show a strong seasonal pattern, with the highest number of cases in the summertime. For Skopje, it was estimated that the increase in the weekly temperature of 1°C above the detected threshold of 17.9°C is associated with a 2.8% rise in the number of salmonellosis cases.[8]

Though the number of **cold waves** in Skopje is falling in the last few decades it still can be a threat to human health, especially among the elderly population and people with low socioeconomic status. The last year with a significant number of cold waves was 1991, but the years with the longest occurrence of cold waves were 2001 and 2002 (22 days). Most frequently the cold waves in Skopje occur in January and February. On another side it is obvious that mortality within the City of Skopje displayed a marked seasonality, with peaks in the winter and relative troughs in the summer. In the Skopje study in 1996-2000, the average daily total of deaths was 7% and 13% higher in the cold when compared to the whole period and warm period respectively. The same relationship was noticed for deaths caused by cardiovascular diseases. Excess winter mortality can be defined as an indicator of the cold wave's health impact on an annual basis. An inverse correlation between the temperature of the ambient air in Skopje

[8] D.Gjorgjev : Climate Change impact on the Health Sector in the city of Skopje in : City of Skopje : Resilient Skopje – Climate Change Strategy , 2017

and the concentrations of PM10 particles was registered, which means that the highest concentrations of PM10 particles were measured during the periods when the ambient air temperature is the lowest. Investigations showed that annually Skopje loses more than 600 citizens due to high air pollution.[3]

As per the other diseases that could be linked with climate change effects. The study on the climate change impact on pollen found out that the prevalence of sensitivity to standard pollen allergens in Skopje shows an increase from 16.9% in 1996 to 19.8% in 2009/2010. The trend of malignant melanoma (skin cancer) in Skopje region that could be associated with UV-light exposure, is slightly increasing, mainly predominant in males.

In the last 60 years in the Skopje region, three major **floods** were registered and recorded. In 1962 when the water level of the Vardar River was at its highest more than 6000 ha in the region were affected and the economic loss was estimated to be about 7% of the GDP[9]. High effects were registered during the flood in 1979. The most prone area to the appearance of stormy events is the north parts of Butel and Gazi Baba municipalities, in the vicinity of the villages Stajkovci, Strachinci, Brnjarci and Viniche. In summer 2016, a very strong storm event in this region totally destroyed the infrastructure, and crops on several thousand hectares, infrastructure and caused 22 human casualties. Several neighboring communities were seriously damaged with more than 4500 households affected and the economic loss was estimated at 30 million Euros

[9] City of Skopje-UNDP: Studija za modeliranje na poplavite vo gradot Skopje, 2016

Table 8. Past and current Climate hazards and health risks in Skopje region

Climate hazards/extremes	Probability	Past and current health impact/risk	Probability to happen	Future expected change in hazard/impact intensity/frequency	Time frame
Extreme Heat (Increase Temp, Prolonged number and duration of heat waves, Heat islands in the central urban areas Tropical nights, extended summer days	**High**	Increased heat mortality; Increasing additional deaths and cardiorespiratory diseases, especially among the elderly and chronically ill patients Increased cardiorespiratory diseases Increased water and foodborne diseases during summer Possible spread of new vector-transmitted infectious diseases Increase in heat-related consultations, emergency calls, and hospital admissions Overheating of HC buildings, impact on infrastructure and supplies Central urban municipalities are at the greatest risk (Skopje)	**High**	Increasing of the Temp.' number and duration of heat waves, extending summer	**Short term** **Medium-term** **Long term**

Low temperature and cold waves	**Low to moderate**	Increased morbidity and mortality for vulnerable and elderly people especially during extremely cold days with high air pollution	**Low**	**Low**(winters will be warmer)	**Short term** **Medium-term**
Extreme precipitation and rain accumulation Flooding	**High** (in some parts of Skopje)	Increased population exposure to a range of negative health impacts like drowning, injuries, mental health effects, and increased spread of waterborne infectious diseases. Damaging in the infrastructure, transport, and healthcare facilities including the accessibility Deterioration of the epidemiological situation especially drinking water quality in the affected areas(esp. microbiological quality) The increased need of emergency and mental health support River-side communities at greatest risk	**Moderate to high** in some parts of Skopje	Will increase especially in autumn and decrease in summer	**Short term** **Medium-term**

Droughts	**High** in Skopje valley	Decreased availability and quality of drinking water with the increased trend of waterborne infectious diseases	High to moderate	The risk could **increase** in Skopje valley (esp. in rural settlements with no safe drinking water)	**Mid to Long term**
Forest fires	**Moderate to high**	Destroyed huge areas of forest and wood mass, increased emission of fine particles and ozone precursors Increase risk of premature deaths and adverse chronic and acute cardiovascular and respiratory health outcomes. (Possible risk/impact)	**High**	will **increase** in the dry and forest areas in all three municipalities	**Short to Long term**

Table 9. 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)**

5.3 Agriculture sector

Simplified Vulnerability explanation is presented on Figure 3. In general, agricultural vulnerability provides a useful theoretical framework, as it evaluates the possible susceptibility of crop yields, and assists in the appraisal of the trade-offs between climate-induced vulnerability of crop yields and farmer livelihoods (Berry et al., 2006). Such an analysis aids the development of relevant adaptation strategies (Fellmann, 2012). Agricultural vulnerability is a variable condition generated by multiple environmental and social processes, and would depend and differ on diverse contexts and circumstances (Berry et al., 2006).

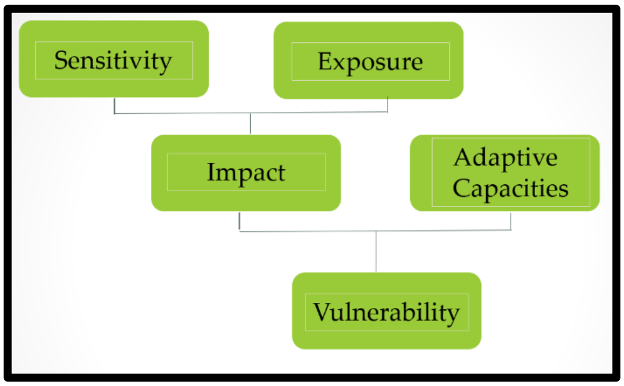

Figure 14. Simplified vulnerability graph

The UNFCCC explain that adaptation of agricultural sector refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. In simple terms, communities need to develop adaptation solution and implement action to respond to the impacts of climate change that are already happening, as well as prepare for future impacts. Therefore, adaption to climate change means taking action to prepare for and adjust to both the current effects of climate change and the predicted impacts in the future.

The risk and vulnerability assessment of the agricultural sector in the Municipality of Skopje, was prepared in three phases: Assessment of the past climate risks on agricultural sector, future climate risks and Identification of priority risks and indicators. In the first phase an assessment of the vulnerability to past climate events was performed for the agricultural production in the Municipality of Skopje.

The vulnerability assessment of the agriculture was based on analysis of basic climatological parameters and certain weather extremes which are of importance for the agricultural sector. Global climate data sets were used with a spatial resolution of 12x9 sq. km. Climate data used for this assessment covers the past climate events for the period 1990-2020 and three other periods of future events on a short (2016-

2035), medium (2046-2065). The future climate events and indices were modeled on the basis on the medium RCP 4.0 scenario[10]. Additional spatial data sets from previous investigations and information for the Municipality of Skopje were collected as well.

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 ten municipalities encompassed within the City of Skopje, 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

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. These two parameters give the initial hints for the possibility of growing of certain agricultural crops and varieties and are closely related with some other climate indices which are of importance for crop growing, such as evapotranspiration, dater deficit, humidity aridity index etc.

The dynamics of the average annual air temperatures was estimated on the base of the available spatial data for the monthly averages for the periods: 1980-2020. Out of the data presented in Graph 1 it can be seen that the majority of the territory is with average annual air temperatures in the ranges from 10.8-11.5 C^{o}, except certain parts on west within the municipalities of Gjorche Petrov and Saraj and on north of the municipality of Butel where the yearly averages are much lower. Obviously, the air temperature averages are closely related to the altitude and proximity of mountainous frame of the valley.

The yearly sum of precipitations is the second meteorological parameter which shapes the climate conditions in the area of City of Skopje. The yearly sum of precipitation for the period 1990-2020 is in the ranges of 465-642.9 mm, for the central part of the city and the majority of the surrounding area except municipalities on a higher altitude. Obviously air temperatures and precipitations have same pattern of its spatial distribution which is mostly correlated with the altitude.

[10] Report on climate change projections and changes in the extreme weather events in North Macedonia, Vladimir Gjurgjevic, February 2020

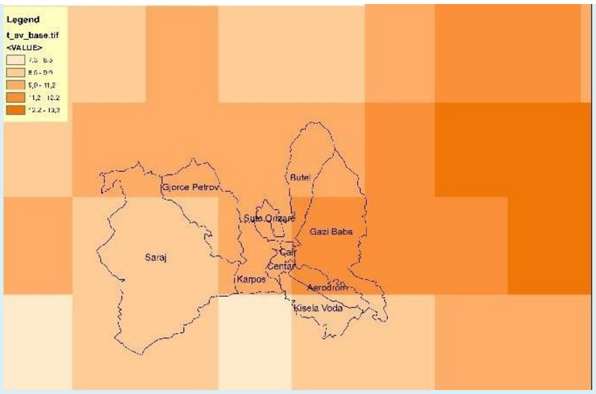

Figure 15. Average annual air temperatures (1990-2020)

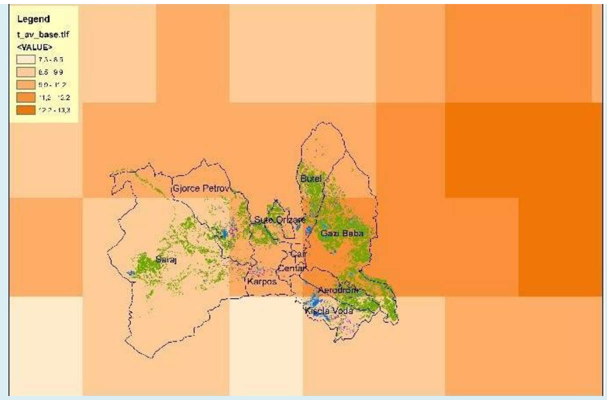

Figure 16. Agricultural areas vs. temperature (1990-2020)

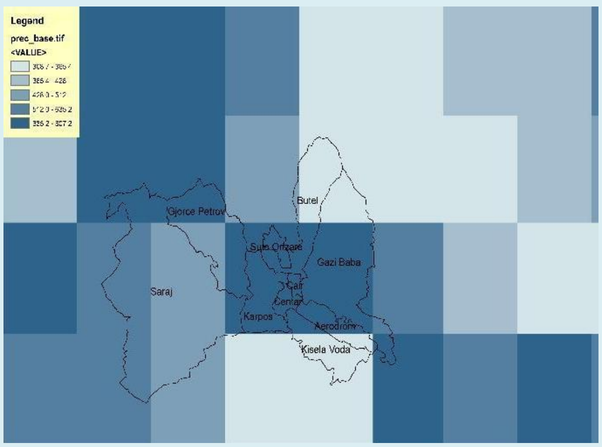

Figure 17. Average annual sums of precipitations (1990-2020)

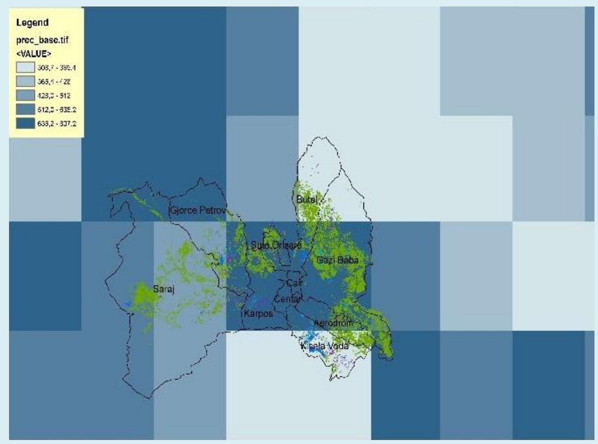

Figure 18. Agricultural areas vs. precipitation (1990-2020)

With regards to the exposure of agriculture sector to the past and current climate conditions, it should be noted that almost all agricultural area in the City of Skopje falls within the hottest part of the valley with annual average air temperature in the ranges of 10.9-12.5 Co. Precipitation map for the same period shows that all agricultural area is located in the driest easter part on east and north east with average annual sums of only 465-557.6 mm, except a small part of agricultural land in Saraj municipality, mainly grown with vegetables, where yearly sums are in the ranges of 557.5-642.9 mm.

<u>Frost days and last spring frosts</u>

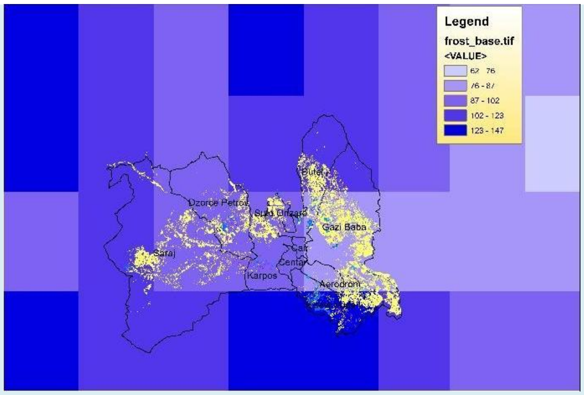

Figure 19. Frost days

Table 10. Date of extreme events of last frosts

Year	Month	Day	Region	T, C^o
1999	4	9	K.Voda	-4.61
2001	4	17	Butel	-2.09
2015	4	9	K.Voda	-3.01
2012	4	2	Saraj	-2.85

Number of frost days during the year especially their temporal and spatial distribution defines the length of the vegetation season. On Figure 19 are presented the spatial distribution of the sums of frost days in the City of Skopje for the period of 30 years (1990-2020). The majority of the agricultural land falls within two categories with 76-87 and 87-102 frost days, respectively. However, certain part of the Kisela Voda municipality which is dominantly grown with perennials (orchards and vineyards) is in the category with higher number of frost days (123-147), which indicates strong exposure of perennial agricultural crops to frosts.

To this end, of particular importance especially for fruits is the data of the last frosts at spring, when they are in the very sensitive phase of flowering and bud formation. The vulnerability of orchards in this phase is very high to the last frost, which within several hours in the morning can compromise the whole yield. There are many examples in the past period of appearance of late frosts, but in Table 10 are presented only the year with frost after the first week of April with temperatures of minus 2 or lower. The lowest temperatures are detected on April 9-th 1999 when the air temperature was -4.61, while in 2001 in the latest frost in spring with temperature bellow -2 C^o.

Heat waves

Heat waves are calculated on the base of daily measurements of the air temperatures for the period 1990-2020. Temperatures above the maximum air temperature of 30 C^0 was set as a threshold for the air temperatures to be considered as extremes. The duration of the events is another dimension; hence, events longer than 6 days are counted as heat waves. Heat waves usually appears 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 of the overheated plants. Having in mind all these facts it can be concluded that the most of the agricultural plants are highly sensitive to heat waves. For evaluation of the exposure to hot waves, two parameters were analyzed: the average duration of the longest hot waves events and the average number of events per year. Out of the data presented in Figure 20 it can be concluded that the area of the City of Skopje falls within 3 categories of hot waves duration. The central part is in the category with the average duration of 11-13 days/year, the northern parts of the municipalities of Gazi Baba and Butel falls in the category of 9-11 days/year. While some parts of Saraj and K. Voda on east have the lowest average duration of heat waves have the average duration of 3-9 days/year.

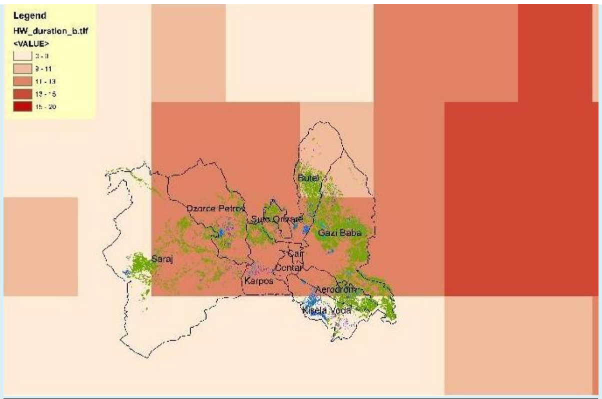

Figure 20. Average duration of longest HW events

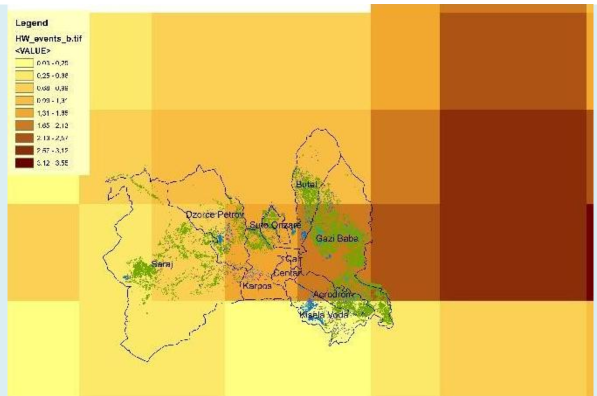

Figure 21. Average number of HW events/year

The number of heat waves events is presented on Figure 21. The average number of heat events for the analyzed period 1990-2020, increases toward east starting with re determined in the eastern parts of the City of Skopje which are the lowest part of the valley, starting with 0.2-0.3 events per year, up to 1.65-2.12 events on east where the most part of vegetable production is located. The lowest number of heat waves events was detected in eastern part of Saraj and on southern part of K. Voda with 0.25-0.3 and 0.03-0.25 events per year, respectively. This is in favor for the vegetable production in Saraj and orchard and vineyards in K. Voda.

