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Gap Analysis & ESIA Disclosure Pack

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Volume 1: Environmental and Social Impact Assessment Report

Chapter 9 Climate

October 2023

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Western Balkans Investment Framework (WBIF)

Infrastructure Project Facility Technical Assistance 8 (IPF 8)

Infrastructures: Energy, Environment, Social, Transport and Digital Economy

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Volume 1: Environmental and Social Impact Assessment Report

Chapter 9 Climate

October 2023

The Infrastructure Project Facility (IPF) is a technical assistance instrument of the Western Balkans Investment Framework (WBIF) which is a joint initiative of the European Union, International Financial Institutions, bilateral donors and the governments of the Western Balkans which supports socio-economic development and EU accession across the Western Balkans through the provision of finance and technical assistance for strategic infrastructure investments. This technical assistance operation is financed with EU funds.

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4	10/10/2023	ESIA Report – Chapter 9 Climate	Team of experts	Irem Silajdžić	Richard Thadani

CONTENTS

List of tables

List of figures

9 Climate

9.1 Introduction

This chapter reports findings of the assessment of the potential climate and climate change impacts during both the construction and operational phases.

The assessment of the Project has been undertaken primary through desktop research using available information relating to climate, climate change and climate risks. The methodology included calculation of GHG emissions for baseline and project scenarios, as well as climate vulnerability assessment.

This chapter should be read in conjunction with the following chapters:

Chapter 1	Introduction
Chapter 2	About the Project
Chapter 3	Detailed Project description
Chapter 4	Policy, legislative and institutional context
Chapter 5	Assessment methodology
Chapter 17	Cumulative impacts
Chapter 18	Residual impacts
Chapter 19	ESMP

9.2 Baseline Conditions

9.2.1 Climatic Factors

9.2.1.1 The Area of Konjic

The City of Konjic is located in northern Herzegovina, surrounded by the slopes of the mountains Bjelasnica and Prenj, along the upper course of the river Neretva. Precisely because of the canyon of the river Neretva, warm air penetrates the area of Konjic and gives it the characteristics of a modified Mediterranean climate. This climate is characterised by hot and warm days.

The Federal Hydrometeorological Institute has not owned a meteorological station in Konjic since the previous was destroyed in the 1990s. The nearest meteorological station is located in the area of Ivan Sedlo, 17 km north of Konjic. However, given the significant difference in their altitudes (about 700 m), data from this meteorological station cannot be taken as relevant. Therefore, the analysis of climate and climate change for the Konjic area is partially difficult.

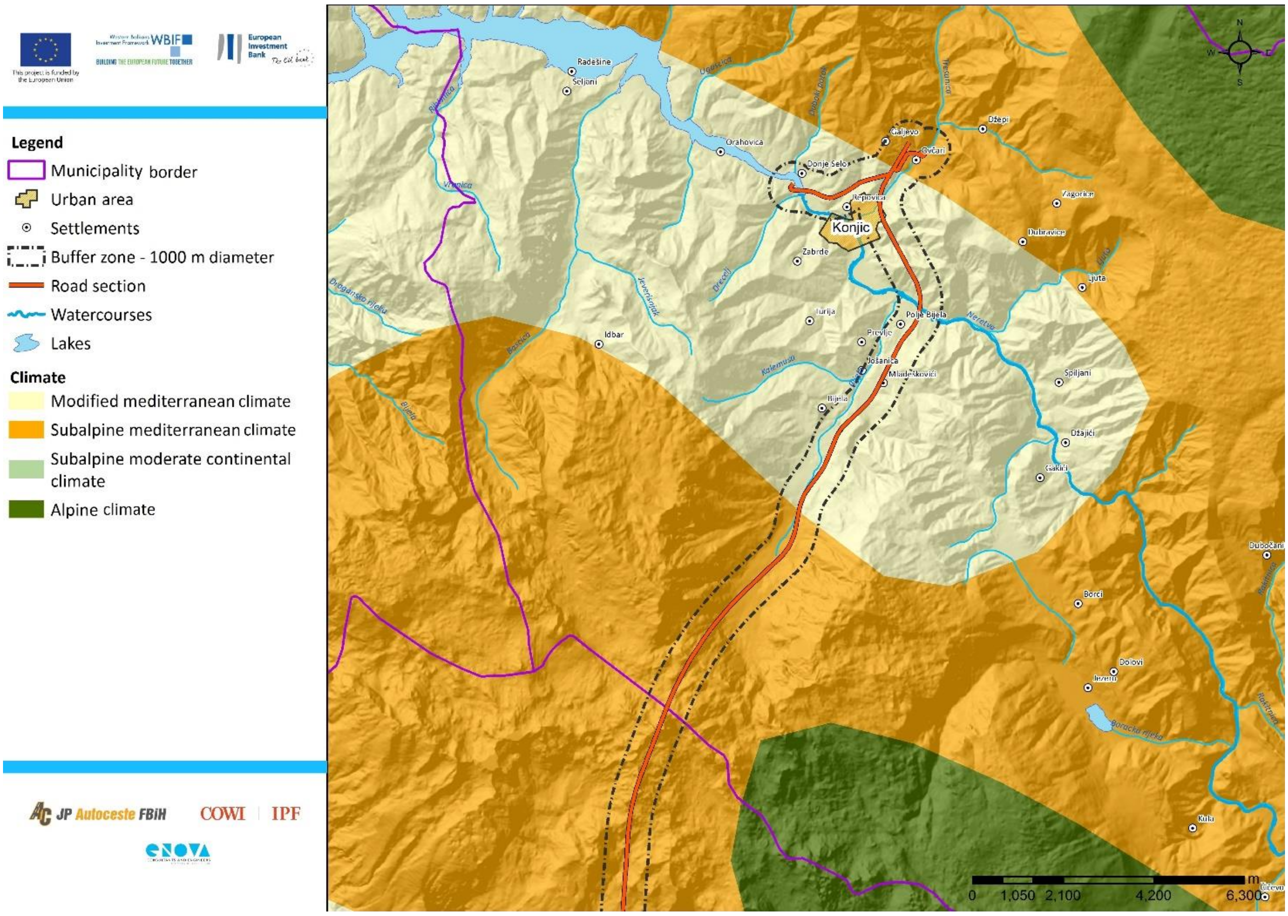

Figure 9-1: Climate zones on the territory of Konjic in relation to the motorway route

According to the available data of the Federal Hydrometeorological Institute for the period 1961-1990, the average air temperature in Konjic was 10.8 °C. The warmest month was August with an average temperature of 20.1 °C, and the coldest January with a temperature slightly above 0 °C[1].

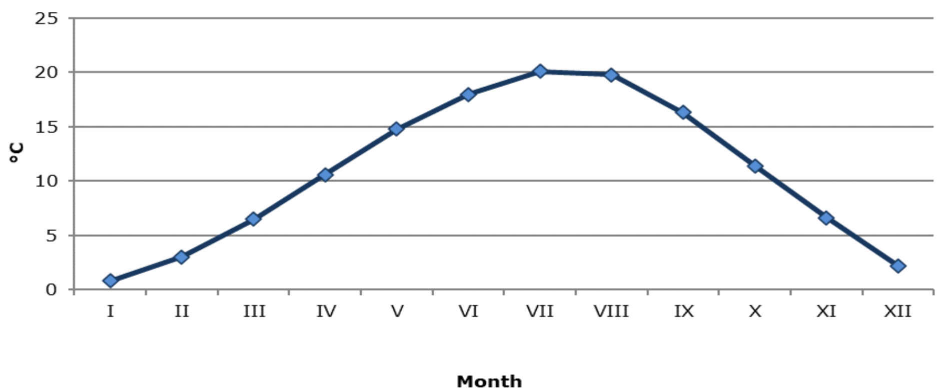

Figure 9-2: Average monthly temperature in Konjic from 1961 to 1990[2]

According to the latest available data from the Meteoblue website, which analyses the recorded air temperatures in Konjic over the last 30 years, the highest average

[1] Federal Hydrometeorological Institute, Archive of Annual Meteorological Reports 1961-1990
[2] Ibid.

daily maximum temperatures were recorded in August and July and were 28 °C, and the lowest average daily maximum temperatures in January and February were 7 °C. The highest average daily minimum temperatures were also recorded in August and July and amount 17 °C, and the lowest average daily minimum temperatures in January and February were 1 °C. These temperatures are followed by the number of tropical days, which is highest in July and August. The coldest nights are in January, when the average temperature is even -10 °C.