Drought events

Drought events during the vegetation seasons represents a serious risk for agricultural crops, especially in particular phases of plant development. Absence of rainfalls for a longer period coupled with high air temperatures when evaporation is at its peak, can cause serious water deficits for the plants, causing serious stress and reduced yields. More frequent drought events and prolonging of its duration, are the main outcomes of the negative impact of climate change on rainfall regime. Most of the drought events appears during the months of the vegetation season. The average duration of drought events is very important, because long periods with no rain can have a serious negative effect even on irrigated crops. the spatial variability of the average duration of drought events for the area of City of Skopje is presented on Figure 23. The map represents the average duration of the longest dry events from the period 1990-2022. The most part of the City zone is in the first category with the average duration of drought periods from 10.47 to almost 12 days, while some parts of Saraj, G. Petrov and Kisela Voda have a slightly longer average duration of drought periods (11,98-13,11). The general conclusion is that the City of Skopje is in a better position that the adjacent wide area on north east. However, the duration of the average dry events is still worrying, having in mind that the most part of the agricultural area is in a zone with average length of more than 13 days, which indicates that certain picks might be much longer.

A 2 weeks periods with no precipitation, during the vegetative period is a serious risk for the agricultural plants. Some parts of the City of Skopje (Aerodrom and Gazi Baba) belong in the semi arid zone of the valley (Figure 22), while the other parts are located in the sub humid and humid zones (Blinkov *at all* 2021).

According the result presented in Figure 24 the number of dry events (periods with no rainfalls longer than 1 week), have the same distribution like the duration of the longest dry period. The average numer of dry events in the City of Skopje area is in the ranges from 4.6-5.8 events (1990-2020) for the western part of the city (G. Petrov and Saraj) to 5.5-7 events. The most vulnerable zone is the northern part of Butel municipality with 8.5-9.7 events during the year.

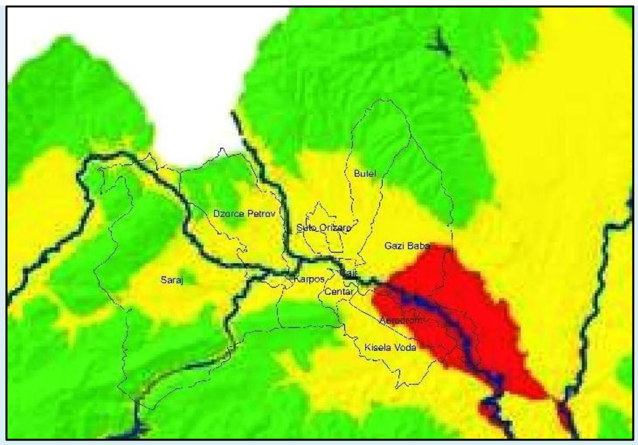

Figure 22. Aridity in City of Skopje

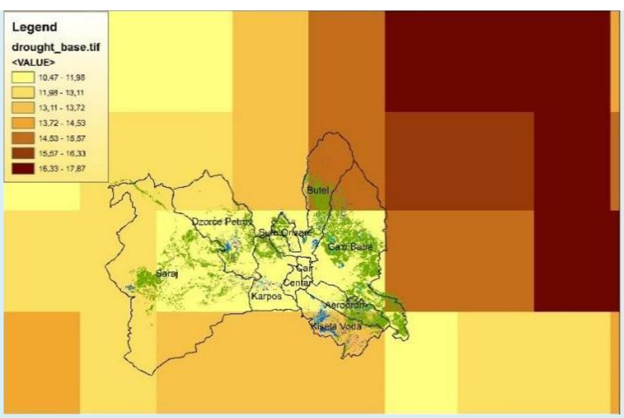

Figure 23. Maximum duration of dry periods

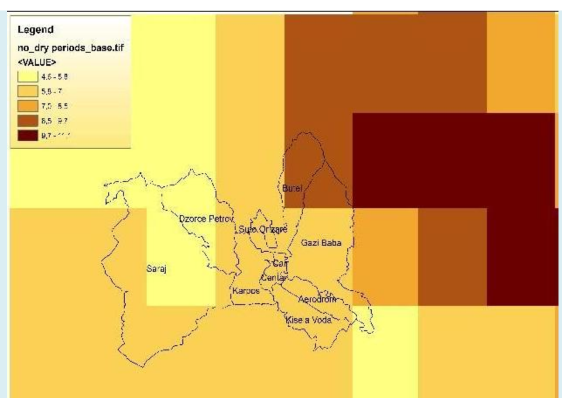

Figure 24. Average yearly number of dry periods

Days with precipitation over 40 mm

Another aspect of a disbalanced rain regime is the appearance of very intensive rainfalls, when huge amounts of water that collapses within a very short period of time. Usually, such stormy events happen during the summer period over a small area. Huge amounts of excessive surface water which cannot be infiltrated into the topsoil, causes serious run-offs downstream on a sloppy terrain. Such torrential waters dragging enormous quantities of sediments and depress can cause serious damages on agricultural crops and the overall infrastructure (houses, roads, channels etc.). The average number of events with rainfalls bigger than 40 mm that appears every year, for the period 1990-2020 are presented on Figure 25.

Most of the area of the City of Skopje as well as the majority of agricultural land is located in the areas with average of 1.3-1.6 stormy events with precipitations over 40 mm. The most prone area to the appearance of stormy events are the north parts of Butel and Gazi baba municipalities, in the vicinity of the villages Stajkovci, Strachinci, Brnjarci and Viniche. In the summer 2016, a very strong storm event in this region totally destroyed the infrastructure, crops on several thousand hectares and caused 22 human casualties.

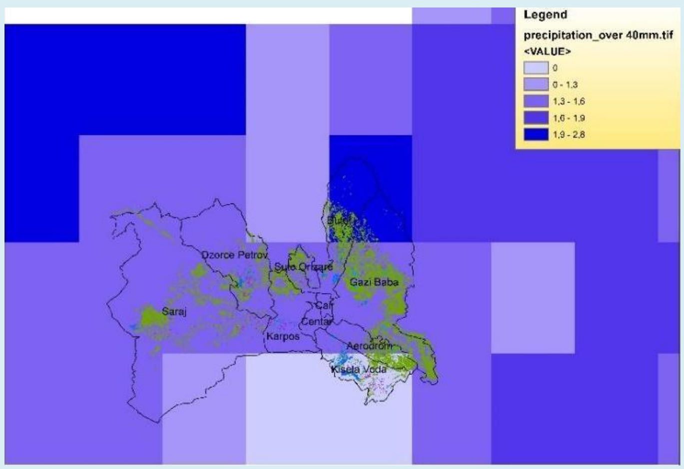

Figure 25. Events with precipitation >40 mm/year

<u>Length of vegetation season</u>

The length of vegetation season is very important parameter when creating the cropping pattern and land use in a certain area. When air temperatures reach above 5 C^0 in spring, this moment is counted as a start of the vegetative season for the autumn crops, while for the spring crops, the air temperatures should be above 10 C^0. Obviously, this climate parameter is closely related to the air temperatures, mining that with projected ricing of air temperatures due to global warming, once would expect prolonging of the vegetation season, or shifting of start and end dates. Such shifting of vegetation season influences the other phases of plant development. For these reasons phenological observations of the plants are very important for timely application of certain agro-technical operations, like: irrigation, fertilization, plant protection etc. Omission to timely apply certain operations can seriously affects the plant health and appearance of pests and diseases, nutrient deficiency symptoms or water deficits. In all of these circumstances, the plant will be under stress causing yield reduction. Shifting of vegetation season start date is related to certain risks for the plants, namely in many years in the past the appearance of late frosts caused severe damages to the orchard plantations. Such risks are even higher with earlier start of the vegetation season, because plants start growing earlier making them more vulnerable to the negative effects of late frosts.

The average duration of vegetative season in days (above 5 C^0) for the period 1990-2020 for the City of Skopje area, is presented in Figure 26. The results shows that the length of the vegetation season in some parts of City of Skopje is very diverse, staring from its maximums of 283.7-294.7 days in Saraj, to only 217-236 days in the higher parts of Kisela Voda municipality. In general, the urban area of the territory have longer season, compared to the adjacent rural areas.

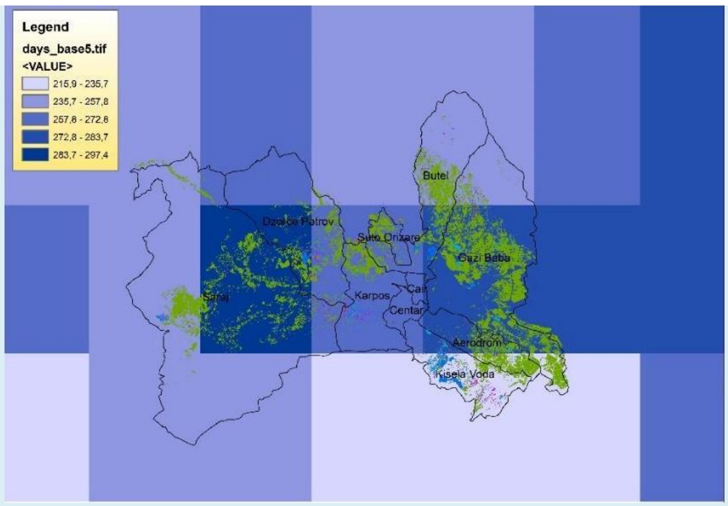

Figure 26. Length of vegetation season, (>5 C^0)

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

Yearly sums of temperatures is another climate index that is closely related to the overall climate conditions, especially air temperature (average, min,. and max), the number of days of the vegetative season etc., hence there are similarities with regards of the spatial distribution of this index and the lenght of the vegetative season (Figure 26).

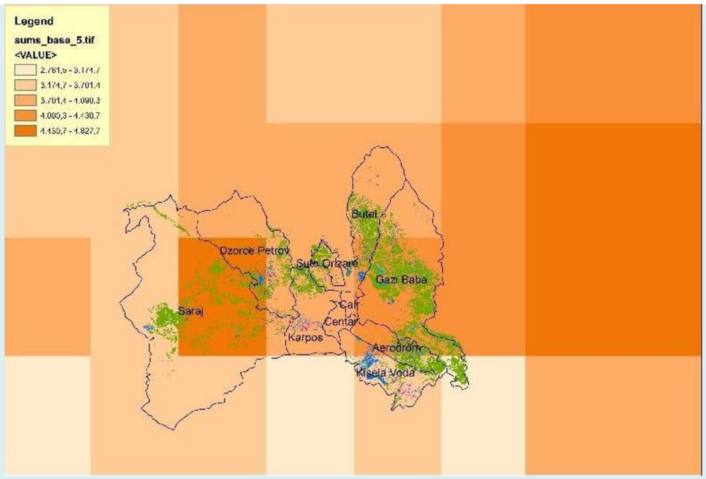

Figure 27. Yearly sums of effective temperatures >5 C^0

Agricultural plants have certain thresholds for the optimum sum of temperatures during the vegetative season. The temperature sums for the City of Skopje, are significantly variable. The highest sums of temperatures (4430-4827 C^0) is detected in the municipalities of Saraj and G. Petrov, which in the same time have the longest vegetative season, while the lowest sums are in the highest locations of Biutel, G. Baba and K. Voda municipalities towards the foothills of Skopska Crna Gora and Vodno mountains. The majority of the agricultural land is in the zones with yearly temperature sums higher than 3700 C^0, which indicates hot climate. Some agro-technical operations, are related to the sum of temperatures at certain points, like application nitrogen fertilizers, irrigation etc.

<u>Thermal Humidity Index for livestock</u>

Livestock production in the City of Skopje accounts for all main species. However, due to the urban character, the majority of the livestock is in peri-urban municipalities. Even though the City of Skopje is not a main agricultural area in the country, a significant livestock population still occurs, primarily due to the high demand for livestock products by the inhabitants. 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 City of Skopje suggest that the resilience of the sector is very low, stressing high vulnerability in the future.

Table 11. Number of heads in different livestock species in the City of Skopje

	Cattle	Sheep	Goat	Swine	Poultry	Honey bee hives
City of Skopje	7994	12902	2890	5185	54080	2545

Source: SSO, 2018

The majority (above 70%) of the ruminant population (cattle, sheep and goats) are in Butel, Gazi Baba and Saraj; 57% of the swine population is in Gazi baba and Kisela Voda; 72% of poultry are located in

Butel, Gazi Baba and Gjorche Petrov; while 72% of the hives of honey bees are in Butel, Gjorche Petrov, Kisela Voda and Saraj. Hence for the analysis of the impact of climate change on livestock production in the City of Skopje, the municipalities Centar, Karposh, Chair and Shuto Orizari are of less importance.

Table 12. Distribution of the livestock species over municipalities in the City of Skopje

	Cattle	Sheep	Goat	Swine	Poultry	Honey bee hives
Aerodorm	2%	3%	7%	13%	10%	1%
Butel	15%	23%	17%	9%	15%	15%
Gazi Baba	25%	24%	22%	41%	37%	14%
Gjorche Petrov	7%	9%	22%	11%	20%	21%
Karposh	3%		3%	6%	4%	8%
Kisela Voda	3%	2%	14%	16%	6%	15%
Saraj	43%	31%	11%	2%	6%	20%
Centar		2%	1%			5%
Chair	1%	2%	1%			
Shuto Orizari	2	5	3	2	2	

Assessment of the impact of climate change - methodology

The assessment was considered the data used by Djurdjevic, 2020. The set consisted 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 load (THI). THI is calculated on the basis of temperature and humidity for each day. The load is the number of consecutive days with a certain level of THI. The different levels of THI are manifest heat stress described as alert (yellow), emergency (orange), and dangerous (red). The last one is also considered as lethal. Since, animals have individual capacities for adaptation it was considered that the THI load should be calculated if the event above threshold is lasting for at least two days in a row. The THI was developed for ruminants (cattle, sheep and goats), since they are the most vulnerable to climate change.

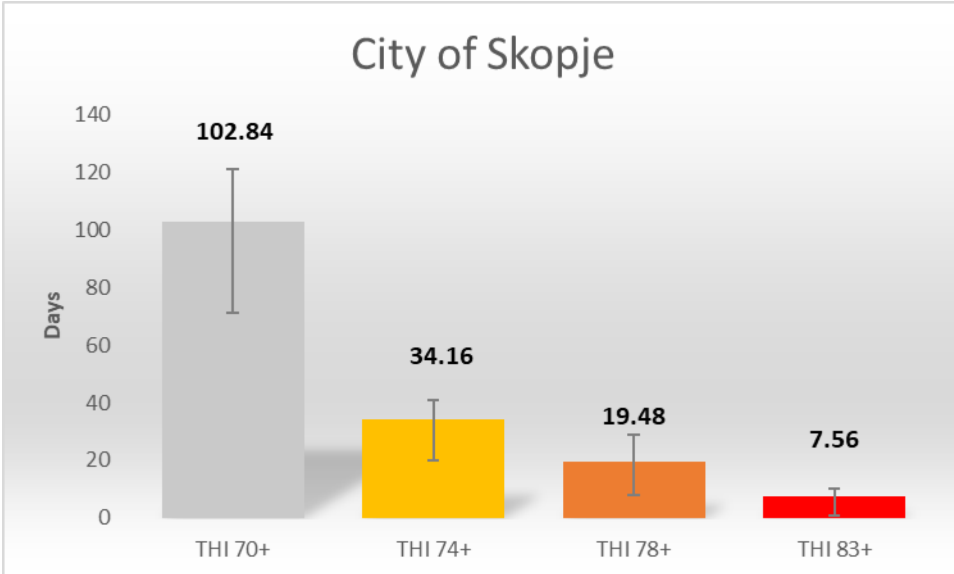

Figure 28. The average number of days for the period from 1990 to 2020 under different THI loads in the City of Skopje (for points of interest).

Past climate risks and hazards in the City of Skopje were estimated at 28 points. However, here the assessment was done on the points that are located in the municipalities of interest, where the majority of the livestock population is located. 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 34 days, the emergency phase 20 days and the dangerous phase lasted for more than a week.

Conclusion on current vulnerability to extreme weather events

The current vulnerability of the agriculture in the City of Skopje to the extreme weather conditions is estimated taking into 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 by 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.