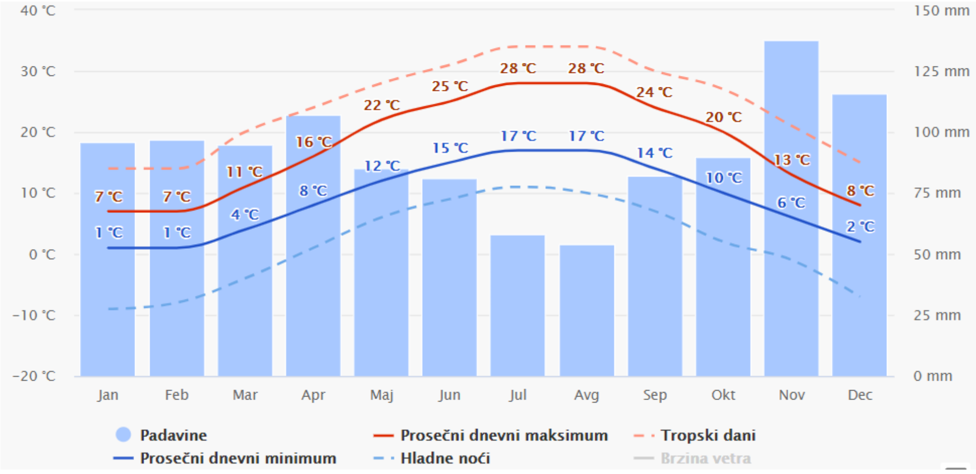

Figure 9-3: Average daily maximum (solid red line), average daily minimum (solid blue line), precipitation amount (columns), number of tropical days (dashed orange line) and average night temperature (dashed blude line) in Konjic[3]

The average annual rainfall for Konjic is 1449 mm[4]. Average rainfall is higher during the winter months. The highest amounts of precipitations were recorded in November and amounts about 135 mm, while the lowest amounts of precipitations were recorded in August and amounts slightly above 50 mm.

Figure 9-4 shows the proportion of days in month with the values of the corresponding temperatures. The highest number of days with a maximum temperature value (over 30 °C) was recorded in August, while the months characterised by extremely cold days (with a temperature lower than -5 °C) were January, February and December. Also, the black line shows the number of days with frost, which in January and December are approximately 23. The average annual number of days with frost in the period from 1961 to 1990 was 74 days. This meteorological phenomenon is most pronounced in December, January, and February[5].

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3 https://www.meteoblue.com/sr/vreme/historyclimate/climatemodelled/konjic_%d0%91%d0%be%d1%81%d0%bd%d0%b0-%d0%b8-%d0%a5%d0%b5%d1%80%d1%86%d0%b5%d0%b3%d0%be%d0%b2%d0%b8%d0%bd%d0%b0_3337476

4 Lepirica A., Physical Geography Traits Of Endemic Development Centre Prenj-Cvrsnica-Cabulja, 2008

5 Federal Hydrometeorological Institute, Archive of Annual Meteorological Reports 1961-1990

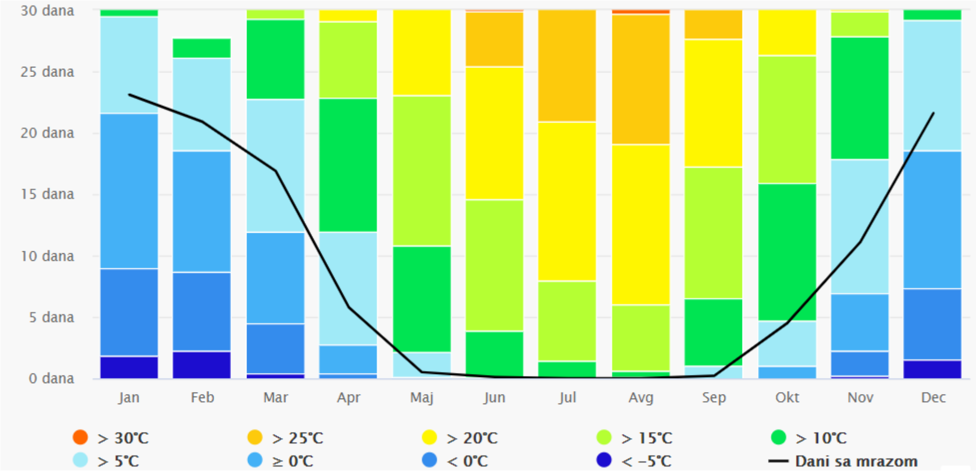

Figure 9-4: Number of days in month with the values of corresponding temperatures[6]

Figure 9-5 shows the number of sunny (yellow), cloudy (dark grey) and partly cloudy (light grey) days of the year, with the number of days with precipitation (blue line). August is the month with the largest share of sunny days, while December has the largest number of cloudy days. The highest number of rainy days was recorded in May. Generally, most rainy days occur during the spring.

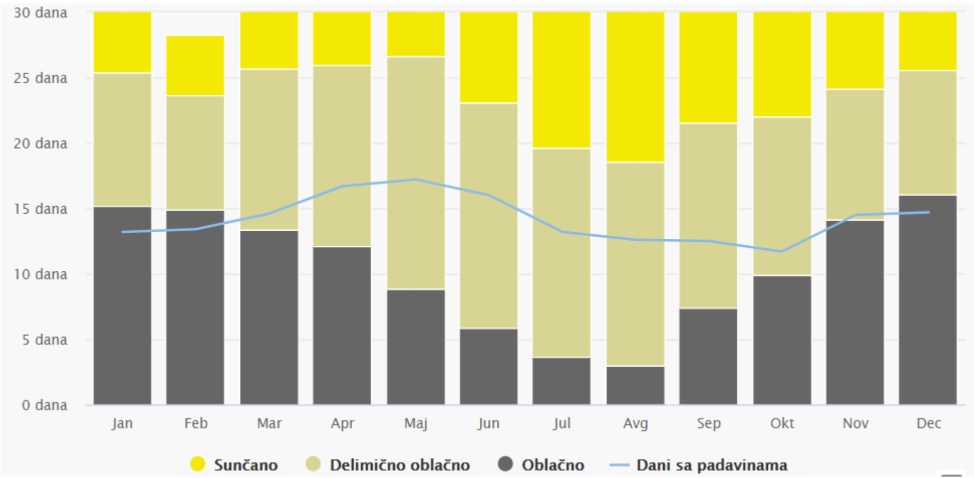

Figure 9-5: Number of sunny, cloudy, and partly cloudy days, and number of days with precipitation in Konjic[7]

Precipitations are not so common for the Konjic area. In each month, the largest share is dry days, followed by days with a rainfall of less than 2 mm. However, the number of days with precipitation of 20-50 mm and 50-100 mm is the highest for

6 https://www.meteoblue.com/sr/vreme/historyclimate/climatemodelled/konjic_%d0%91%d0%be%d1%81%d0%bd%d0%b0-%d0%b8-%d0%a5%d0%b5%d1%80%d1%86%d0%b5%d0%b3%d0%be%d0%b2%d0%b8%d0%bd%d0%b0_3337476

7 https://www.meteoblue.com/sr/vreme/historyclimate/climatemodelled/konjic_%d0%91%d0%be%d1%81%d0%bd%d0%b0-%d0%b8-%d0%a5%d0%b5%d1%80%d1%86%d0%b5%d0%b3%d0%be%d0%b2%d0%b8%d0%bd%d0%b0_3337476

November and February. Figure 9-6 also shows the number of days with snowfalls (black line), which is highest in February and is almost 8 days.

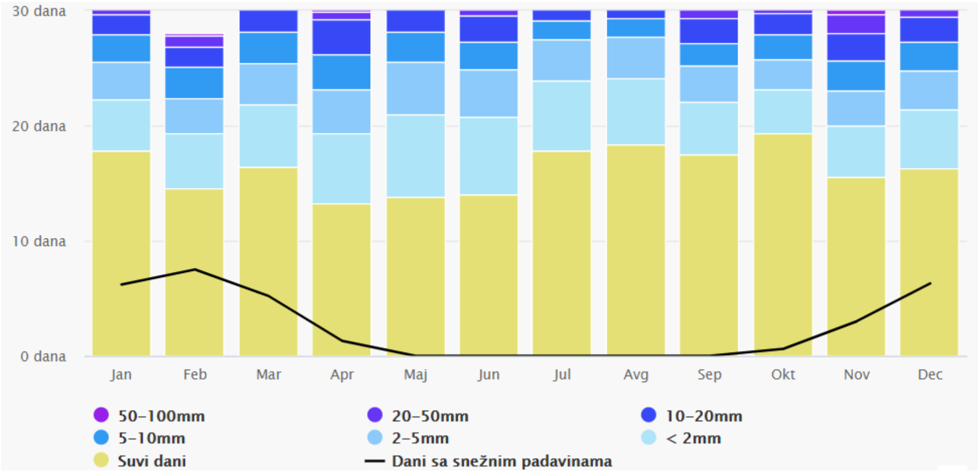

Figure 9-6: The amount of precipitation per day in the month and the number of days with snowfall[8]

When it comes to wind speed, most days of the year have wind speeds of up to 20 km/h. The highest speed (over 61 km/h) were recorded during March. The wind rose is shown in the following figure, which shows how many hours a year the wind blows from certain direction. The wind blows from the direction of the NNE for the largest number of hours during the year, while those who blow from the south are among the strongest.