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Table 13. Vulnerability assessment matrix

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

Table 14. Vulnerability of most vital agricultural sectors

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

5.4 Assessment of the vulnerability risks to forestry sector

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

The City of Skopje in the recent years is under intense pressure of urbanization. The city is growing intensively, the green areas are removed unplanned and the permeable surfaces are diminishing. Consecutively this contributes to converting it to impervious surfaces and soil sealing. This results into creating less permeable surfaces, diminishing the ability of the surface to absorb the rainfalls and in turn after every rain event the streets are covered with water. In cases when the rains are more intensive this contributes to larger flooding. On the other hand the city is expanding its borders and is ingesting surrounding natural areas. At the moment the Mountain Vodno is under intense pressure to the expansion of the city . The Mountain Vodno until the mid of the last century, 70 years ago, was totally bare area and the torrents of the mountain were threatening the city with every intense rain. In the 1950's the slopes were afforested and the torrents were stopped, thus accomplishing complete protection of the inhabited 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 2020-2022 is 1690 fires, the total burned area is 6513 ha. A third of this area consists of forests (2731 ha). 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 most risk from aspect of forest fires are the urban/semi urban forests Vodno and Gazi Baba. The next table shows about fire occurrence in the park-forest Vodno. It can be seen that there are several years with larger areas in which several forest complexes, mainly pine forests, were burnt. This is a mayor future risk for the critical infrastructure and the dense populated area of the city.

Year	No. of fires	Area (ha)
2006	6	0.9
2007	4	12.6
2008	6	13.7
2009	5	0.1
2010	0	0.0
2011	12	18.5
2012	11	5.5
2013	13	16.9
2014	3	0.7
2015	6	6.3

2016	0	0.0
2017	10	31.4
2018	3	4.5
2019	13	6.0
2020	7	0.5
2021	6	2.3
Total:	105	119.8

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 City of Skopje:

- 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 first graph that the temperatures have tendency of increase and on average for the period 1961 to 2015 the temperatures are increased by 2 degrees. On the other hand, on Graph 2 it cannot be seen a distinct trend for the rainfall. So for the last period of 55 years it can be concluded that there is increase of temperatures and the average rainfall remain the same. 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 Skopje valley is with low average precipitation of around 500 mm. The aridity index of the lower parts show semi-arid climate.

Drought vulnerability

Based on the vulnerability map of the country[11] can be concluded that City of Skopje is affected by drought in some way. The most dominant classes are Vulnerable and Strongly vulnerable to drought. The climatic data used for this analysis was 1981 to 2010.

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

5.5 Economy of the City of Skopje

5.5.1 Entities in the City of Skopje by sectors

The number of entities in the City of Skopje in 2021 is 35,444. Their sectoral analysis represents a first look at the economic structure of the City, although it does not give a clear picture compared to the output and the number of employees by sector, which we will analyze further. The largest number of entities are in Municipality of Centar (30.7%), and together with Karposh and Kisela Voda they make up over 70% of the total number of entities in Skopje. The most dominant number of entities are in the trade sector (wholesale and retail) representing 23.6% of the total. Also, entities from the Trade sector are are the most numerous in all municipalities in the City. Taken as a whole, the City of Skopje is dominated by entities from the domain of trade and services, and the percentage of entities from the domain of real production is small.

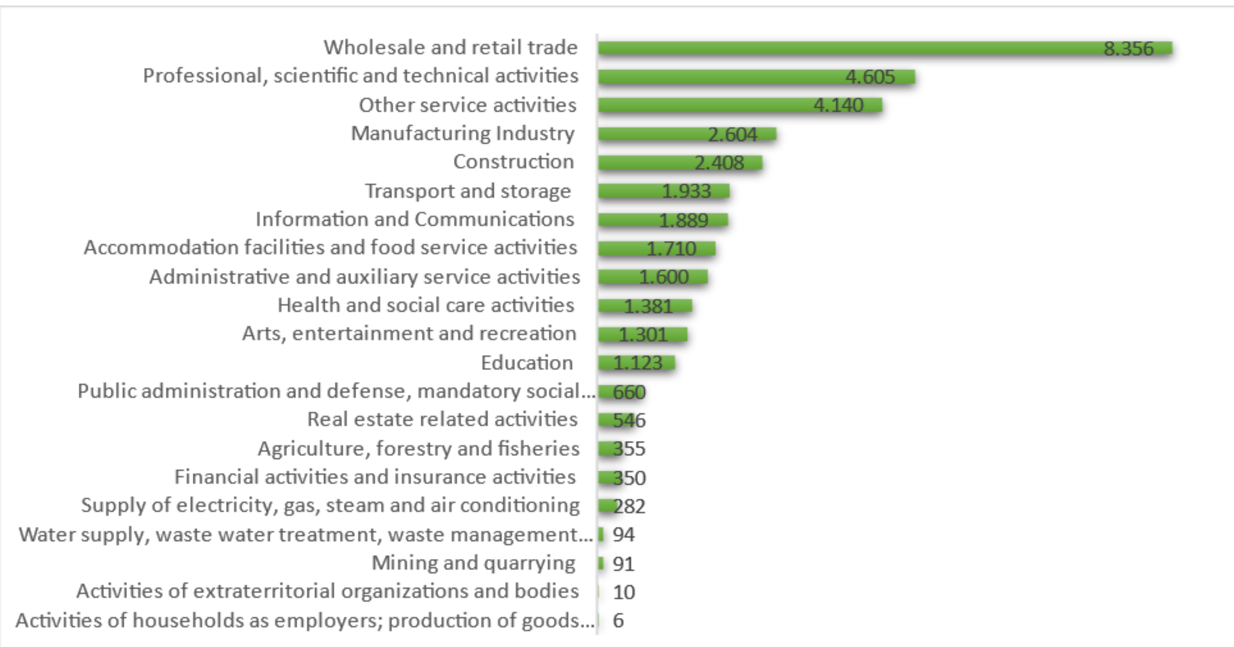


Figure 29. Structure (number) of entities in the City of Skopje by sectors

[11] 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

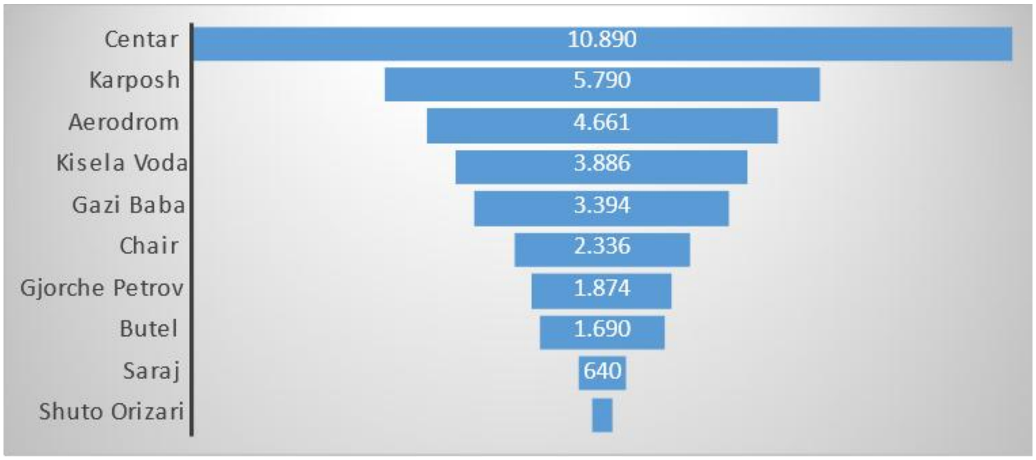


Figure 30. Structure (number) of entities by municipality in the City of Skopje

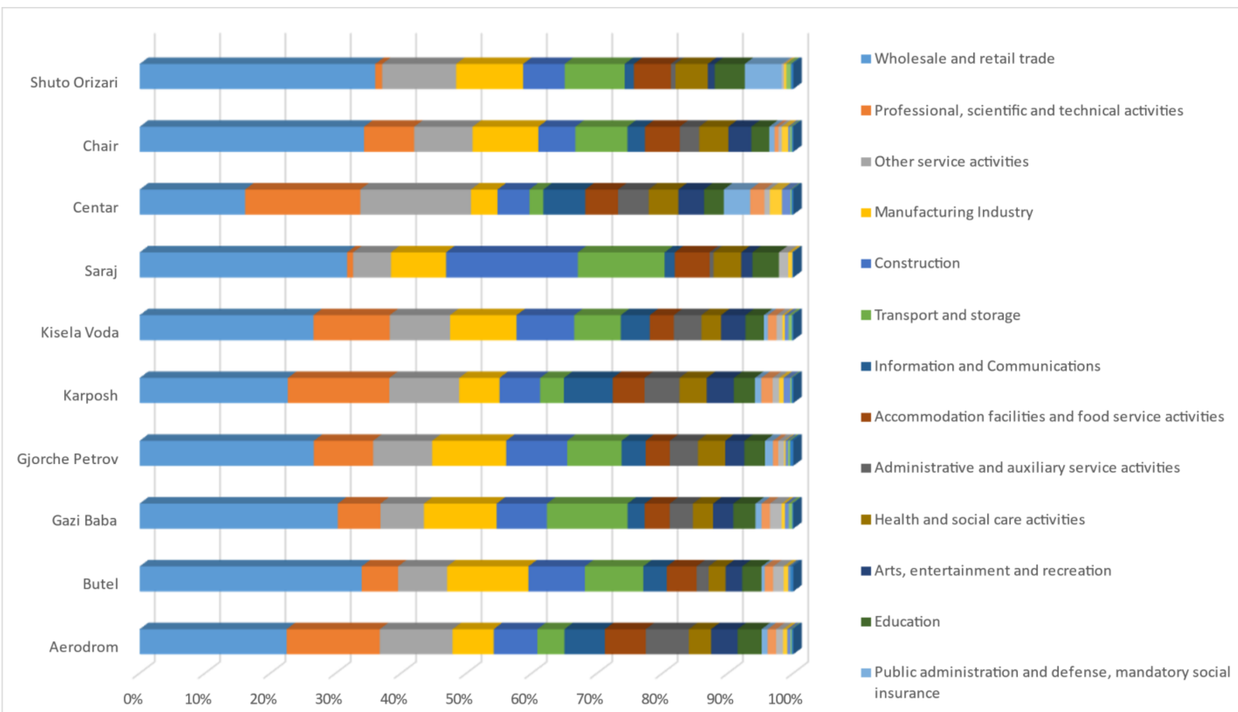


Figure 31. Structure of entities in the municipalities of the City of Skopje by sector

5.5.2 Analysis of the labor market in the City of Skopje

The active population in the City of Skopje in 2021 numbers 432,001 people of which 22,769 are unemployed, which represents 10.4% unemployment. The following charts and tables provide a more detailed overview of the labor market in the municipalities of the City of Skopje.

Table 15. Overview of the labor market in the City of Skopje

Total population in the City of Skopje	**526,502**
Total population with working abilities	**432,001**
Active population - total	**219,289**
Active population - employees	**196,520**
Active population - unemployed	**22,769**
Total Idle Population	**202,883**
Unknown	**9,829**

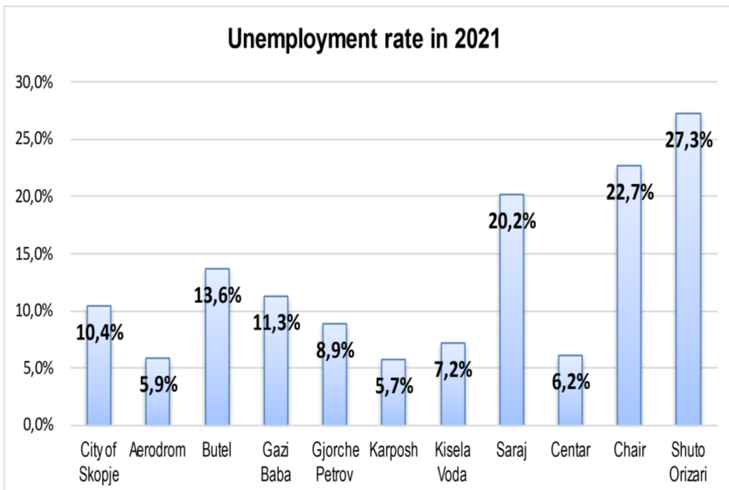


Figure 32 Unemployment rate by municipalities in City of Skopje.

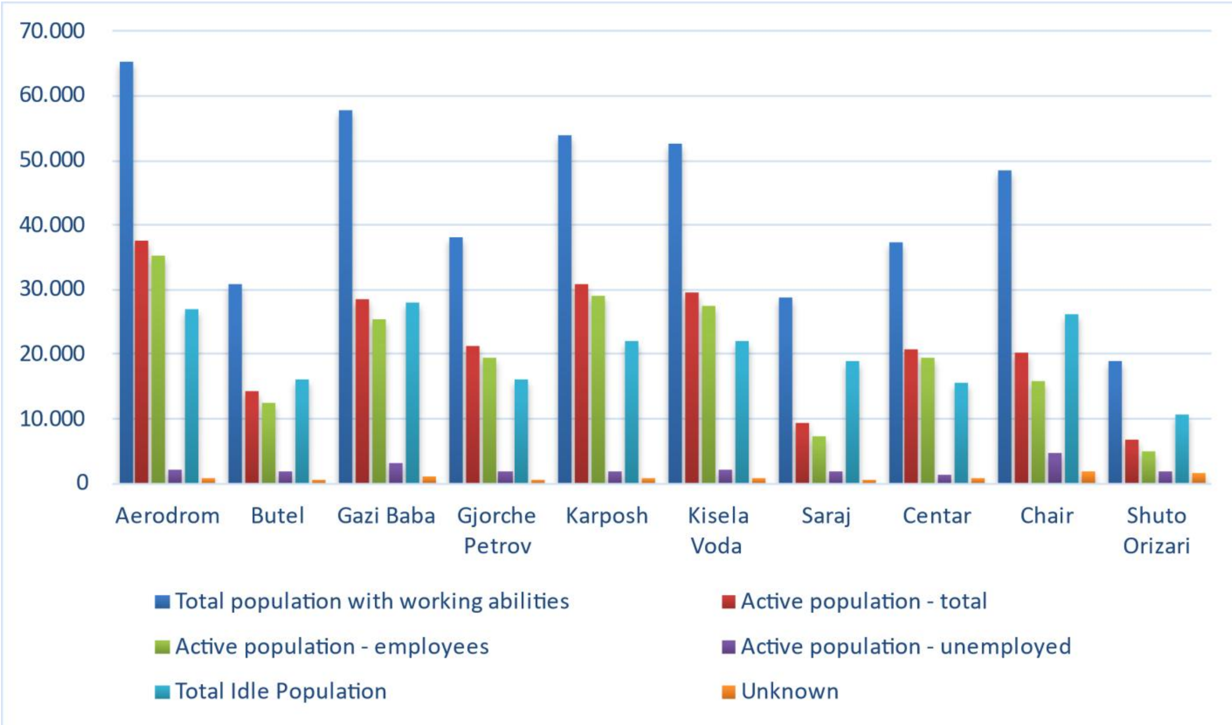


Figure 33. The structure of the labor market by municipalities in the City of Skopje in 2021

We presented above that the number of residents of the City of Skopje who are employed is 196,250. This is data provided by the Statistics Office according to the 2021 census. However, some of these people work outside the City of Skopje (eg in the wider vicinity of Skopje). But on the other hand, the City of Skopje absorbs a large amount of labor that comes from other cities and from the near and wider surroundings of Skopje. Thus, a large number of people with residence in Kumanovo, Veles, Tetovo, and from the wider vicinity of Skopje work in the City of Skopje. The number of people working in Skopje, regardless of their residency, in 2021 is 255,121. Half of them work in the municipality of Centar, which is the smallest municipality in terms of territory. The dominant economic sector that absorbs 17% of the workforce is wholesale and retail trade. The City of Skopje is the capital of the Republic of North Macedonia, where the central administration of the country is located. That is why the second largest sector is the public administration. The third largest labor force absorber is the manufacturing industry. The most climate sensitive sectors absorb a small part of the labor force, such as construction where 5.8% work and agriculture with only 1.5%. However, the comparison between the municipalities within the City of Skopje shows that there is diversity in terms of sectoral employment. In almost all municipalities, the dominant employer is the wholesale and retail trade sector, except for the municipality of Centar, where the public administration strongly dominates, given that the administration of the central government, state ministries, government agencies, and public enterprises are located here, but also the administrations of City of Skopje and Municipality of Centar. Taken as a whole, in the City of Skopje more than 90% are predominantly employed in the trade, service and administrative sectors, including financial services, and a very small proportion are employed in real production sectors such as industry, construction and agriculture.