8 https://www.meteoblue.com/sr/vreme/historyclimate/climatemodelled/konjic_%d0%91%d0%be%d1%81%d0%bd%d0%b0-%d0%b8-%d0%a5%d0%b5%d1%80%d1%86%d0%b5%d0%b3%d0%be%d0%b2%d0%b8%d0%bd%d0%b0_3337476

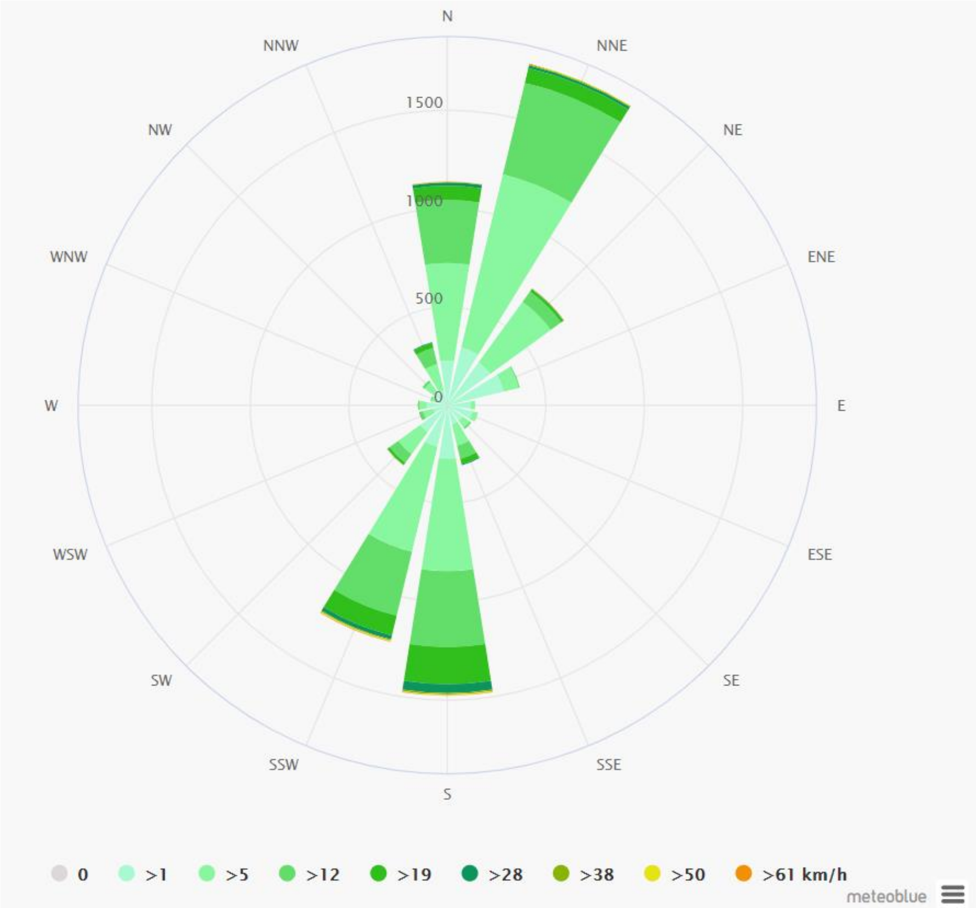

Figure 9-7: Wind rose for Konjic[9]

9.2.1.2 The Area of the Prenj Mountain

The project area includes area of the Prenj mountain, which are especially connected to the planned tunnel on this section. The climatic characteristics of Prenj are influenced by the proximity of the sea, the relief, and the altitude. The southern sides of the mountain are affected by the modified Mediterranean climate, which penetrates along the Neretva River valley.

Prenj is characterised by a subalpine Mediterranean climate (Figure 9-1) before the motorway enters the Prenj Tunnel at around 717 m asl. Mountain peaks prevent the penetration of cold masses from the north, but also Mediterranean currents into the interior. Such a collision of different air masses causes frequent and sudden changes in weather. The climate is very changeable and capricious, so snow can also fall in the summer[10].

There is no meteorological station in the area of the Prenj Mountain where air temperatures would be measured. Therefore, there are no exact temperature values, but they are estimated on the basis of comparison with neighbouring similar

[9] https://www.meteoblue.com/sr/vreme/historyclimate/climatemodelled/konjic
[10] https://www.dinarskogorje.com/b42-prenj-masiv.html

areas where measurements are made (Bjelasnica, Ivan Sedlo). Also, more detailed analyses based on estimated temperatures do not exist.

The estimated average annual temperature in this area is about 14 °C. Monthly air temperatures in January and February range from -1.5 °C to 8 °C. The average temperature decreases with the increasing altitude, so the possibility of frost on the road increases proportionally[11]. For six "cold" months of the year, the average monthly air temperature is below 0 °C. During the coldest months on Prenj, the temperature drops to -30 °C. The warmest months on Prenj are July and August, but the average monthly air temperature in the highlands is between 10 °C and 18 °C.

The intensity and amount of precipitation in Prenj is above the BiH average level – up to 2,000 mm per year in central part. The annual distribution of precipitation is uneven, so that from March to September the average is from 600 to 800 mm, and in July and August only 40 to 70 mm. Therefore, climatic influences result in heavy precipitation, which from October (sometimes from September) turns into snowfall, which is up to 3 meters high. Winter winds often blow snow off cliffs and ridges, filling depressions and sinkholes with deep snowdrift. The snow on Prenj usually melt by the end of May, and snow patches on the northern slopes can remain until the end of summer[12].

The most pronounced winds are those blowing from the north. The bora and northerly wind blow all year round, but in winter they are more frequent when they reach speeds of up to 200 km/h. On the southern slopes of Prenj, the south wind in significantly pronounced. When the south wind blows, the humidity is very high, and the temperature rises with heavy rainfall[13].

9.2.1.3 The Area of Mostar

Mostar is located in the valley of the river Neretva, which brings the Mediterranean climate from the south. The modified Mediterranean climate is mostly present on the territory of the city of Mostar, while the Mediterranean, pre-alpine, pre-alpine moderate continental, and alpine climates are in the vicinity (Figure 9-8). The motorway section is located at the territory with dominant modified Mediterranean climate, strongly under the influence of climatic conditions from the Adriatic Sea.

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[11] http://www.zeleni-neretva.ba/pdf/Brosura_Prenj.pdf
[12] Ibid.
[13] Ibid.

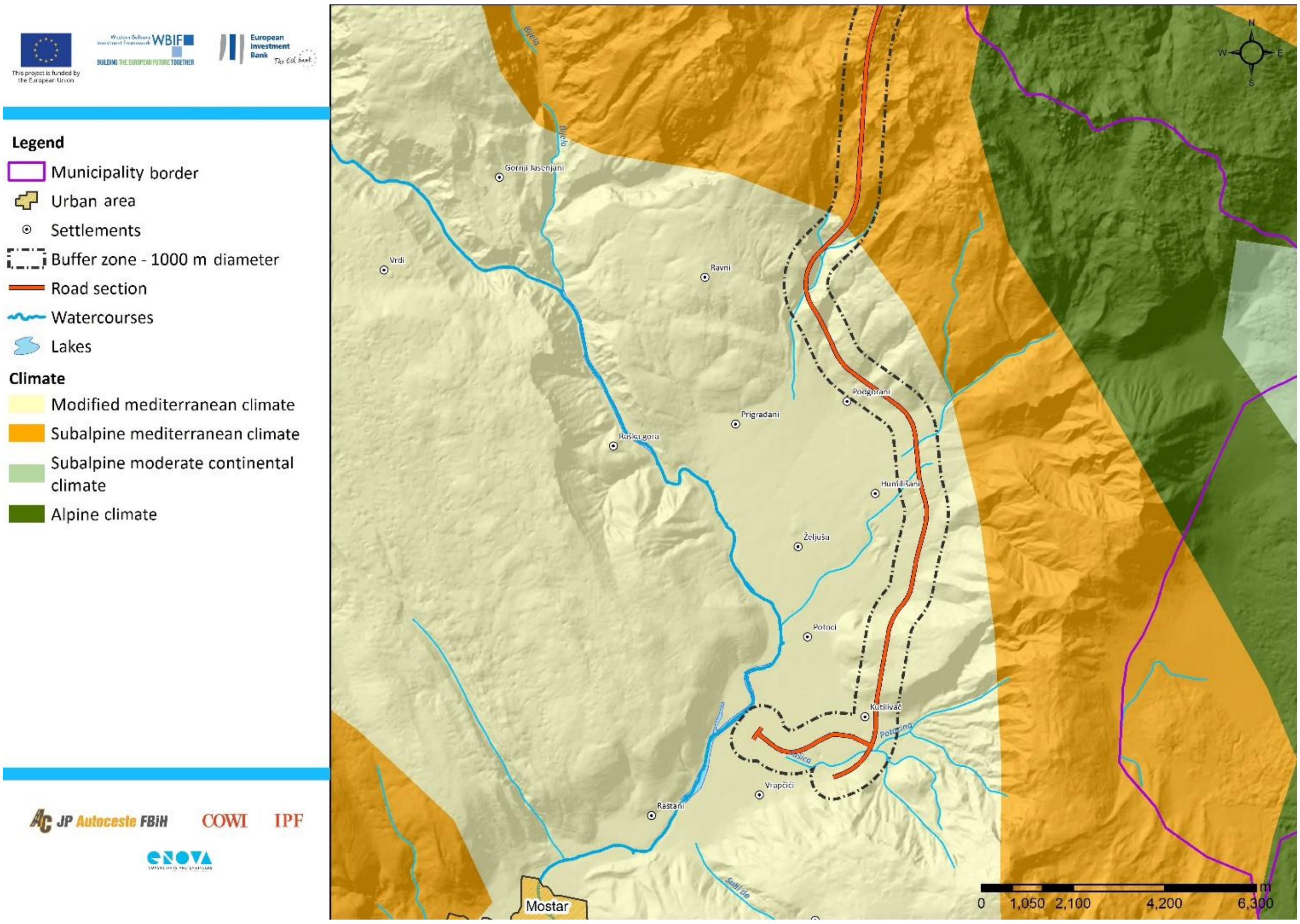

Figure 9-8: Climate zones on the territory of Mostar in relation to the motorway route

Federal Hydrometeorological Institute has a meteorological station in Mostar, located in the settlement of Bijeli Brijeg at about 99 m asl.