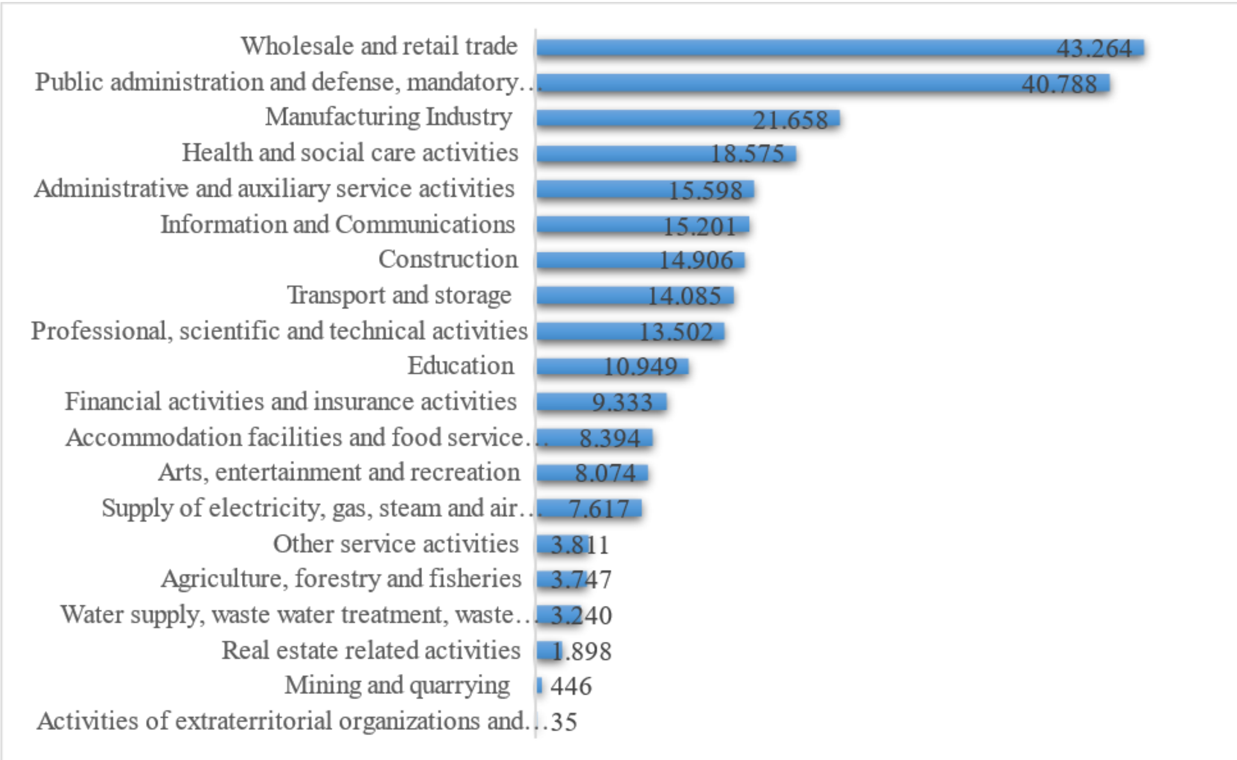


Figure 34. Structure of employees in the City of Skopje by sectors in 2021

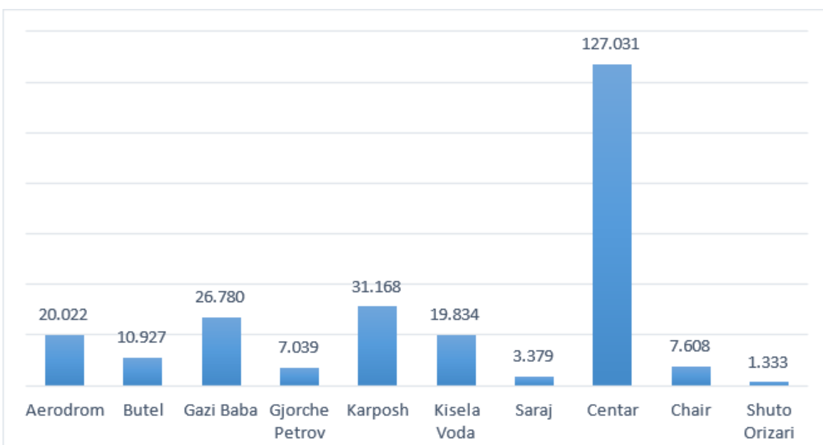


Figure 35. Structure of employees by municipality in the City of Skopje in 2021

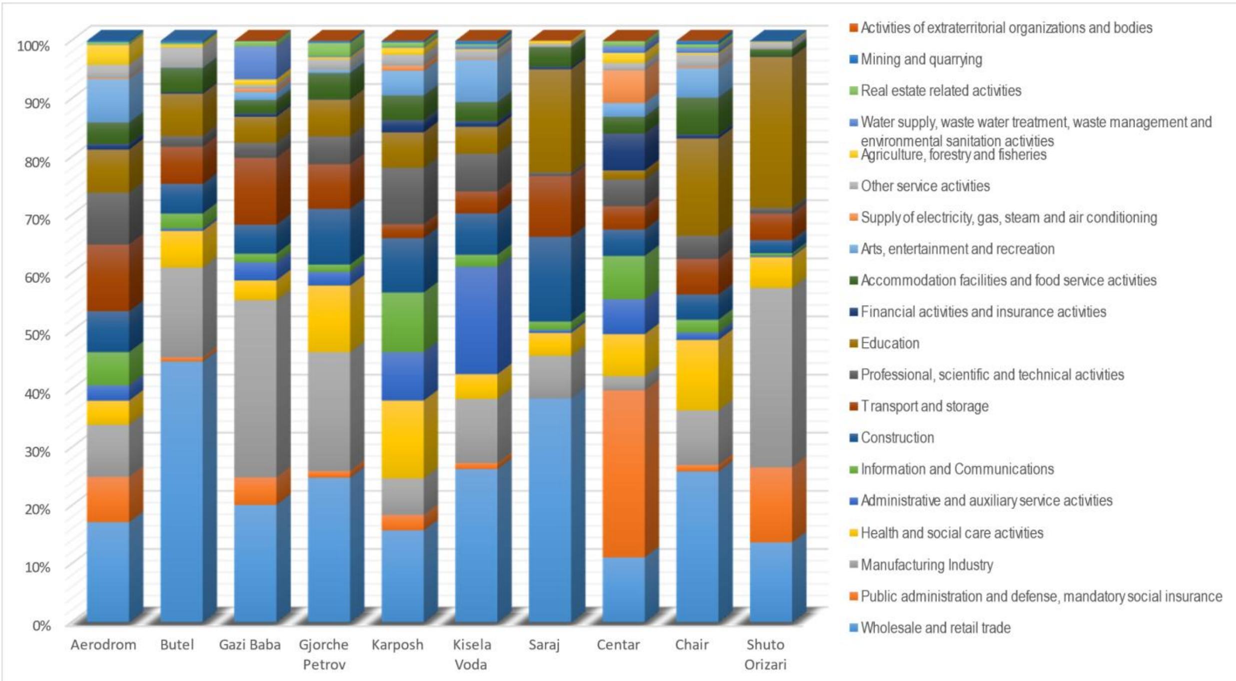


Figure 36. Structure of employees in the municipalities of the City of Skopje by sector in 2021

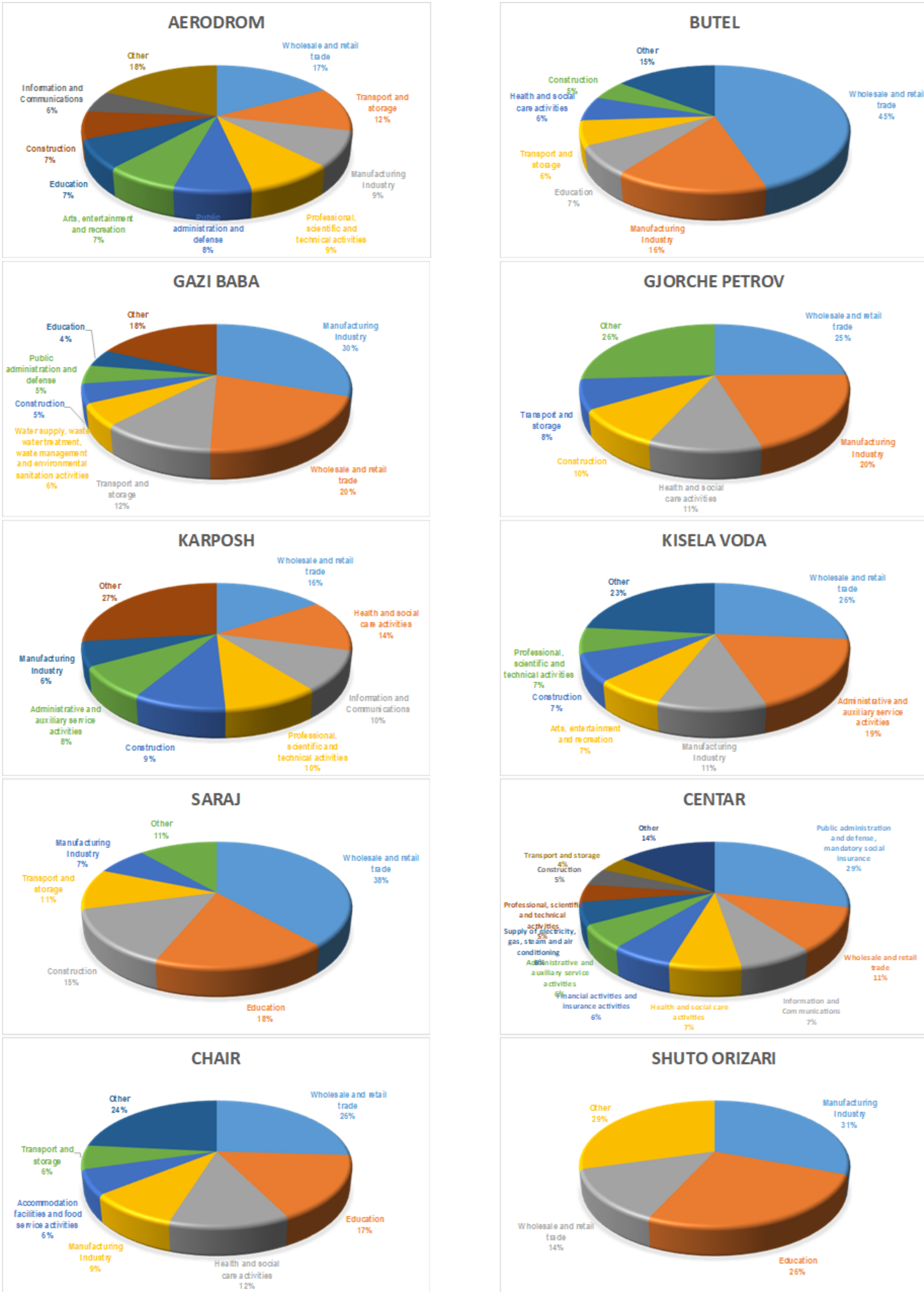


Figure 37. Dominant sectors of employment by municipalities in 2021

5.5.3 Revenues generated in the City of Skopje by sectors

The size of the revenues generated indicates the size of the sector. In 2021, public administration generated 33% of total revenues. In fact, this is tax and other public revenues that are generated in public budgets. If we exclude them, the largest economic business sector in terms of revenue is the sector trade (wholesale and retail), which generates 23.6% of the revenue in the City of Skopje, which is a quarter of the total revenues. The next production sector according to the size of generated revenues is Supply of electricity, Manufacturing Industry, Health and social care activities, Construction, Financial activities and insurance activities etc. Agriculture, forestry and fisheries is a marginal sector according to the size of the income and participates with only 0.28% of the total revenues.

The most revenues were generated in the Municipality of Centar, even if public revenues are excluded. In almost all municipalities, the Wholesale and retail trade sector is the sector with the most revenue. However, there is a great diversity between the municipalities in terms of the realized incomes in the other sectors. Among the sectors that dominate more often are Construction and Manufacturing Industry.

Figure 38. Structure of revenues in the City of Skopje by sectors in 2021

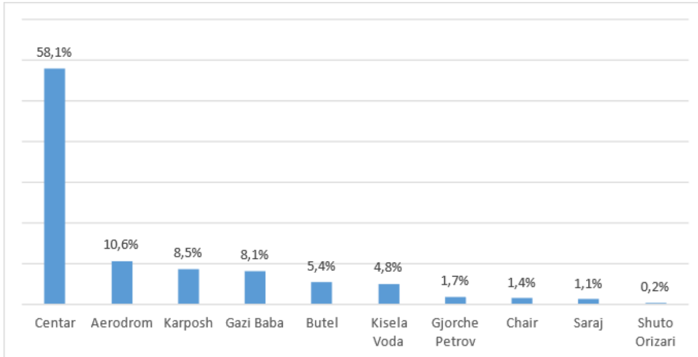


Figure 39. Structure of revenues by municipalities in the City of Skopje in 2021

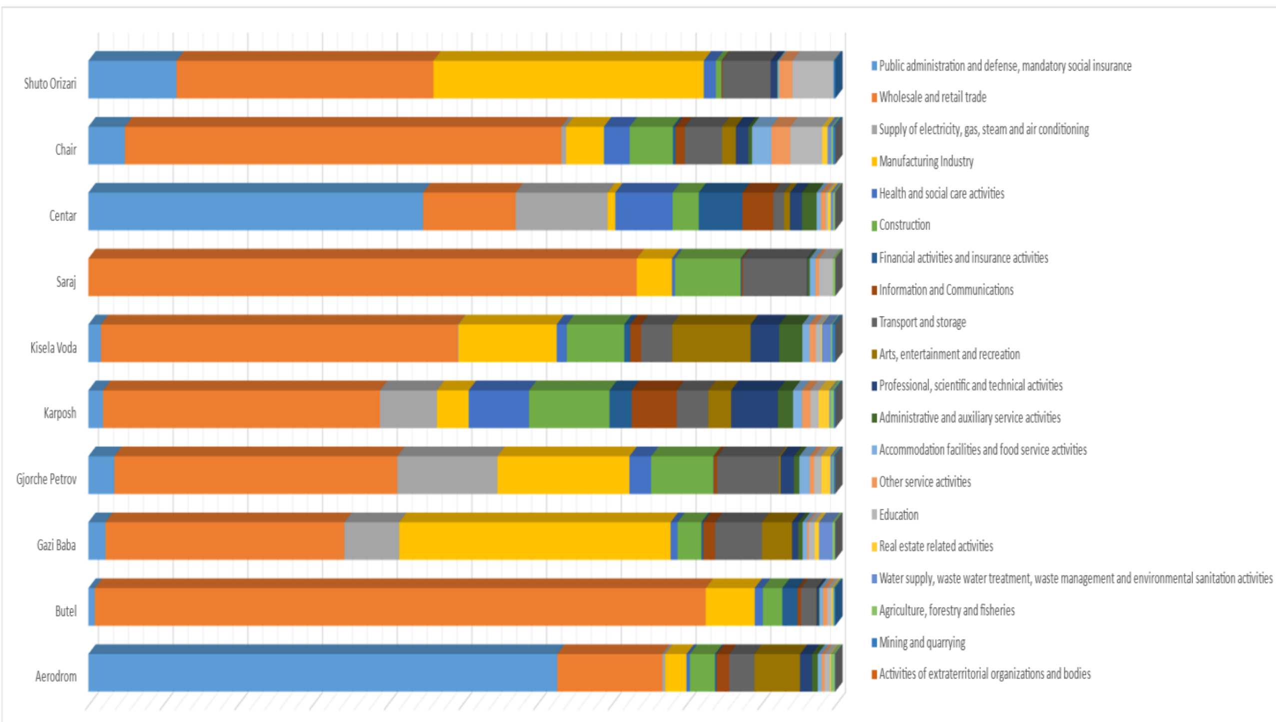


Figure 40. Structure of revenues in the municipalities of the City of Skopje by sector in 2021

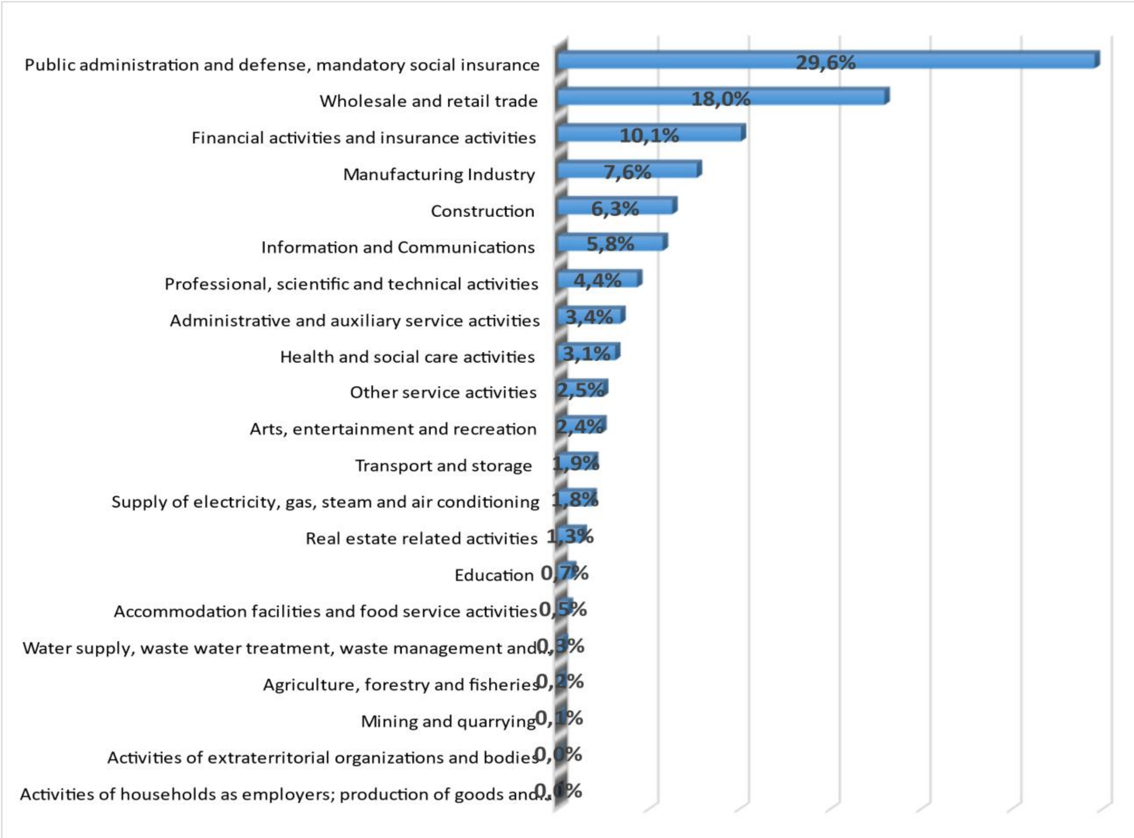


Figure 41. Structure of net profit in the City of Skopje by sectors in 2021

Weaknesses and risks of the local economy

- Aging of the population in the City of Skopje
- Competition from foreign corporations and their investment agencies
- Attractiveness of EU countries for employment of young educated people;
- Great external competition that can lead to the collapse of local companies;
- Outflow of qualified workforce, mainly young people (brain-drain);
- High dependence on energy imports
- Globalization and great competition in the global market;
- Irrational use of drinking water.
- Deterioration of the economic situation in the city and the state.
- Higher costs of living and doing business
- Insufficiently available favorable sources of financing for SMEs
- Insufficient efficiency of the legal system.
- Recovery of the economic crisis in the country and on an international scale (geo-politics)

5.5.4 Assessment of the past and current climate risks and hazard related to the economic sector in the City of Skopje

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 an estimate here.