In the summer period, the temperatures are very high and can reach 45˚C. High summer temperatures cause droughts and state of natural disasters. Due to the proximity of Adriatic Sea, the winter temperatures are stable with average temperature being around 4˚C[14]. The average annual air temperature in Mostar in 2021 was 16.0 °C. The highest daily average air temperature in Mostar was recorded in July 2021 and was 28.5 °C. Also, the maximum air temperature was recorded in the same day and was 41.4 °C. The following Figure 9-9 shows the average monthly temperatures for Mostar. The blue columns show the recorded values in 2021, while the red line shows the mean value for the base period 1961-1990.

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[14] CETEOR Sarajevo, Environmental Impact Study for Motorway LOT 5, 6: Section Mostar North- Mostar South-Pocitelj; Mostar South-Buna, Updated Study, 2017

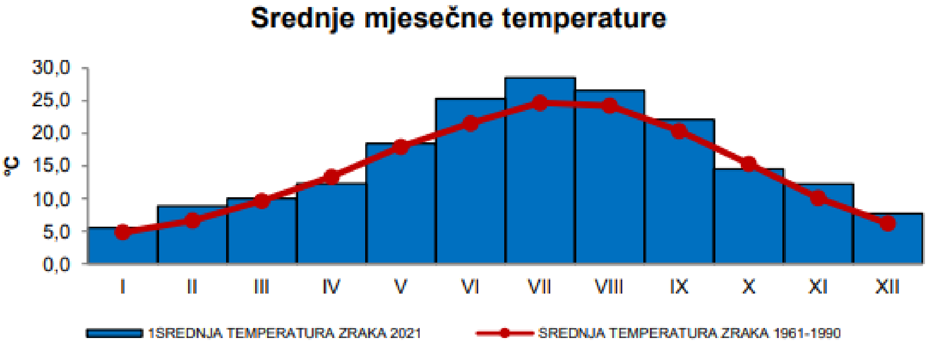
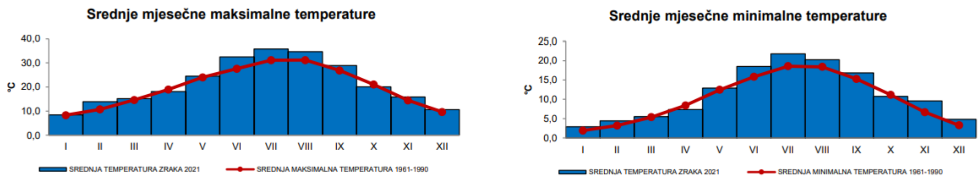


Figure 9-9: Average monthly temperatures in 2021 in Mostar[15]

It is concluded that the warmest months were July and August with an average temperature above 25 °C.

Figure 9-10 shows the mean monthly maximum and minimum temperatures. The highest values of mean monthly maximum temperatures were recorded in July and August, while the lowest value was recorded in January. The same goes for average monthly minimum temperatures.



a) average monthly maximum temperatures | b) average monthly minimum temperatures

Figure 9-10: Average monthly maximum and average monthly minimum temperatures in 2021 in Mostar[16]

It is concluded that values of mean monthly, mean monthly maximum and mean monthly minimum temperatures in almost all months are higher than in the base period, which is especially pronounced in summer and transition periods (spring-summer, summer-autumn).

Also, the number of warm days and the number of hot days in Mostar in 2021 was higher than the average for the period 1961-1990. The average monthly cloud cover in almost all months of 2020 was lower compared to the base period.

[15] Federal Hydrometeorological Institute, Annual Meteorological Report, 2020
[16] Federal Hydrometeorological Institute, Annual Meteorological Report, 2020

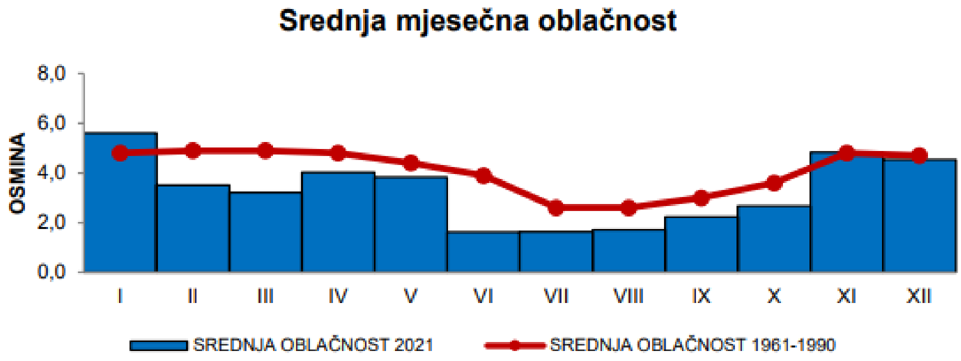


Figure 9-11: Average monthly cloud cover in 2021 in Mostar[17]

According to the Annual Report of Federal Hydrometeorological Institute from 2021, the number of sunshine at all meteorological stations, including Mostar (2,404 h), is higher that the thirty-year average (1961-1990).

In November 2021, 356 mm of precipitation was measured at the meteorological station in Mostar, which is the highest monthly value in 2021. In other months (except January, July, October, and December), below-average values were recorded.

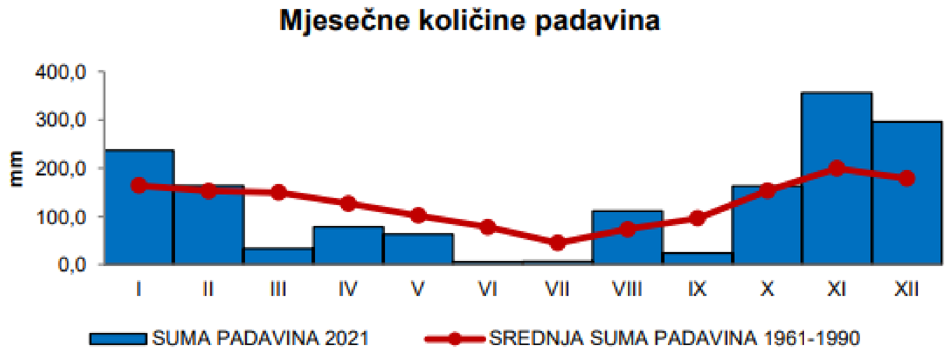
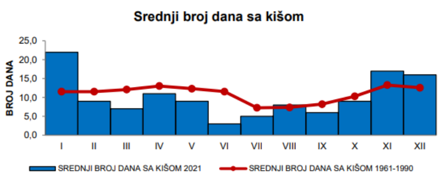
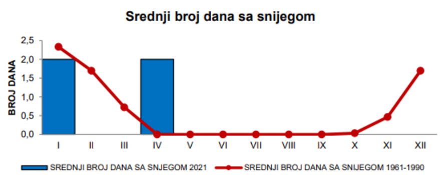


Figure 9-12: Monthly precipitation in Mostar in 2021[18]

The number of rainy days and days with snow cover by months are shown in Figure 9-13.



a) average number of days with rain



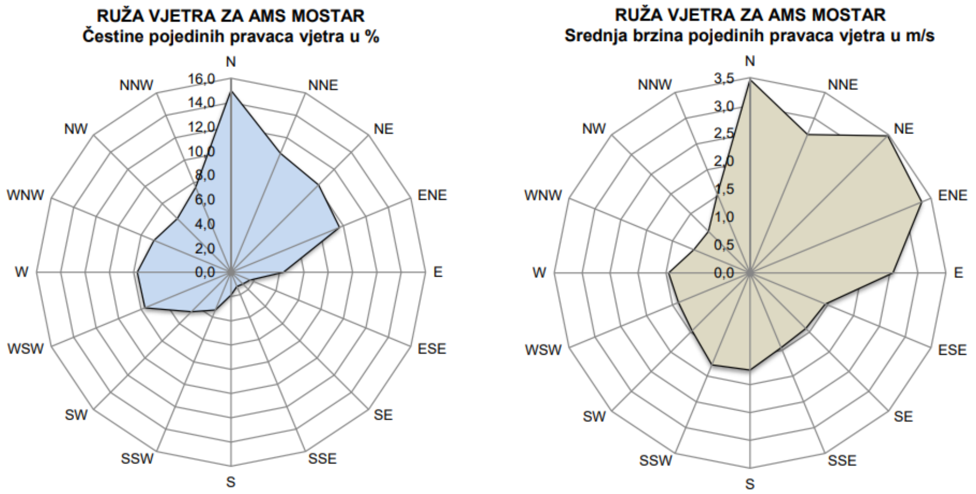
b) average number of days with snow

[17] Ibid.
[18] Federal Hydrometeorological Institute, Annual Meteorological Report, 2020

Figure 9-13: The average number of days with rain and snow in 2021 in Mostar[19]

The number of days with snow cover is below the average values in all months, except in April.