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 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.

The only official data on the negative impact of extreme weather conditions caused by climate change was the report of the Insurance Supervision Agency related to the unusual storm that hit Skopje on August 30, 2022. Insurers from the Skopje region reported a total of 349 property losses in all insurance companies after the strong storm that hit Skopje on August 30, 2022. Of all the reported damages, the largest number, ie 215, are on property insured by natural persons. Companies and other legal entities based in Skopje reported 134 property damages as a result of the unprecedented strong storm in the capital, according to data provided by the Insurance Supervision Agency (ASO) from all 11 non-life insurance companies. However, although this is the only one, it is a very scarce data for two reasons: i) this data includes only those who were insured, but not those who were not insured, for whom no one keeps official data even though the number of people in our country is small who voluntarily insure the property; ii) this data does not show us the value of the damaged claims expressed in money.

There is no such data for the huge storm followed by torrential flood six years before, on August 6, 2016 in the western part of the Skopje valley. In a very short time of just a few hours, several villages were flooded, a large number of people lost their lives, and the material damage was enormous. The damages in the farming and agricultural companies were huge, a large number of companies went bankrupt, thereby defaulting on the loans they had to the banks, and the insurance companies had to pay large damages.

Data for forest fires in the City of Skopje are given in the following table. From here, you can see the number of fires in the last eight years, and for the last three, the area that was burned. However, there are no estimates of the economic damage from this event either.

Table 16. Forest fires in the City of Skopje

Year	Number of forest fires	Surface area (ha)
2015	605	/
2016	391	/

2017	559	/
2018	446	/
2019	914	/
2020	561	2044
2021	629	3282
2022	530	1212

Apart from these events described above, another frequent extreme event is the heat waves that usually affect the City every year in July and August. 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 in outdoor activities such as construction and agriculture. There, in particular, business process interruptions, business discontinuities and reduced output occur.

Skopje is an administrative city, the capital of the country, which houses the entire state administration, the local administrations of the ten municipalities, and public enterprises. The headquarters of the largest number of companies are in Skopje, especially all financial institutions. Thus, in addition to the state administration, there is a large business administration. Most of the workers in Skopje work in office conditions where people can protect themselves and adapt to extreme weather conditions.

The general assessment is that the economy of the City of Skopje is not very vulnerable to extreme weather events. In the economy of the City of Skopje, the dominant economic sector is trade (wholesale and retail) by all parameters. Second is the public administration. In the trade sector, no high vulnerabilities have been detected, but they are moderate or low. High vulnerability is assessed in the construction sector to heat waves and extreme precipitation. Agriculture is a marginal economic activity in the City of Skopje. Therefore, focusing on the vulnerabilities of the dominant branches, the eventual conclusion is that the City of Skopje is currently moderately to lowly vulnerable to extreme climate changes.

Table 17. Assessment of past and current climate risk and vulnerability of the local economy of the City of Skopje

ECONOMIC SECTOR	EXTREME WEATHER EVENT	CURRENT VULNERABILITY
Housing	Extreme Heat	High

	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Medium
	Forest Fires	Low
Industry	Extreme Heat	Medium
	Extreme Cold	Low
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Medium
	Forest Fires	Low
Trade (wholesale and retail)	Extreme Heat	Medium
	Extreme Cold	Medium
	Extreme Precipitation	Low
	Floods	Low

	Droughts	Medium
	Storms	Low
	Landslides	Medium
	Forest Fires	Medium
Construction and Civil engineering	Extreme Heat	High
	Extreme Cold	Medium
	Extreme Precipitation	High
	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Medium
	Forest Fires	Low
Transport and storage	Extreme Heat	High
	Extreme Cold	Medium
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Low

	Forest Fires	Medium
Tourism and hospitality	Extreme Heat	Medium
	Extreme Cold	Low
	Extreme Precipitation	Medium
	Floods	Low
	Droughts	Low
	Storms	Low
	Landslides	Low
	Forest Fires	Medium

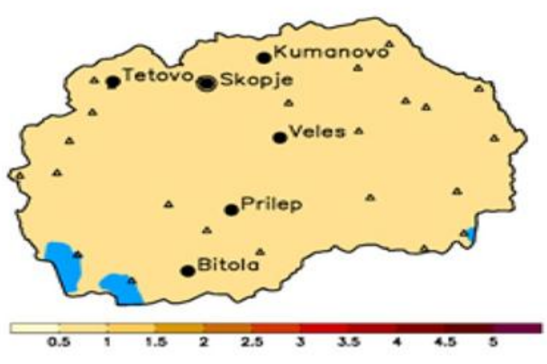
6 IDENTIFICATION OF FUTURE CLIMATE THREATS FOR EACH LSGU (ON A SHORT, MEDIUM, AND LONG-TERM)

The identification of thefuture climate threats was conducted based on the climate scenarios conducted for the purposes of preparation of the Fourth National Communication on Climate Change in 2020. The scenario that is taken into consideration is scenario RCP 4.5, for the two periods: 2016 – 2035 and 2046-2065.

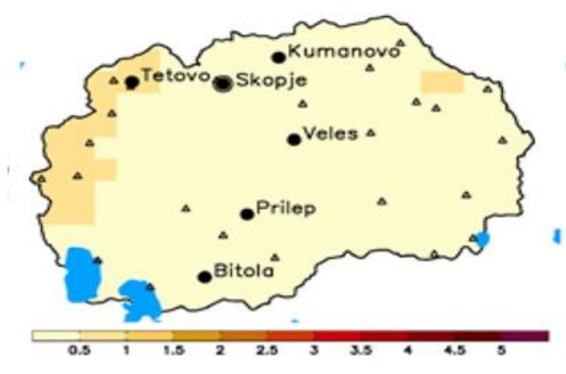
6.1 Water sector

In this chapter are identified and presented the future climate threats for the Skopje region on a short term, for the period 2016-2035 according to Gurgevic scenarios. Here were analysed the climate extremes that are mainly affecting the water resources and that have significant impact to water sector.

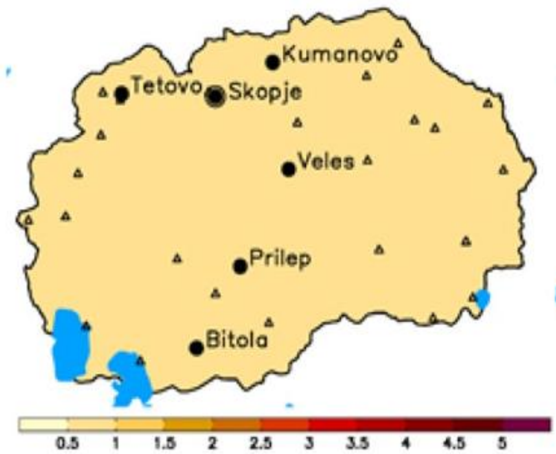
- Temperatures and precipitation for period 2016 – 2035, scenario RCP 4.5



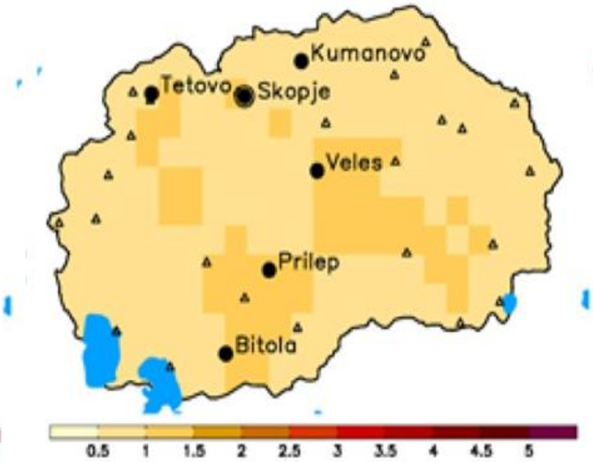
Average annual temperatures



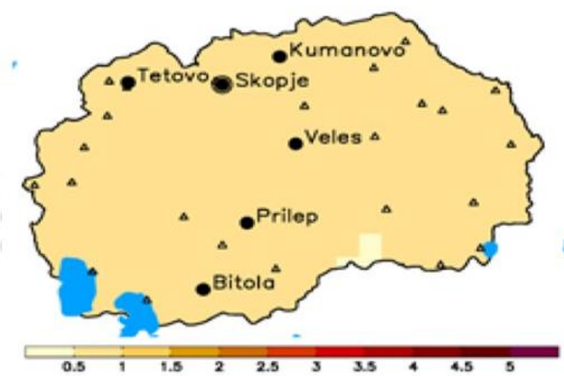
Average winter temperatures



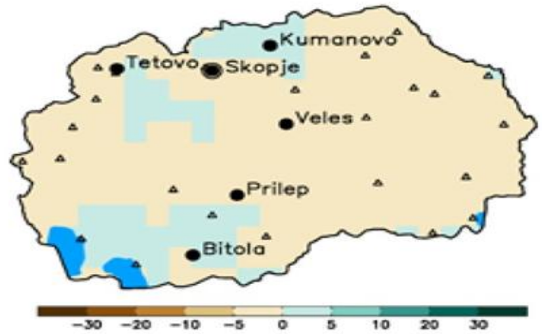
Average spring temperatures



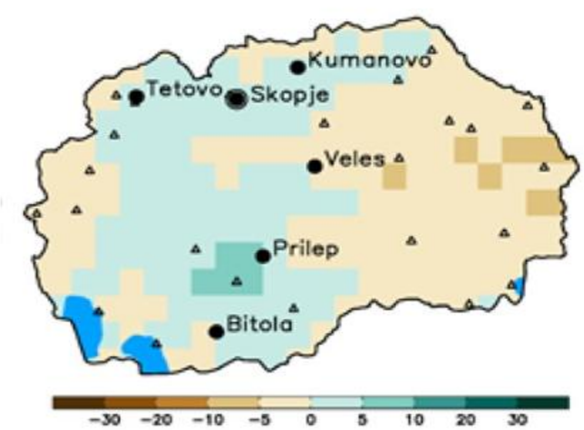
Average summer temperatures



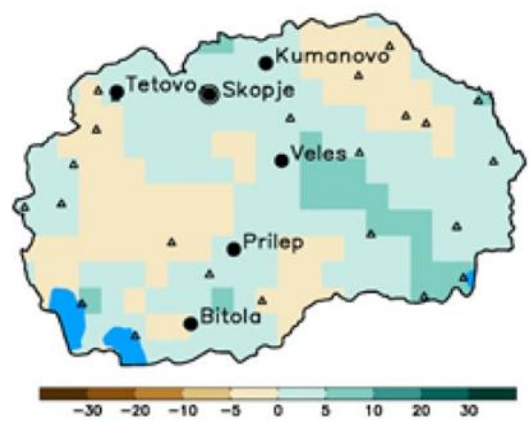
Average autumn temperatures



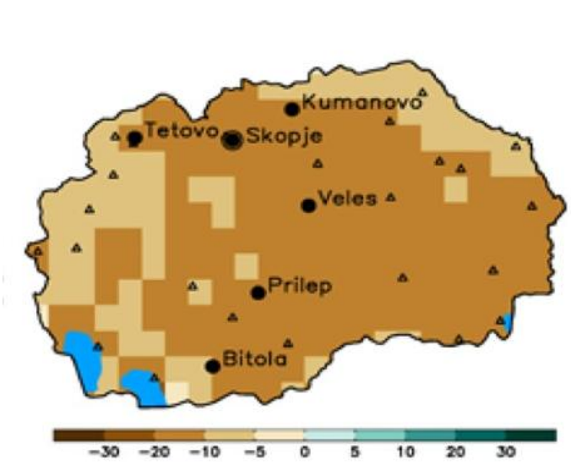
Average annual precipitation



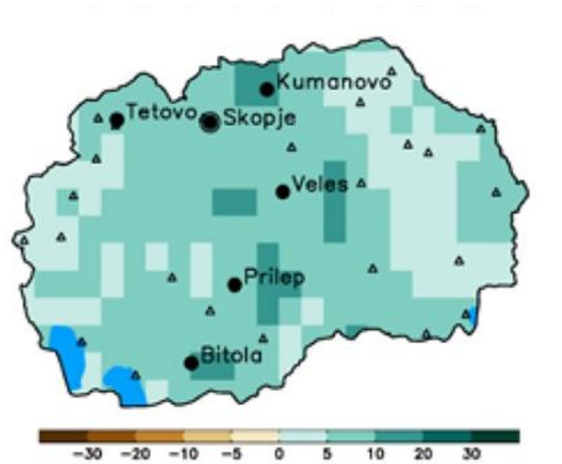
Average winter precipitation



Average spring precipitation



Average summer precipitation



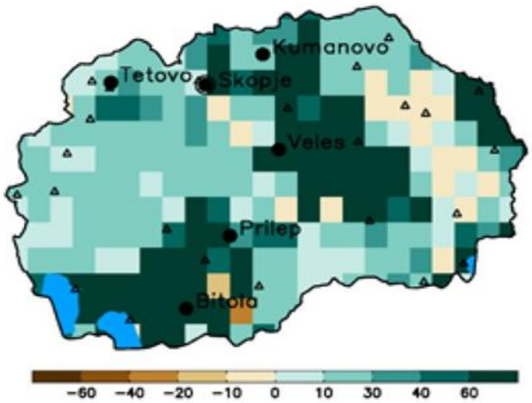
Average autumn precipitation

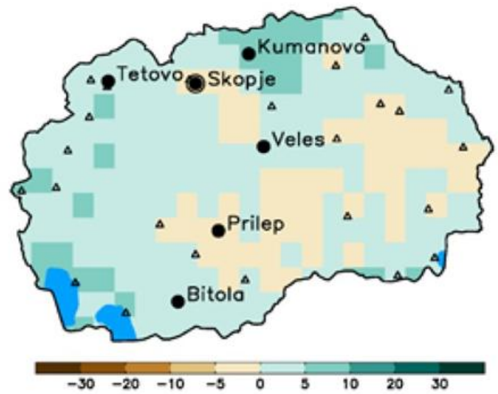
According to maps[12] on the future climate extremes like temperatures and precipitation, in the future it is expecting increasing of the air temperatures and decreasing of average sums of precipitations. This predictions will affect the water resources through occurring short and middle term droughts periods and decreasing of the average discharges in the r. Vardar, r. Serava, r. Markova and r. Kadina, which with part of their catchment areas belongs in the Skopje region, then decreasing of groundwater levels (including the Nerezi-Lepenec well system), possible decreasing of the capacity of spring Rasche, as well as decreasing of the water inflow in the artificial accumulations on r. Treska (Kozjak, st. Petka anad Matka) and Mavrovo Lake.

But, we must mentioned that the maps are maked 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 eastern part of the region causing ponded areas and moors.

- **Days with precipitation above 40 mm and number of events with extreme precipitation**

[12] Report on the projections on climate change and changes of the extreme weather events in North Macedonia, Vladimir Gjurgjevic, February 2020



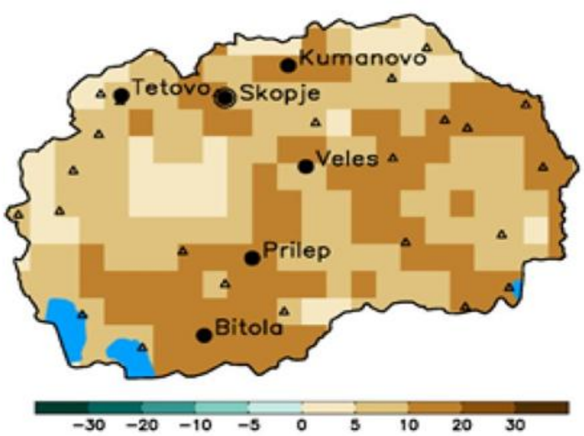


Number of events with extreme precipitatiom

Max daily precipitation

According to map of the days with precipitation above 40 mm and map of the number of events with extreme precipitation, there are indications that region of Skopje has serious possibility of occurring intensive precipitation in the future causing flash floods on the small rivers and torentials in the region, as well as appearances of urban floods in the City of Skopje. Although in the future period are expecting decreasing of the average sums of precipitation, we can not 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**



Consecutive drought days

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

It can cause problems with water supply of the region and providing (supplying) drinking water in future. Also, during the summer periods the capacity of the spring Rasche will decrease and groundwater levels of wells system NEREZI-Lepenec (that are used for replenishment of Rasche) is expected to decrease. So, in the future it will be needed to investigate new ways for additional replenishment of water from another sources and another river basins. Spring Vrelo and waters from river Kadina and Patishka are investigated as possible solution for this purpose.

- **Seasonal oscillation of the extremes**

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

6.2 Health sector

In the Skopje region, an **increase in future temperature** is expected from 1.5-2^{0} C in the RCP 4.5 scenario[13]. The change in **heatwave duration is increased** from 1-2 days and the duration of the waves is projected to be increased for 5-10 days. The number of tropical nights will increase by 5-10 nights and the summers are expected to be extended for 20-30 days. An average **decrease in 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 Skopje region in the RCP4.5 scenario during the summer, it will decrease by 20% on average and during the autumn it will increase for the same percentage with an increase of the rain accumulation in certain vulnerable areas in and around the city with the potential risk of flooding.

The **number of consecutive dry days will increase** from 0-3 days in the first half of the century and even 6 days at the end. With the significant risk for droughts especially in some of the municipalities in Skopje Valley like Ilinden.[14]

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[13] Report on the projections on climate change and changes of the extreme weather events in North Macedonia, Vladimir Gjurgjevic, February 2020

[14] Djurdjevic V.Report on Climate Change Projections and Changes in Extreme Climate Events in North Macedonia, UNDP/GEF 2020

According to the predicted scenarios for the mortality trend in the country and Skopje in the period after 2035, as a function of temperature only, the projected mortality is recorded with a change only in relation to the average monthly temperatures by 1°C in relation to the period 1996-2000 (reference period). This increase in the monthly death rate in the country would be greater in the months of April, May and June and would amount to an average of 10% compared to the reference period. The impact of the increased temperature will affect mostly the elderly and people with chronic diseases and will be especially pronounced in urban areas where the temperature is higher than in rural areas by several degrees. During the winter the continuous air pollution in the city will have synergistic effects with the temperature and will contribute to higher all-cause and specific-cause mortality rates again among elderly and chronically ill people. For the near future - the projection for 2030 of the seasonal index by month for food-borne diseases caused by salmonellosis, due to air temperature rise, shows two peaks in the summer months and one possible peak in winter months because of a decrease in the average monthly temperature in the future period. Increased trend of vector transmissive diseases could be also a realistic (though moderate) threat.

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, indirect indicators and existing models – the risk prediction confirms that the occurrence of **high temperature and heat waves**, especially in the summer period, is the **highest climate change risk** for the population in Skopje region. Not all population groups are equally at risk, so the focus of the risk is on the old population, the chronically ill, workers who work outdoors (which includes agricultural workers and those working in reconstruction sites) and socially marginalized groups who live in substandard conditions. If we add the seasonality of high air pollution in Skopje and the additional adverse health impact of air pollution, this prediction is even worse then. In conditions of such a health risk, there will be a special burden on the health system with a focus on certain services (for adults and the elderly and emergency medical care) whose strengthening must be among the first priorities for adaptation. Cardio-respiratory morbidity and mortality are the main health outcomes to expect (Annex 1 and 2). **Floods and droughts** are also among the climate change risk with a high probability to happen and cause health effects, especially in some more vulnerable parts of the region (Annex 1 and 2). Like in other municipalities the threat of **forest fires** is will be increasing.

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.. The indicators presenting the demographic and socio-economic sensitivity including the status of the healthcare facilities 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 direct research and estimations. (Annex 2) 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 group the most vulnerable on the Climate change impacts** are

- Patients with chronic cardiovascular and respiratory diseases
- Elderly (65+)
- Lonely pensioner households and the elderly accommodated in the institutions
- Homeless
- Communal, agricultural and other workers working outdoor
- Population groups living in poor households in risky and/or affected locations (Table 18. Vulnerable groups and RVA indicators for the Health Sector)

Table 18. 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)**

6.3 Agriculture sector

Identification of the 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 trends 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 provided within the former Fourth communication of climate change, developed by WCRP CORDEX. Meteorological data were organized into four periods: 1990-2020 (baseline period), 2021-2030 (short term), 2031-2040 (mid-term) and 2041-2050 (long term). 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.

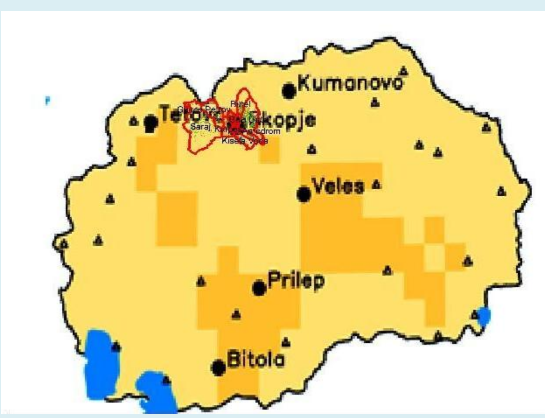
Temperatures

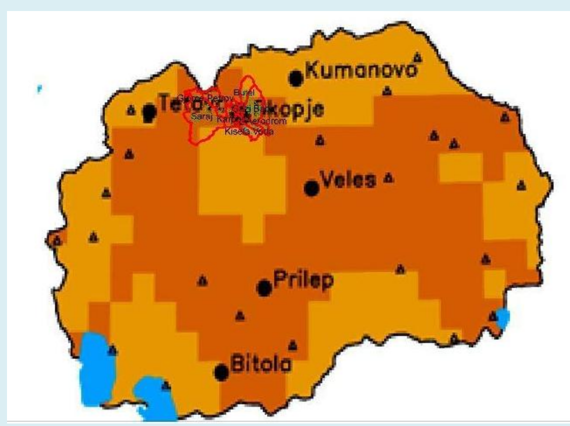
The future trends of the annual and air temperatures in vegetation are evaluated using the "medium" RCP 4.5. The trends of the average air temperatures are estimated by comparing the projections of two periods 2016-2035 and 2046-2065. Main findings are that the average annual air temperature will increase for 0.5-1.0 C° in a short term period 2016-2035, compared to the baseline period. In the midterm, the increase of the annual air temperatures is expected to be up to 2 C° . This is a significant increase which will seriously affect agricultural production. The increases in both periods will evenly affect the whole agricultural areas, and the expected impact is very high.

More important are the trends of increase of air temperatures in vegetative season. As expected the air temperature in this period will stay the same as in the base period except the central part of the City and some agricultural zones in the municipality of G. Petrov and Aerodrom, where the increase of air temperatures is expected to be for 1.0-1.5 C^{o}. In a long term period the projections are that for the most part of the City of scope the annual temperatures will increase for 2-2,5 C^{o} except certain areas on the north part of Butel and G. Baba municipalities. Such increases will harmful effects on agricultural crops in this region, due to the increased water demands and decrease of the production due to a temperature stress

Annual air temperatures 2016-2035

Annual air temperatures 2046-2065



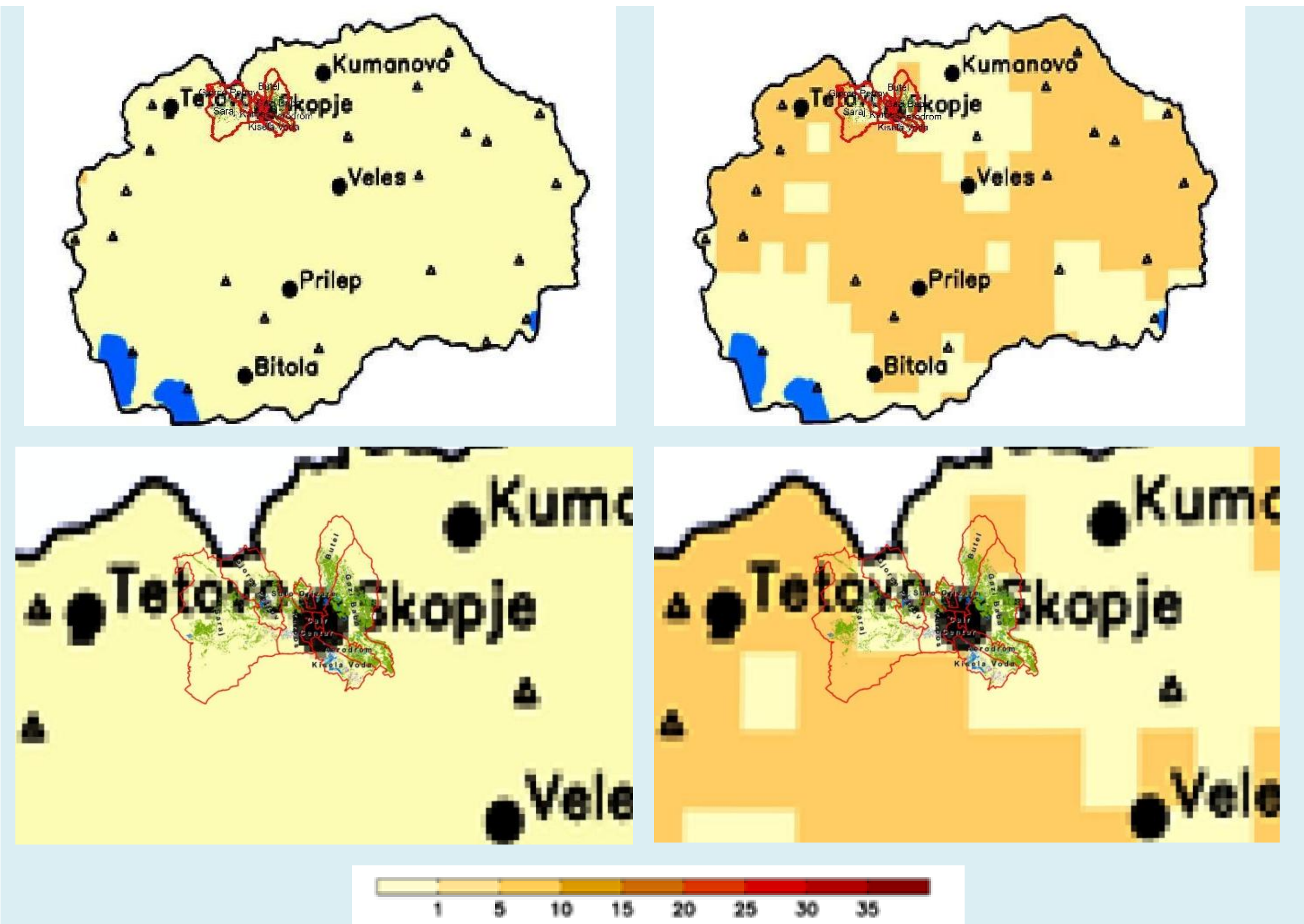


Air temperatures in vegetation 2016-2035

Air temperatures in vegetation 2016-2035

Heat waves

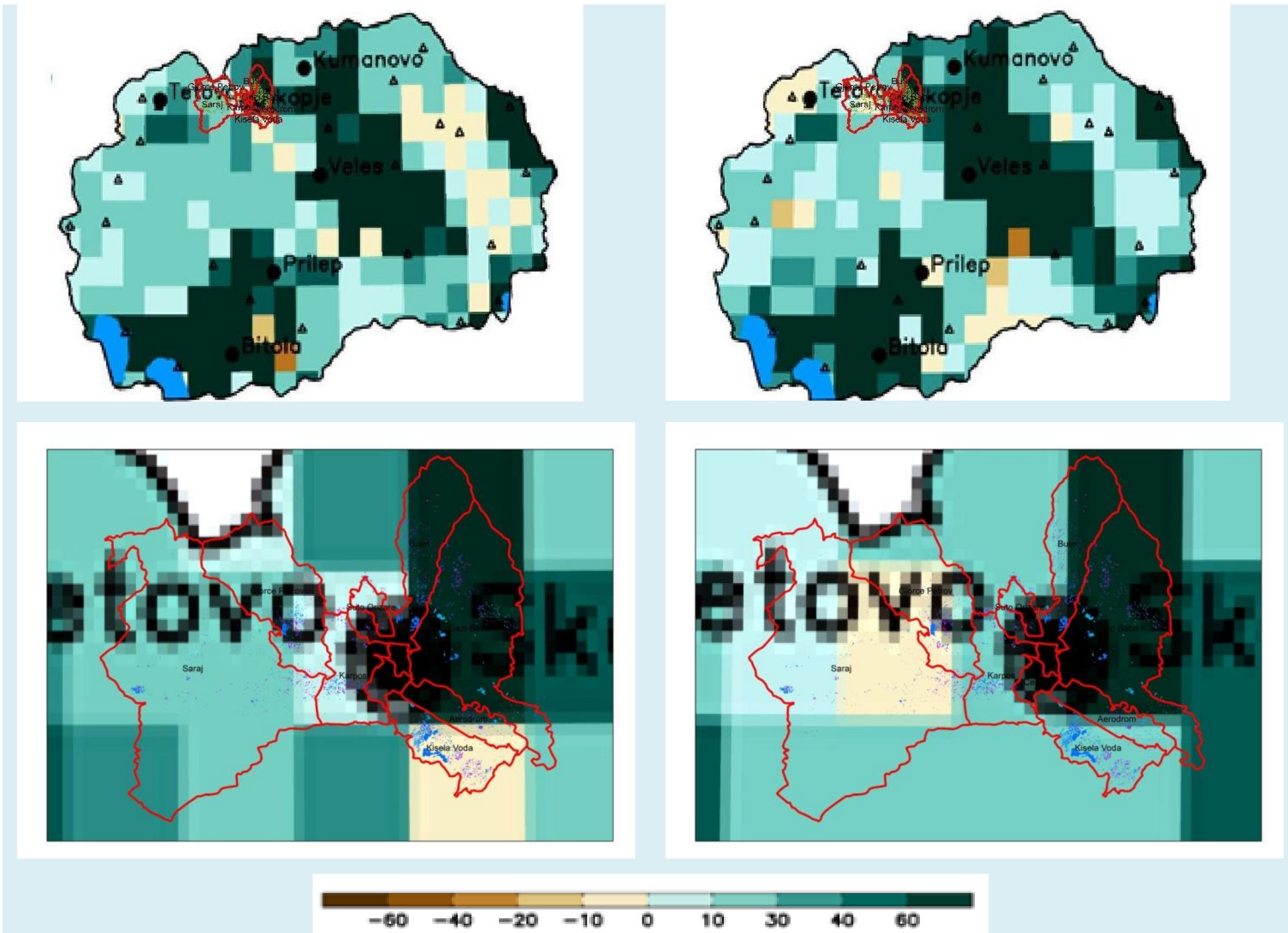
Heat waves are not expected to be more frequent according to the findings for the near future up to 2035 compared to the base period. According to the data presented on Map below for the mid-term period (2045-65) heat waves events are expected to be more frequent for certain parts of the City of Skopje with an average increase of 1-5 events/year. The most affected zones will be the southeast (municipality of Saraj) and northern parts of the municipalities of Butel and G. Baba where are located the biggest areas with vegetable production.