The most common winds in the Mostar are the North and North-East winds, also known as the Northern wind ("sjeverac") and Bora ("bura"). Bora is a phenomenon occurring on the east coast of the Adriatic Sea which penetrates the inland through Neretva valley. Bora is a very dry and cold wind blowing in the winter months. In spring and autumn another dominant wind is the Southern wind ("jugo") also penetrating from the Adriatic Sea. Jugo is a very humid wind and brings heavy rains. Figure 9-14 shows the wind rose for Mostar for 2021.



a) wind frequency and direction in % *b) wind speed in m/s*

Figure 9-14: Wind rose for Mostar in 2021[20]

9.2.2 Climate Change

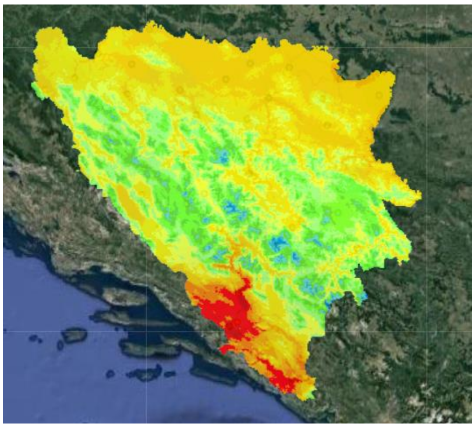
The analysis of future climate characteristics of project area is based on the following data sources:

- Third National Report and Second Biennial Greenhouse Gas Emissions Report of Bosnia and Herzegovina
- 5th Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR5)
- Climate Atlas of Bosnia and Herzegovina (1961-1990, A1B[21] 2001-2030, A1B 2071-2100, A2[22] 2071-2100)
- www.climatewizard.org (1961-1990, A2 2046-2065)
- RCP 8.5 (Representative Concentration Pathways) scenario[23].

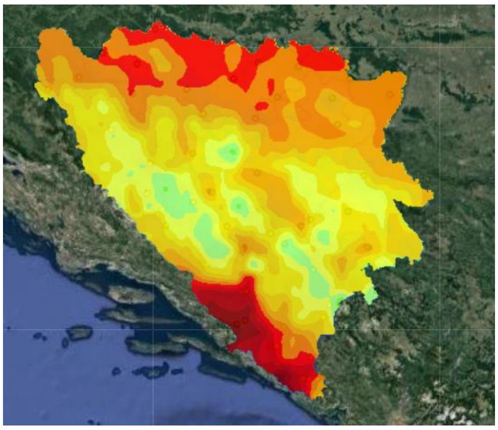
[19] Federal Hydrometeorological Institute, Annual Meteorological Report, 2020
[20] Federal Hydrometeorological Institute, Annual Meteorological Report, 2020
[21] A1B assumes a balanced mix of technology and use of basic resources, with technological improvements that make it possible to avoid using only one energy source.
[22] The A2 scenario assumes a very heterogeneous society. In the background of this society are demand to rely in local resources and preserve the identity of local communities.
[23] RCP 8.5 combines assumptions about large populations and relatively slow income growth with moderate rates of technological change and improved energy intensity.

9.2.2.1 Temperature Change Projections

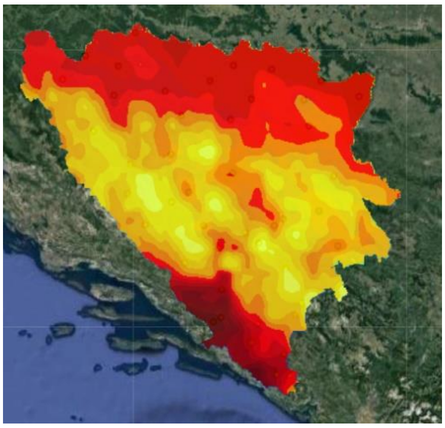
The values of mean annual temperatures were analysed according to the RCP 8.5 scenario, as the scenario in which climate change is most pronounced. Maps for the baseline period and three periods: 2011-2040, 2041-2070 and 2071-2100 are shown in the following Figure 9-15.



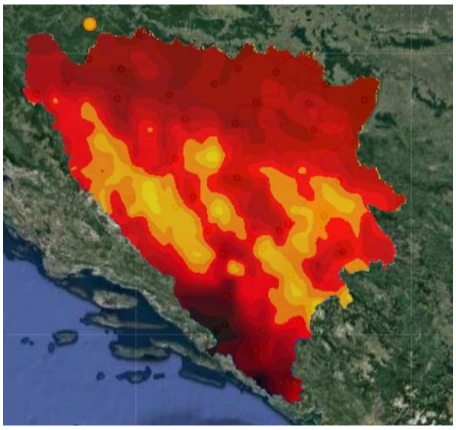
a) 1961-1990



b) 2011-2040



c) 2041-2070



d) 2071-2100

Figure 9-15: Average annual temperature for the baseline period (1961-1990) and for the periods: 2011-2040, 2041-2070, 2071-2100 according to the scenario RCP 8.5[24]

Table 9-1 gives the values of the estimated mean annual temperatures in the indicated periods.

Table 9-1: Values of average annual temperatures according to scenario RCP 8.5

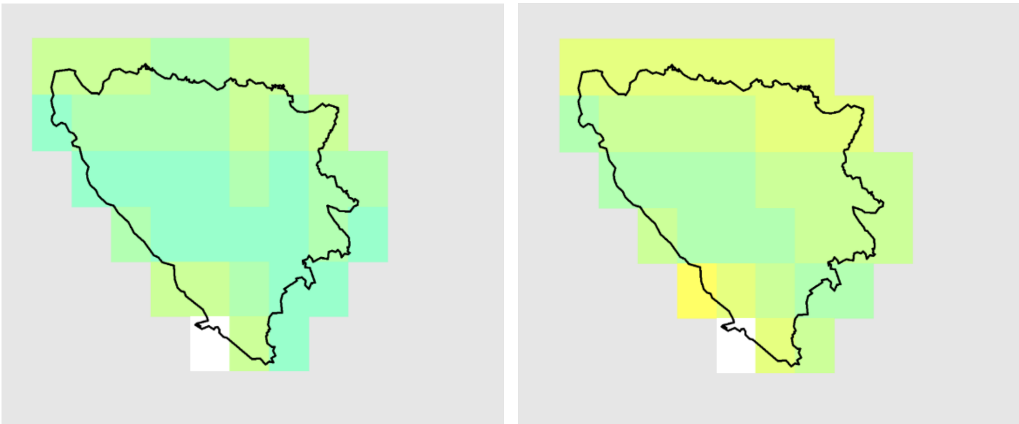
Scenario RCP 8.5			
Period	Average annual temperature for project area, °C		
	Konjic	Prenj	Mostar
1961-1990	10,8	6,8	14,6
2011-2040	11,8	8,2	15,7
2041-2070	12,9	9,0	16,5
2071-2100	14,5	10,6	18,1

[24] http://www.unfccc.ba/klimatski_atlas/index.html

By the end of the 21st century, in the project area, as well as in the entire territory of BiH, a continuous increase in the average annual temperature is predicted. Based on the shown maps and the estimated values of annual temperatures, it can be concluded that the average annual temperature in the project area is expected to increase by about 4 °C.

For a more detailed analysis of the climatological characteristics of the project area, the data obtained through the online tool, the so-called "Climate Wizard"[25]. Analyses can be done for two scenarios and for the purpose of this document, scenario A2 was selected as more stringent.

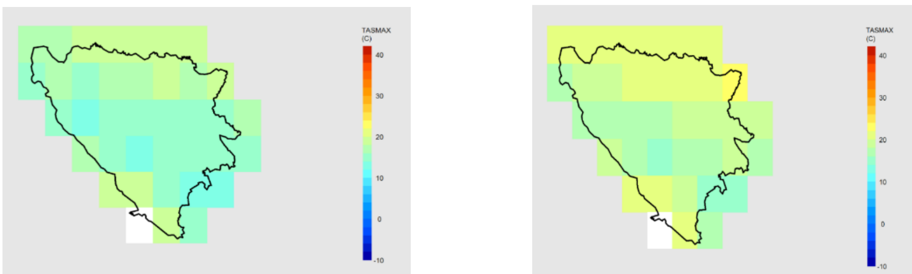
The following Figure 9-16 shows the values of the average minimum temperature for the periods: 1961-1990 and 2046-2065.



a) 1961-1990 b) 2046-2065

Figure 9-16: Average annual minimum temperature[26]

Based on the presented values, the expected temperature increase in average annual minimum temperature in the project areas is between 2.5 °C and 3.0 °C. Figure 9-17 shows the average maximum temperature for the periods: 1961-1990 and 2046-2065.



a) 1961-1990 b) 2046-2065

Figure 9-17: Average annual maximum temperature[27]