Heat waves 2016-2035 Heat waves 2046-2065

Extreme precipitations

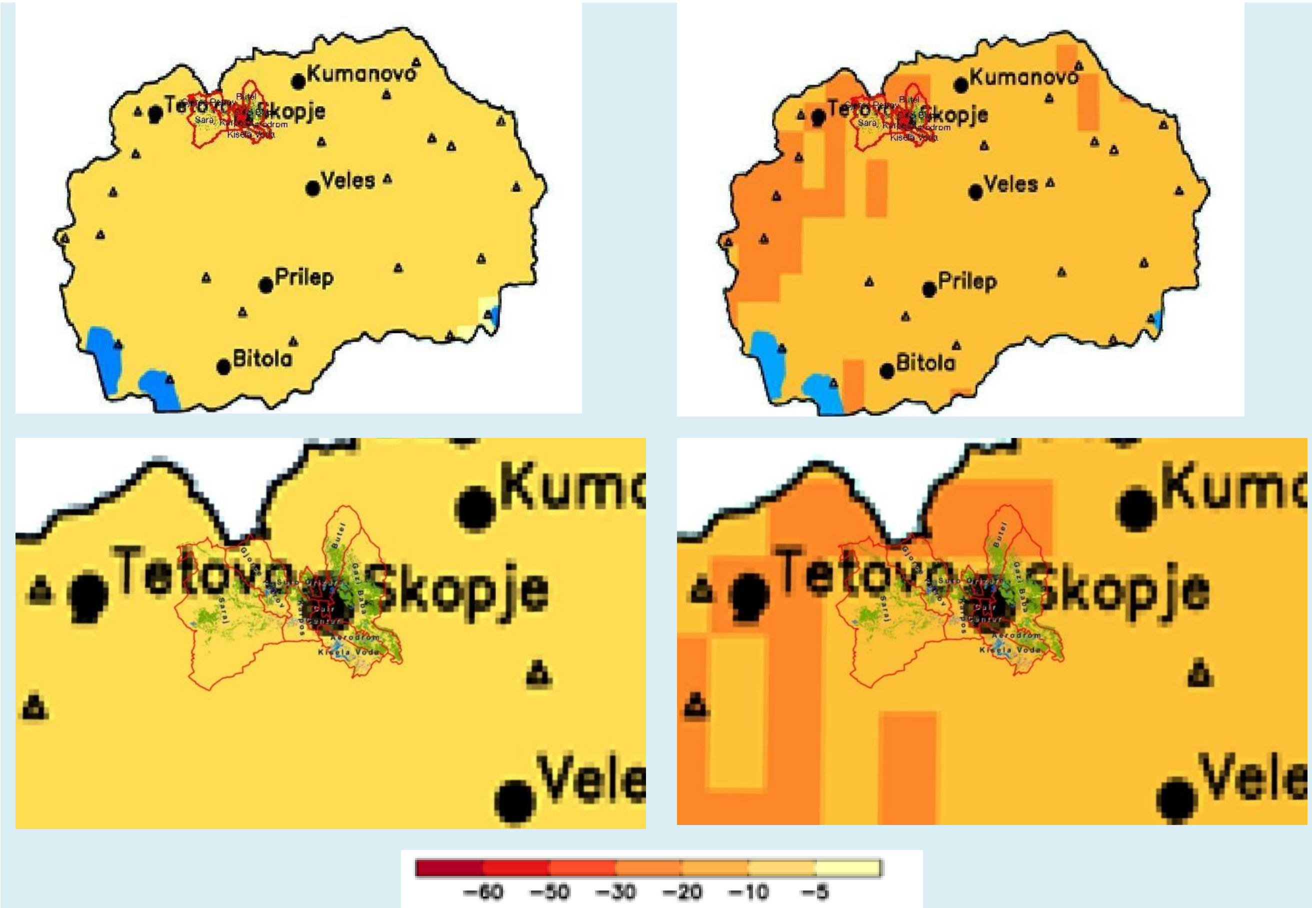
Projected trends of the extreme rainfalls in the short term period indicate significant increases of extreme rainfalls especially in the eastern and northern parts of the City of Skopje for about 60 days, while in the other parts of the west (G. Petrov and Saraj) the increase of this extreme is expected to be up to 30 days . On the other side, in the central part of the City, a slight decrease of this extreme might be expected up to 10 days. In the medium term period, no big alternations of the extreme rainfall trends are expected to happen. The eastern and other parts of the City will be prone to extreme precipitation with 60 days increase compared to base period. Extreme rainfalls can cause serious damages especially on cultivated soils in sloppy terrain causing intensive run-off and processes of soil erosion. Moreover, if accompanied with strong winds, intensive rainfalls can cause damage to plants. Vegetable and crop production in the most affected areas are expected to be most prone to this climate extreme.



Intensive rainfalls 2016-2035 Intensive rainfalls 2046-2065

Frosts

As presented in the Maps below, the number of frost days is expected to increase for 5 days randomly over the whole territory of the City of Skopje, while in the medium term (2046-2065) the number of frost days is expected to increase for an additional 10 days/year. The number of frost days will be evenly distributed over the whole area of the City of Skopje, but for the mid term period, some parts of the City will be more affected, especially the northern part of the municipalities of G. Baba and Butel. This can seriously increase the vulnerability of the perennial crops (orchards and vineyards) in this part of the City, since the increased numbers of frost days, indicates higher risks of late frosts which can cause damages to the orchards.

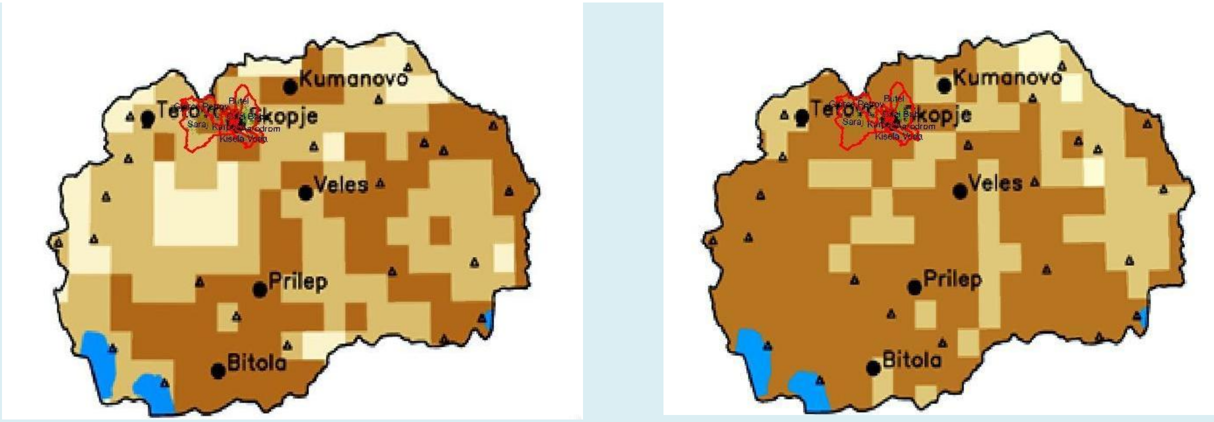


Frost days 2016-2035

Frost days 2046-2065

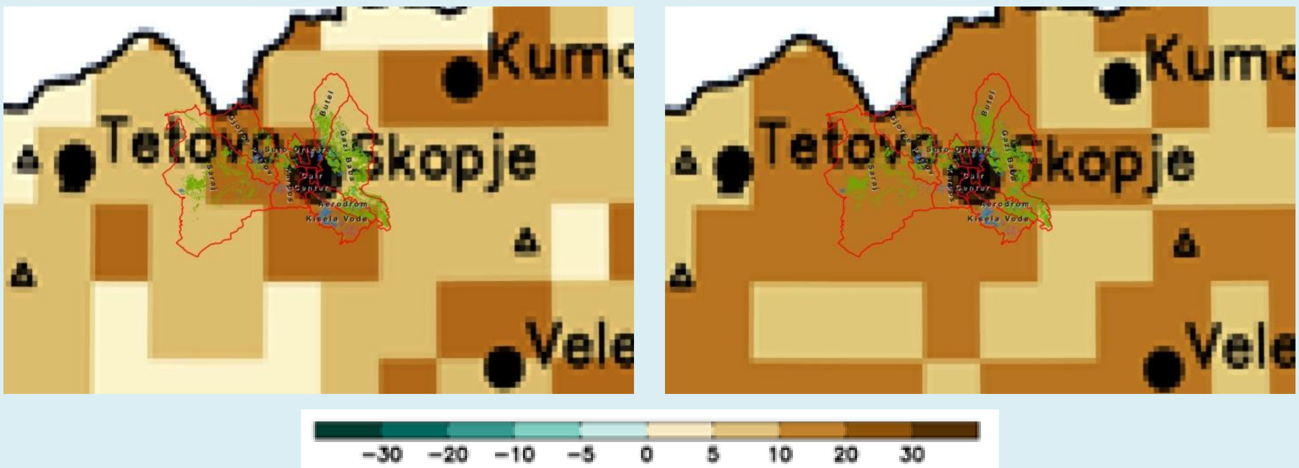
Drought

Drought is one of the biggest threats for most of the agricultural plants especially if followed with high temperatures and evapotranspiration in the summer period. The increase of days with drought are expected to vary in the ranges of 10 days/year in the surrounding areas, up to 20 days in the central part of the City which is insignificant for agriculture. In the mid term period (Graph below) In the mid-term period, the drought days are expected to increase for additional 20 days/year on the whole territory of the City including the agricultural area, which represents a serious risk for the agricultural production. Increased dry periods, increases the water deficit which should be overcomed with intensive irrigation. On a rain feed crop a serious reduction of yields can be expected due to water stress. Spring crops are also vulnerable and under high risk, especially if irrigation is limited or not properly organized in terms of applied techniques of irrigation and scheduling.



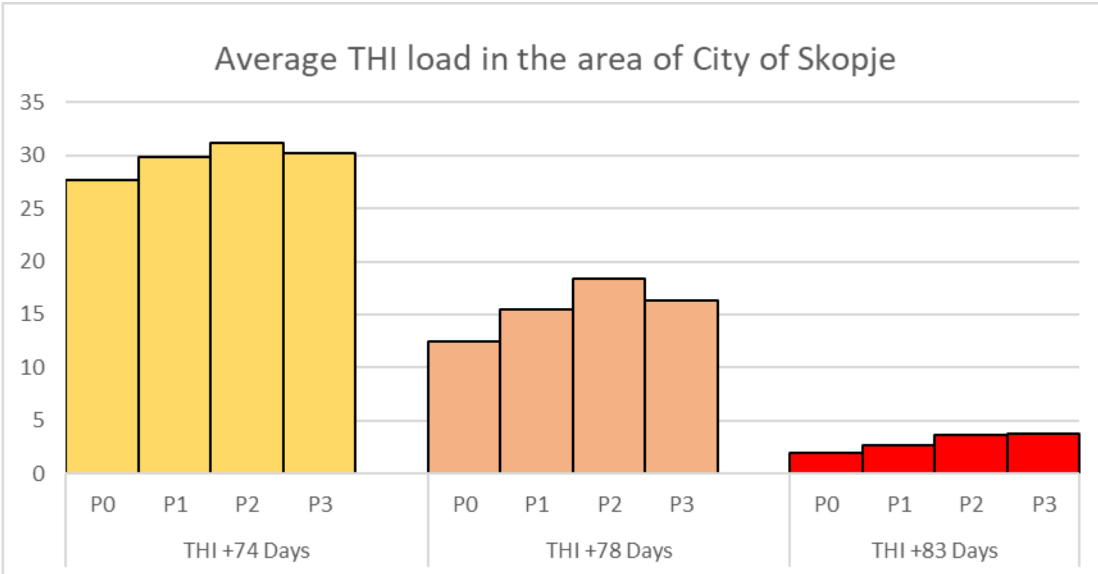
Drought 2016-2035

Drought 2046-2065



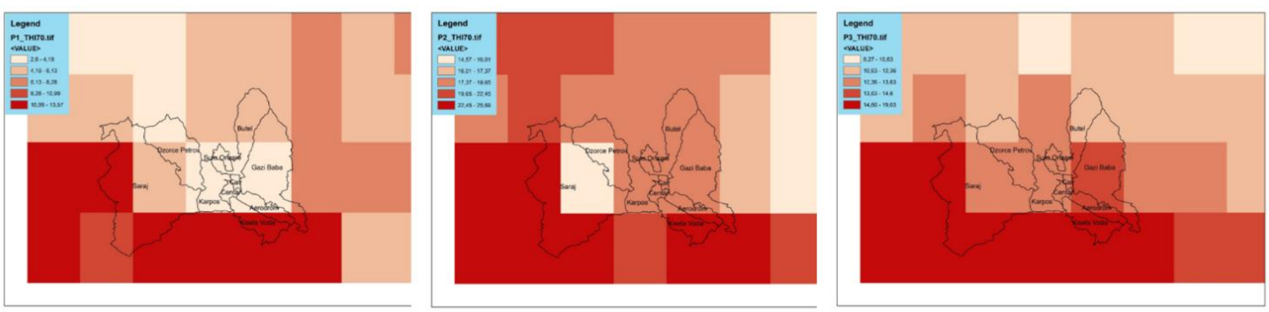
Livestock

All mean annual THI loads were averaged for the periods.

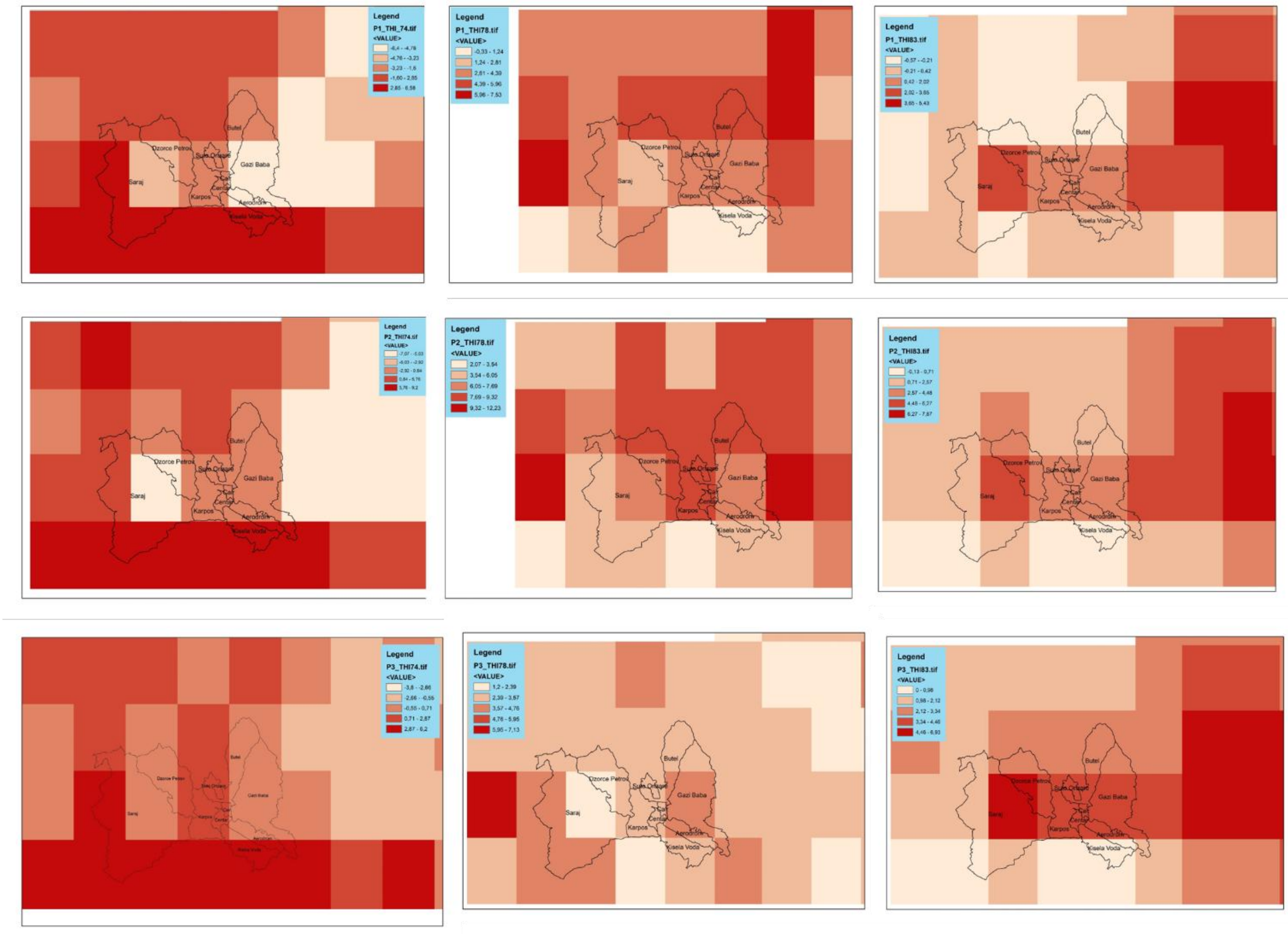


Average THI loads in ruminants in the area of the City of Skopje, for the reference period (P0: 1990-2020), short (P1: 2021-2030), medium (P2: 2031-2040) and long (P3: 2041-2050)

The estimated average annual THI load in P2 for the alert, yellow phase with THI between 74 and 78 was 35 days, in an emergency, orange phase with THI between 79 and 83 - 18 days, and in dangerous, red phase THI over 83 – 4 days. Overall average annual exposure of the livestock in phase overall would last above 30 days for the period from 2021 to 2050. The average annual THI load would be 12% higher than in P0. Worth mentioning is that the +83THI load will be close to 4 days in P2 and P3, compared to P0 when it will last only 2 days. 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)



Spatial distribution of 3 THI loads in alert (yellow THI 74+), emergency (orange THI 78+) and dangerous (red THI83+) in the City of Skopje, 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. Except for the northeast areas, all other parts of the City of Skopje could expect an increase of the THI 74+ load for 5-6 days, compared to the reference period. It is also expected that the increase for 7-10 days than in the reference period for THI 78+ load. These could be expected in the northern and western parts of the municipality. The dangerous period of THI 83+ load will be increased mostly in the northeast and central part of the municipality, where the duration should be expected to last additionally for 5-7 days.