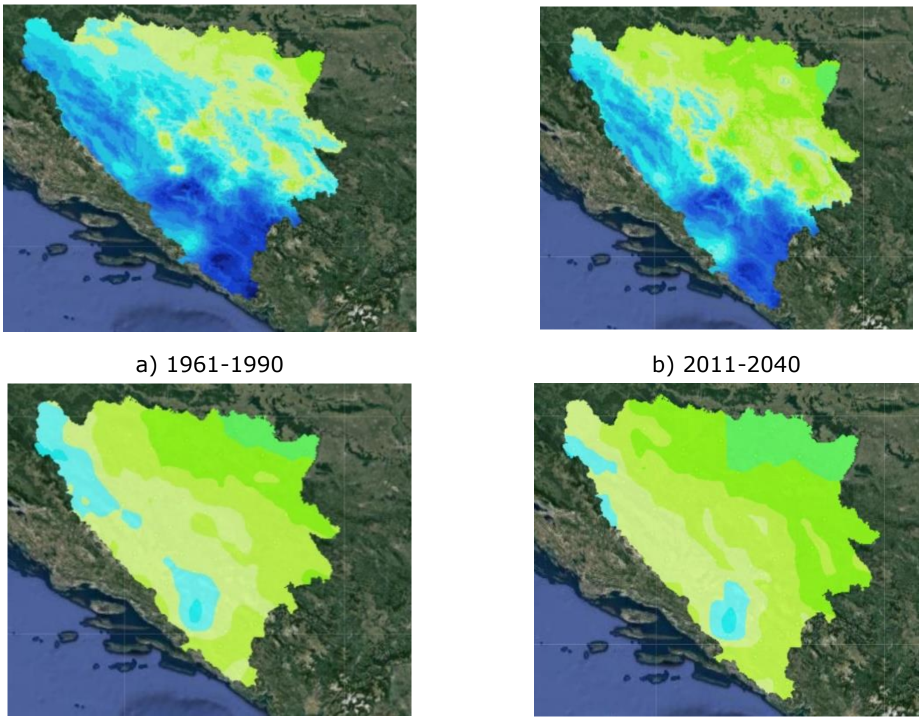
The expected increase in the average annual maximum temperature in the project area is between 3.0 °C and 3.5 °C.

[25] http://climatewizard.ciat.cgiar.org/index1.html
[26] Ibid.
[27] Ibid.

9.2.2.2 Changes in Precipitation

According to climate models for Bosnia and Herzegovina, precipitation is predicted to decrease by 10% in the west of the country and increase by 5% in the east. The autumn and winter seasons are expected to have the highest reduction in precipitation[28]. In recent years, the impact of climate change on the precipitation regime with consequences on water resources has been increased in BiH. The consequences of these changes are reflected in the distribution of precipitation during the year. Changes in precipitation are more enhanced by seasons than on an annual basis. According to the latest data from the meteorological station in Mostar (2021); January, August and December were rated as rainy months, while November was rated as a very rainy month compared to the multi-year average (1991-2020). Otherwise, March was rated as dry, September as very dry, and June and July as extremely dry months[29].

Estimated precipitation amounts according to the stricter scenario RCP 8.5 are shown in Figure 9-18.



a) 1961-1990 b) 2011-2040

c) 2041-2070 d) 2071-2100

Figure 9-18: Average annual precipitation for the baseline period (1961-1990) and for the periods: 2011-2040, 2041-2070 and 2071-2100 according to the scenario RCP 8.5[30]

Table 9-2 gives the values of the estimated mean annual precipitations in the indicated periods.

---

[28] Results from running the EH50M model presented in Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina (June 2013). This is detailed on p.16 of the Initial National Communication for Bosnia and Herzegovina under the UNFCCC, 2009.

[29] Federal Hydrometeorological Institute, Annual Meteorological Report, 2021

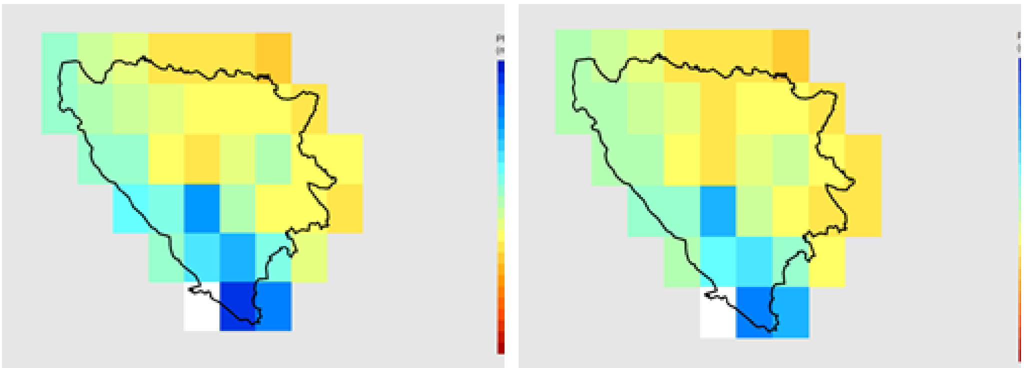
[30] http://www.unfccc.ba/klimatski_atlas/index.html

Table 9-2: Values of average annual precipitation according to scenario RCP 8.5

Scenario RCP 8.5			
Period	Average annual precipitation for project area, mm		
	Konjic	Prenj	Mostar
1961-1990	1455	1850	1515
2011-2040	1110	1150	1250
2041-2070	1035	1080	1220
2071-2100	1010	1045	1140

As previously pointed out, this scenario is the most severe when it comes to climate change, and the expected decrease in precipitation by the end of the century is largest. According to this scenario, there will be an increase in the number of dry days during the year.

A more detailed presentation of the change in precipitation was made for the two time periods: 1961-1990 and 2046-2065 using online tool "Climate Wizard"[31], according to the scenario A2.



a) 1961-1990 b) 2046-2065

Figure 9-19: Annual precipitation for the periods 1961-1990 and 2046-2065 according to the scenario A2[32]

It is clear that the consequences of climate change will be reflected in changes in the value of annual precipitation. The expected reduction of the annual precipitation in the area of Mostar is about 150 mm, in the area of Prenj about 100 mm and in the area of Konjic about 80 mm. The decrease in the number of wet days is shown in Figure 9-20.

[31] http://climatewizard.ciat.cgiar.org/index1.html
[32] Ibid.

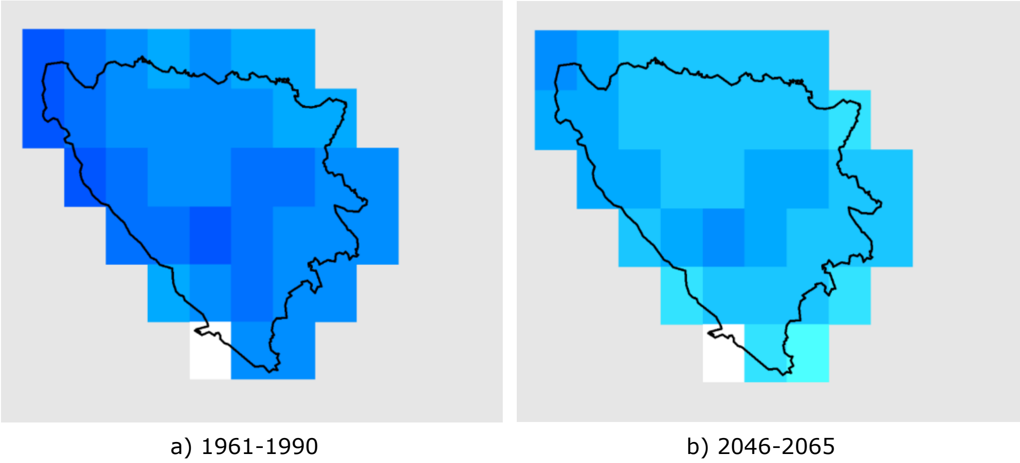


Figure 9-20: Number of wet days per year according to scenario A2[33]

The number of wet days in the subject area will decrease by an average of 25 per year.

9.2.2.3 Current Annual GHG emissions

The most common anthropogenic sources of CO_2 are the combustion of fossil fuels (for power production, industry, transport, heating, etc.), industrial activities (steel and cement production), land use change and forestry activities. In 2013, electricity and heat production accounted for the largest share in total CO_2 emissions, followed by road transport, agriculture, manufacturing industries and construction.
Total CO_2 emissions in BiH come from four main sectors: energy, industrial processes, agriculture and waste, and in 2013 amounted to 24,027.84 tCO_{2e}. The share of CO_2 emissions by sector in 2013 is shown in the following figure..

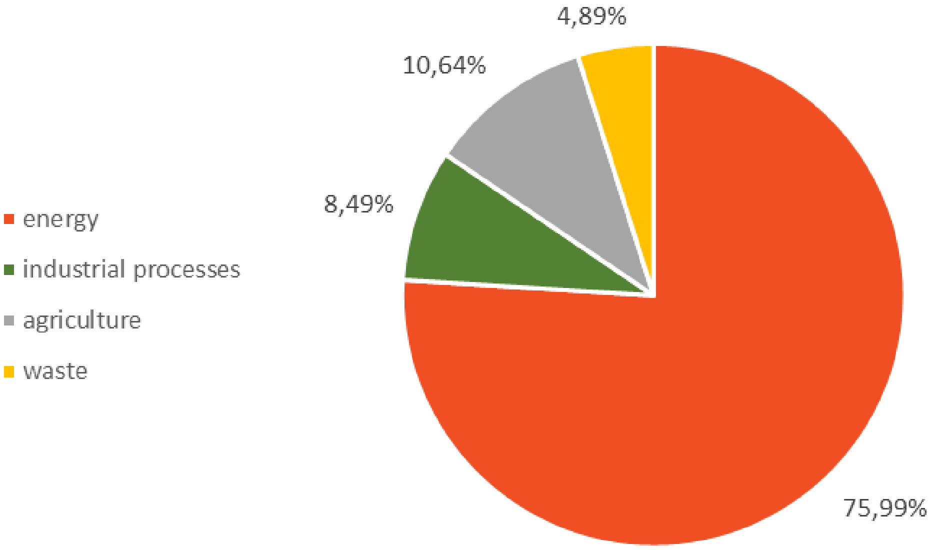


Figure 9-21: The share of CO_2 emissions by sector in 2013 in BiH[34]

[33] Ibid.
[34] UNFCCC, Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of BiH, 2016

Within the total emissions in the energy sector in 2013, 2,896,330 tCO_{2e} were from transport.

Next figure shows the total CO_2 emissions within the energy, resulting from the combustion of fuels, which includes transport.

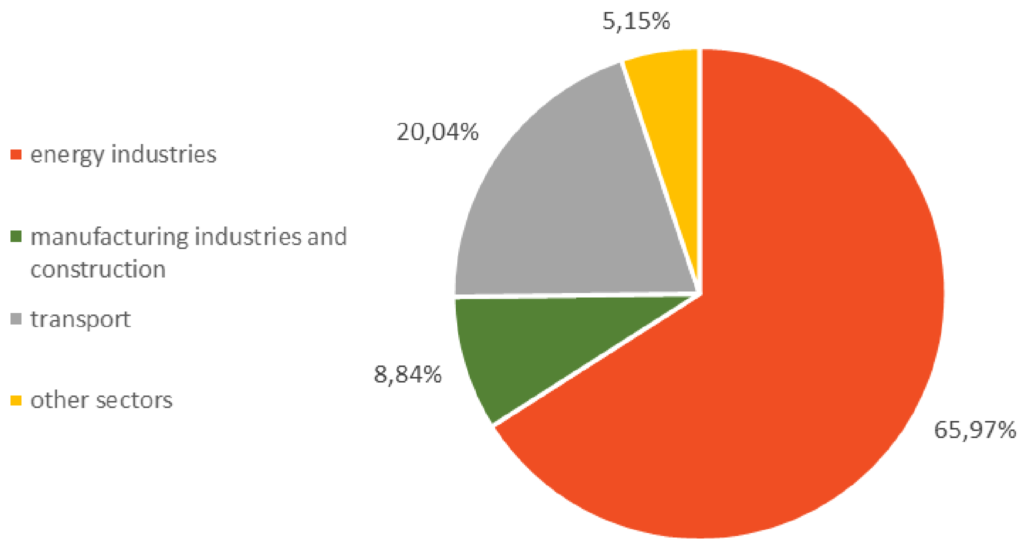


Figure 9-22: The share of CO_2 emissions within energy sector in 2013 in BiH[35]

Based on the latest data from the Worldometers website, CO_2 emissions from the transport sector in 2016 amounted to 3,363,309.72 tons[36].

9.3 Assessment of Impacts

9.3.1 Climate Risks

The key baseline facts that guide the assessment of climate change impacts on motorway infrastructure are:

> In the past two decades, Bosnia and Herzegovina has faced with several significant extreme climate and weather episodes that have caused significant material and financial deficits, as well as the loss of human lives. The two most significant events are the drought during 2012 and the floods during 2014[37].

> A pronounced change in the annual distribution of precipitation with an increase in temperature is one of the key factors that cause more frequent and intense occurrence of drought and floods on the territory of BiH. Also, as a result of floods and heavy rainfall in BiH, landslides occur very often. On the other hand, as a result of high temperatures and droughts, fires can occur.

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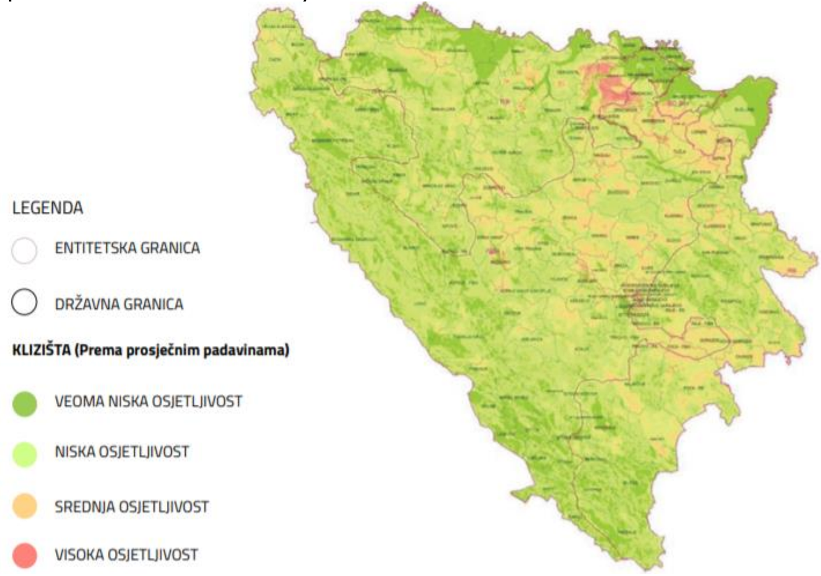
[35] UNFCCC, Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of BiH, 2016
[36] https://www.worldometers.info/co2-emissions/bosnia-and-herzegovina-co2-emissions/
[37] UNFCCC, Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of BiH, 2016

- Triassic, Jurassic, Cretaceous, Eocene, Miocene and Quaternary deposits participate in the geological structure of the terrain that gravitates to the motorway route and facilities on the Konjic (Ovcari) - Prenj Tunnel - Mostar North subsection. The occurrence of landslides and rockfalls is related to the execution of construction works, more precisely because of creation of road cuts or embankments, excavation works on tunnels, topsoil stripping, use of heavy machinery and equipment, soil dewatering.
- According to the Map of flood risk[38], area around Konjic is characterized as a high risk area. Risk maps indicating the flooding risk for inhabitants and objects are not available for Konjic area. According to the Study on Preliminary Flood Risk Assessment for the Category I watercourses[39] there is no flood damage risk from the Neretva river in the area of influence on both Mostar and Konjic side. Moderately significant flood risk is identified for the Tresanica river in the industrial area of Konjic's Repovica settlement.
- Viaducts will be constructed at heights of 30 m and above the Neretva and Tresanica river, therefore no flood risk to the motorway structures is expected.

Landslides. As a result of floods, the project area, especially the area of the City of Konjic is often affected by landslides, mostly local roads and settlements. The most devastating landslides in Konjic in the past period happened in February 2018 and in December 2020, when local roads and power lines were damaged, deposits of earth and stones broke into the family house[40].

The distribution of zones prone to landslides in BiH is shown in Figure 9-23, where the green colour represents areas that are not exposed to landslides, while the red colour represents areas extremely sensitive to the occurrence of landslides.



[38] Available at https://avpjm.jadran.ba/zastita-od-voda
[39] Hydro-Engineering Institute Sarajevo, Study on Preliminary Flood Risk Assessment for for Category I Water Courses in FBiH, April/May 2013
[40] https://www.bljesak.info/vijesti/flash/Nevrijeme-oko-Konjica-i-Jablanice-aktiviralo-klizista-zatrpane-lokalne-ceste/226132; https://www.konjic.ba/ba/vijesti/iz-konjica/519-nacelnik-opcine-konjic-obisao-radove-na-sanaciji-klizista-u-naselju-orahovica.html

Figure 9-23: Distribution of landslide prone zones in BiH[41]

It can be concluded that the project area has a generally low sensitivity to landslides, with some parts being moderately sensitive.

Landslides in the City of Konjic occur at several locations, and one of the most active is the one in the area of road communication Konjic-Lisicici, at the location Kralupi, and the central part of the landslide is in Jezerine. So far, landslides and rock falls in the City of Konjic have not had a significant impact on human life and health and material goods, but it is necessary to repair existing landslides and rock falls, and invest in preventing new landslides and rock falls. Within the SECAP, an assessment of the risk of the landslides, displacement, and subsidence of the soil in the City of Konjic was performed. The results are shown in Table 9-3.

Table 9-3: Characteristics of the identified hazards as a consequences of climate change assessment associated with the risk of landslides and rock falls in the City of Konjic[42]

Risk	Risk characteristics				
	Current characteristics		Future characteristics		
	Probability of risk	Impact of risk	Expected change in intensity	Expected frequency exchange	Period
Soil displacement	Moderate	Moderate	Increase	Increase	Risk in the short, medium, and long term
Landslides	Moderate	Moderate	Increase	Increase	Risk in the short, medium, and long term
Soil subsidence	Low	Moderate	Decrease	Without change	Risk in the short, medium, and long term

As defined in the SECAP, landslides and soil displacements are expected along non-functional roads.

The area of the Prenj mountain does not have a pronounced sensitivity to landslides. However, the destroyed mountain-tourist trails that are a consequence of deforestation create preconditions for future erosion and activation of landslides in the Prenj area[43].

The area of Mostar is among 12 municipalities in BiH most affected by landslides, with an index of 55 (out of maximum of 100). Bearing in mind that one side of the Mostar valley is built of Neogene sediments, Mostar is classified among municipalities with the possibility of landslides, although only 1,09% of the territory of Mostar has a medium and high risk of landslides. The length of railways, motorways, highways, and local roads in areas of extremely significant landslide risk

[41] UNDP, Landslide risk management study in Bosnia and Herzegovina
[42] Sustainable Energy and Climate Action Plan (SECAP) of Konjic Municipality, 2020
[43] WWF, Forests of high protection value in Bosnia and Herzegovina, 2017

is 4.79 km[44]. The settlements where high-risk landslides have been recorded are Semovac and Bjeluse, which are not very close to the project area[45].