Change in THI load in the City of Skopje from the reference point

	P1	P2	P3
THI +70	4.94	**10.22**	7.72
THI +74	2.21	**3.53**	2.53
THI +78	2.94	**5.91**	3.81
THI +83	0.69	1.73	**1.86**

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

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

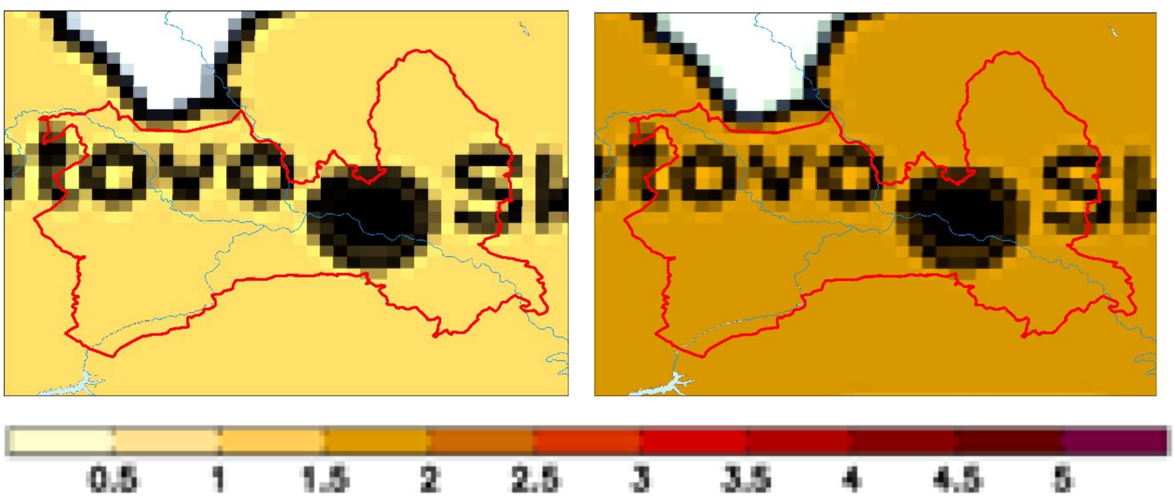
6.4 Forestry sector

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

Temperatures

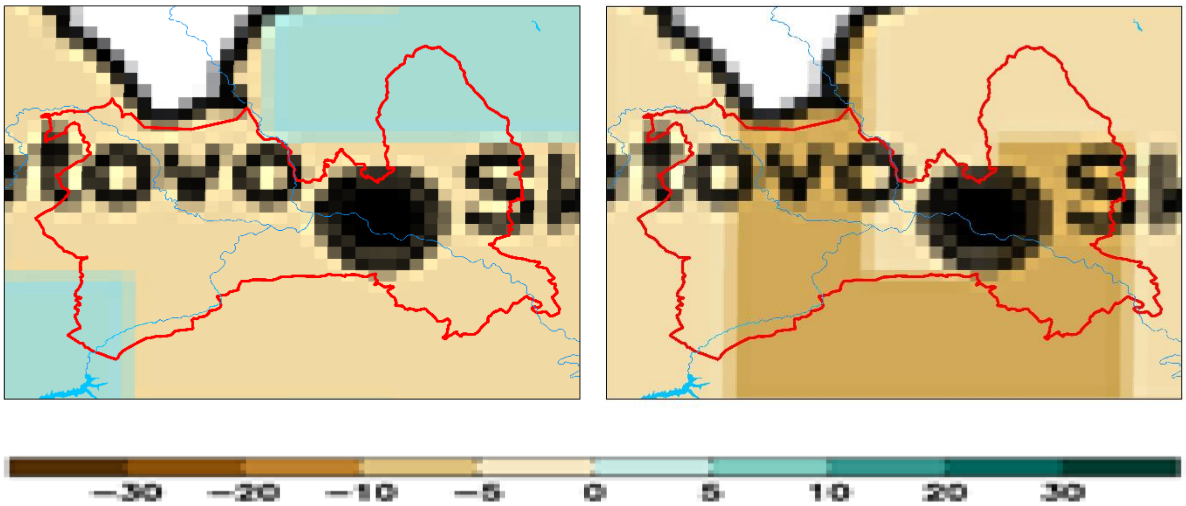
The future trends of the temperatures are evaluated using the “medium” RCP 4.5. The trends of the average air temperatures are estimated as a difference between the base period 1986-2005 and the future: short and mid-term periods. In the Graphs 14 and 15, differences between the base period and the two future periods. Out of the data presented it can be seen that an slight increase of 1 to 1.5 degrees is expected on short-term and on mid-term it is expected and increase of 2-2.5 degrees.



Projected change of average air temperatures 2015-2035 related to 1986-2005	Projected change of average air temperatures 2046-2065 related to 1986-2005

Precipitation

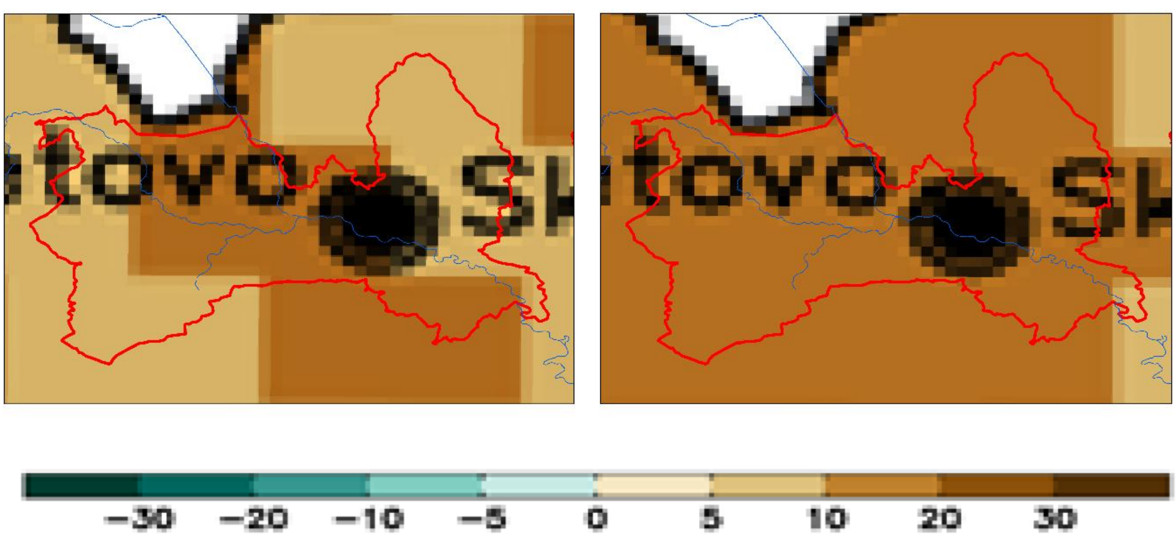
The future trends for the precipitation show a decrease of the annual precipitation sums. It can be seen on the maps below that on short-term it is expected a slight increase in the northern parts of the municipality and small decrease of precipitation in the other parts (+/- 5%). In comparison of the 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 10 %.



Projected change (%) of annual precipitation 2015-2035 related to 1986-2005	Projected change (%) of annual precipitation 2046-2065 related to 1986-2005

<u>Drought vulnerability</u>

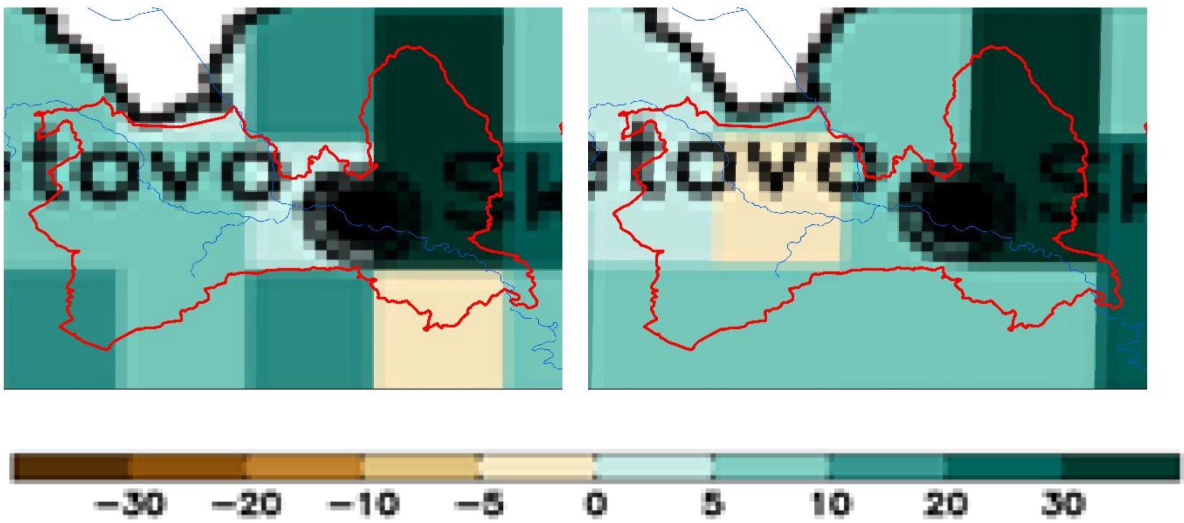
From the maps below it can be seen that on short and mid-term the projected consecutive days are increasing. On short term part of the territory is covered with 5-10 consecutive dry days and the other part is in the higher category 10-20 consecutive dry days. On mid-term, the whole territory is covered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



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



Projected change of extreme rainfall events (%) 2015-2035 related to 1986-2005	Projected change of extreme rainfall events (%) 2046-2065 related to 1986-2005

Main problems in the sector forestry connected to climate change

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

    c. If the burnt land is deciduous or mixed, after few years, if the fire was not devastating, the vegetation will come back, but it will take time for compete forest revitalization, at least 20 years to get the carbon pool as before the fire.
3. The chain effect of forest fires to increase the vulnerabilities and risks to torrential floods
    a. The climate change scenarios predict longer dry periods in the summer and not even distribution of the rain events. In turn the rain events will be with much larger amounts of water. The combination of forest fires in which the land is left bare and torrential events in which the loose soil will be removed, leaving the forest soil poor with nutrients.
    b. The forest fire affected bare land is prone to the adverse effects of the water (erosion, torrential floods). The soil after fire is loose, the organic matter is burnt and transformed in inorganic compounds. The organic matter is the agent which is keeping the structure of the soil in good condition. Without humus layer the soil is loose and prone to erosion. If it is not conserved with the immediate effects of the surrounding vegetation (grasses, herbaceous vegetation or trees) it can be easily washed away. This is on-site effect of the erosion.
4. Soil erosion and torrential streams off-site effects
    a. Not planned removal of the forest ether by illegal cut, forest fires, pests or diseases can lead to large bare areas which can increase the risks of torrential floods and in turn cause damage to downstream inhabited areas and loss of human lives
    b. The soil erosion and torrents impact the site where they occur (on-site), but the larger impacts, expressed as damage to property and human lives, happen far from the site of origin. These are off-site effects. The larger downpours happen up in the mountains where the rainfall amount is the highest. If this water amount is not stored in the subsoil or in the forest, the water flow on the surface and then it will concentrate in the smaller streams and connecting with the larger streams downstream, and on the end the large water wave will create damage in the lower parts of the catchment, where most of the larger inhabited areas are situated. This in turn may flood the inhabited areas and create damage to property and loss of human lives.

6.5 Economic 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.

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

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

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

Business Investments

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

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

6.5.2 Assessment of the future climate risk of the local economy of the City of Skopje

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 City of Skopje, as we point out in more detail above.

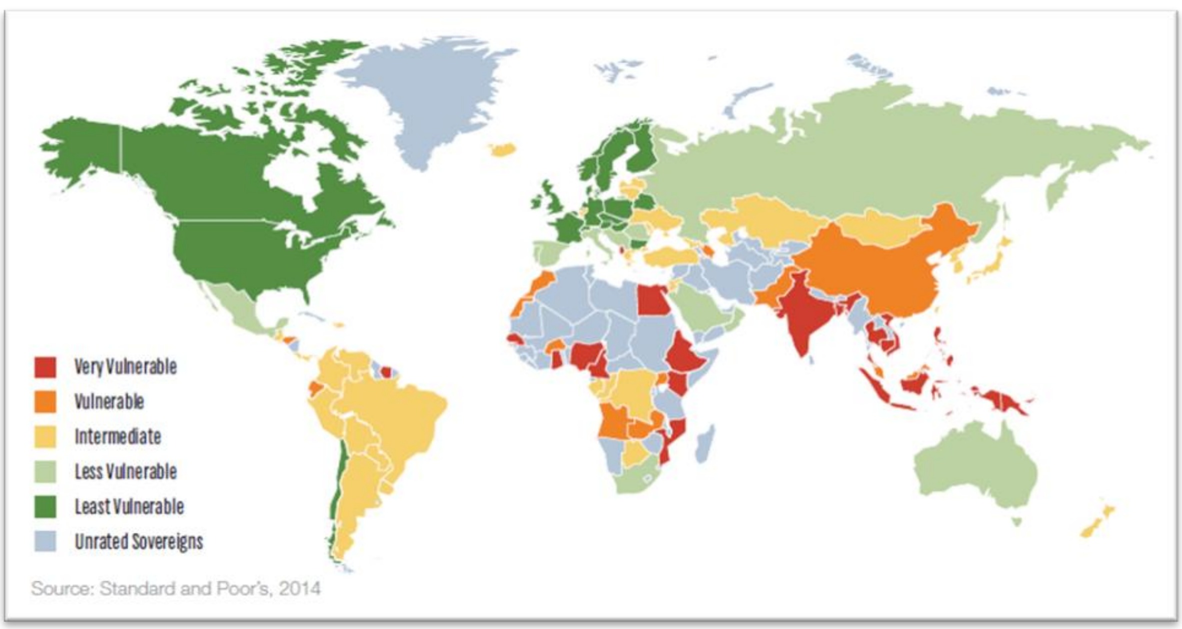


Figure 42. The impact of climate change on the global economy

At this moment there is great uncertainty and we cannot predict with great precision in which direction the local economy of the City of Skopje 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 City of Skopje in relation to the current vulnerability. However, the general assessment is that the economy of the City of Skopje 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 City of Skopje.

Excessive temperatures can have a negative impact on the incentive of tourists to visit the City of Skopje. 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 City of Skopje.

ECONOMIC SECTOR	EXTREME WEATHER EVENT	FUTIRE CLIMATE RISK
Housing	Extreme Heat	Very High
	Extreme Cold	Low
	Extreme Precipitation	Medium
	Floods	High
	Droughts	High
	Storms	Medium
	Landslides	Medium
	Forest Fires	Medium
Industry	Extreme Heat	High
	Extreme Cold	Low
	Extreme Precipitation	Medium
	Floods	High
	Droughts	High
	Storms	Medium

	Landslides	Low
	Forest Fires	Low
Trade (wholesale and retail)	Extreme Heat	Medium
	Extreme Cold	Low
	Extreme Precipitation	Medium
	Floods	Medium
	Droughts	High
	Storms	Medium
	Landslides	Low
	Forest Fires	Medium
Construction and Civil engineering	Extreme Heat	Very High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	Low
	Droughts	High
	Storms	High
	Landslides	Low
	Forest Fires	Medium
Transport and storage	Extreme Heat	Very High

	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Low
	Forest Fires	Low
Tourism and hospitality	Extreme Heat	High
	Extreme Cold	Low
	Extreme Precipitation	High
	Floods	Medium
	Droughts	Medium
	Storms	Medium
	Landslides	Low
	Forest Fires	Medium

7 CLIMATE CHANGE ADAPTATION MEASURES

7.1 Adaptation measures for economy sector

7.1.1 Measures for industry adaptation to climate change

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

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

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

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

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

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

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

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

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

7.1.2 Measures for tourism adaptation to climate change

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

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

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

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

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

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

7.2 Adaptation measures for forestry sector

Short-term measures

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

Long-term measures

- Adaptation of management plans in the forestry sector with climate change trends.
- Introduction of technologies for efficient use of biomass in forestry
- Promotion of green energy production opportunities
- Implementation of a pilot project for the production of renewable energy from biomass.

Identification of critical places in terms of natural disasters

Development of risk maps which will include:

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

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

Monitoring of forest cover loss from illegal logging

Identification of critical places and increased control of them

7.3 Adaptation measures for health sector

7.3.1 Policy level – planning, monitoring, financing

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

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

- To enhance the regular public health-related climate actions (heat waves warnings, air quality and pollution, pollen concentration in air (if possible), vector-transmissive diseases distribution, water and food security and safety (especially in the rural settlements,etc);
- To introduce an early warning system during weather extremes (especially heat, floods, and forest fires) and prepare the health sector for appropriate response;
- To enhance knowledge and skills of the management and human resources (clinicians and public health) in the health care facilities to deal with various climate extremes and climate impacts.
- To provide healthcare facilities with essential medical products, service delivery, technologies, and healthcare infrastructure for climate adaptation and resilience
- Urgently invest inessential measures for disaster risk mitigation for all eath facilities in the municipality
- Conduct as many as possible climate change and health field epidemiological- research studies on prioritized health risks per specific regions and micro-locations (heat, flood, drought, wildfires) with the aim to assess the level of risk and impact and future impact
- Providing healthy and safe working conditions and enough health workers who are well trained, informed, and knowledgeable to respond to climate risks and minimize environmental threats resulting from the operation of the health care facility.
- To check the current status and enhance monitoring and assessment:
    - The healthcare facility should have sufficient information regarding water, sanitation, chemical use, healthcare waste management, and energy services considering climate resilience and environmental sustainability.
    - The health sector should be capable to assess and manage water safety and security, sanitation, chemicals, and health care waste and energy-related risks to workers, patients, and served communities, by including assessments of climate resilience and environmental sustainability in responding to hazards and identifying and reducing exposures and vulnerabilities[15].
- Municipality and health facilities should have established special procedures and budgets for emergency preparedness and response to climate hazard

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

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;
- 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