The identified places of potential landslides occurrence in the project area are far from the motorway section. However, the entire project area is low to moderately sensitive to the landslide occurrence. Based on geological characteristics of the terrain in the narrower and wider area, the occurrence of landslides and rockfalls is mainly related to the execution of construction works, more precisely because of creation of road cuts or embankments, excavation works on tunnels, topsoil stripping, use of heavy machinery and equipment, as well as soil dewatering. However, these impacts can be mitigated, and appropriate measures are defined within this study.

Droughts. As previously shown in Chapter 9.2.2, the average annual temperatures in the project area are predicted to raise constantly, with an increase in the number of dry days and a decrease in rainfall. The document Assessment of the Vulnerability of the Federation of Bosnia and Herzegovina to Natural and Other Disasters states that the drought, which has caused great damage to field and livestock crops, has so far, among others, mostly affected the Herzegovina-Neretva Canton[46]. One of the most radical droughts in recent history, which hit the area of BiH, occurred in 2012. A year earlier, rainfall had been reduced by 50% resulting in historically low flows in all major rivers in the country[47]. Therefore, the tendency for its appearance in the future, with the increase of the average annual temperature and the decrease of the amount of precipitation, is more and more pronounced.

Within the SECAP document for the municipality of Konjic, the degree of threat from the occurrence of high temperatures now and in the future was identified (Table 9-4).

Table 9-4: Characteristics of the identified hazards as a consequences of climate change assessment associated with the risk of droughts in the City of Konjic[48]

Risk	Risk characteristics				
	Current characteristics		Future characteristics		
	Probability of risk	Impact of risk	Expected change in intensity	Expected frequency exchange	Period
Extremely high temperatures	Moderate	High	Increase	Increase	Risk in the long term

[44] EU Floods Recovery Programme, Floods and landslides risk assessment for the housing sector in Bosnia and Heregovina, 2015
[45] http://www.mostar.ba/vijesti_citanje/grad-mostar-poduzeo-niz-aktivnosti-na-zastiti-lokaliteta-i-pribavljanju-potrebne-dokumentacije-kako-bi-se-izvrsila-sanacija-kliz.html; https://www.slobodnaevropa.org/a/mostar-kliziste-odnosi-i-historiju/26832023.html
[46] Federal Administration for Civil Protection, Assessment of the Vulnerability of the Federation of Bosnia and Herzegovina to Natural and Other Disasters, 2014
[47] Amar Causevic, Sasja Beslik, Faruk Hadzic, Robert Griffin, Bosnia and Herzegovina – Impacts and risks of climate change, 2020
[48] Sustainable Energy and Climate Action Plan (SECAP) of Konjic Municipality, 2020

Under SECAP, the transport sector has not been identified as vulnerable to droughts and water shortages.

In the area up to 1.000 m asl on the mountain Prenj, rocky soil contributes to the reduction of moisture. Therefore, the summers are dry, and the vegetation is reduced. The appearance of dry summers is also witnessed by dried-up streams[49].

The number of sunny days, with extremely high temperatures, which cause droughts, is becoming more frequent in Mostar. Mostar was hit by extremely drought in 2011, and the city was one step closer to declaring a state of natural disaster[50].

According to Federal Hydrometeorological Institute, the number of warm and hot days in Mostar in 2021 was higher than the average for the period 1961-1990[51]. Previously extremely dry climate is getting wetter and wetter, which makes the summer heat unbearable and often ripe for declaring a natural disaster.

However, exposure of asphalt to high temperatures leads to an increase in harmful emissions into the air and in summer conditions asphalt can be a greater source of polluting particles than gasoline and diesel from motor vehicles combined[52]. On the other hand, temperature is an important factor that influences the performance of asphalt. In fact, there is a sharp decline of the stability and the structural strength of asphalt concrete with the temperature increasing. The higher the temperature is, the lower the stiffness modulus and rutting resistance of the asphalt concrete are[53]. Precisely because of this, the impact of droughts, which are the result of high temperatures on the motorway is not negligible.

Fires. In recent years, there is an increasing danger of forest fires, which occur in the summer months as a result of extremely high temperatures and droughts, and whose danger is increased by the fact that these fires often break out in inaccessible, hilly and often mined terrain. In the area of the City of Konjic, the largest number of fires was registered in 2012, due to fires that affected forest areas for a longer period during the year. The total number of interventions PFB (Professional Fire Brigade) Konjic in 2012 was 183. In 2013, the number of interventions was 101, and in 2014 - 96 interventions. The number of interventions increased significantly in 2015 and amounted to 235, while in 2016 it amounted to 186. The state of fire risk in the City of Konjic is shown in Table 9-5.

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[49] https://hpd-prenj1933.ba/starine-iz-planine/
[50] https://www.hercegovina.info/mostar-hercegovina/hoce-li-grad-mostar-proglasiti-elementarnu-nepogodu-suse/36829/
[51] https://nap.ba/news/57561
[52] https://revijahak.hr/2020/09/03/visoke-temperature-asfalt-ljeti-moze-zagadivati-zrak-vise-od-benzinskih-i-dizelskih-vozila/
[53] Meizhu Chen, Guangji Xu, Shaopeng Wu, Shaoping Zheng, High-temperature hazards and prevention measurements for asphalt pavement

Table 9-5: The state of fire risk in the City of Konjic[54]

Year	Industries and production facilities	Other business facilities	Residential facilities	Forage	Forests	Open spaces	Vehicles	Other
2012	0	0	14	2	81	40	3	43
2013	0	0	3	2	14	21	5	56
2014	0	0	6	2	15	12	9	52
2015	2	6	4	2	24	67	8	122
2016	0	8	8	0	30	30	4	106
Total	2	14	35	8	164	170	29	379

Also, within SECAP, the danger of fire on the territory of the City of Konjic was assessed (Table 9-6).

Table 9-6: Characteristics of the identified hazards as a consequences of climate change assessment associated with the risk of fires in the City of Konjic[55]

Risk	Risk characteristics				
	Current characteristics		Future characteristics		
	Probability of risk	Impact of risk	Expected change in intensity	Expected frequency exchange	Period
Fires	High	High	Increase	Increase	Risk in the short, medium and long term

In 2016, the City of Konjic has adopted the document Fire Risk Assessment and the Fire Protection Plan.

The area of the Prenj mountain is also characterised by fires in the summer months. The biggest fire was recorded in 2012, when the fire approached local roads and houses [56]. Huge areas of the mountain were damaged in the forest fire in 2015[57]. In 2020, two significant fires were recorded[58].

An increased number of fires in Mostar was recorded in summer, when the dry season and other extreme meteorological conditions coincided (strong wind, high temperature, dry air and lighting strikes). An additional problem is the mined terrain, so in 2020 the fire east of Mostar lasted a few days and caused great

[54] Sustainable Energy and Climate Action Plan (SECAP) of Konjic Municipality, 2020
[55] Ibid.
[56] https://balkans.aljazeera.net/news/balkan/2012/8/28/novi-pozar-na-planini-prenj-u-bih
[57] https://www.klix.ba/vijesti/bih/aktiviran-pozar-na-planini-prenj-planinari-mole-nadlezne-da-sto-prije-pocnu-gasiti-vatru/170819047
[58] https://www.stolac.co/stolac/stolac-vijesti/21198-prenj-dva-po%C5%BEara-uspje%C5%A1no-uga%C5%A1ena

environmental damage[59]. Also, a similar fire effected Rujiste in 2016. In the same year, as many as 8 fires were registered in one day in Mostar[60].

The Federal Hydrometeorological Institute, on its website[61] updates the data on the index of danger from the occurrence and spread of forest fires every day.

9.3.2 GHG Emissions

The possible impacts of motorway construction on the climate are related to emission of greenhouse gases (GHG) from the materials and equipment in the construction phase and road transport and lightening in operational phase. It is worth mentioning once more that, although Bosnia and Herzegovina has low emissions of carbon dioxide from transport, road transport is the dominant means of transport and GHG gas emissions from transport are expected to rise. The per capita emissions are just over half of the EU average: 5.18 tons CO_2 equivalent per capita per annum in 2008, compared to an EU average of 9.93 tons. But compared to relative wealth, Bosnia and Herzegovina's emissions are almost four times higher than those of the EU. Greenhouse gas emissions per unit of GDP were 1.59 kg CO_2 equivalent per EUR in 2008, while the EU average was 0.4 kg per EUR[62].

In order to determine the level of impact, a GHG assessment is carried out in line with EBRD Protocol for Assessment of Greenhouse Gas Emissions (2017).

The specific information related to climate changes and GHG emissions in the City of Konjic and Mostar are available in the SECAP of Konjic and SEAP of Mostar. In 2014, the corresponding CO_2 emissions in the transport sector in the City of Konjic amount to 17,240 tons[63], while the total CO_2 emissions from the transport sector in the area of the City of Mostar amounted to 109,894 tons[64].

The calculation of CO_2 emissions for the project section for the construction and operation phase of the motorway is presented below. The calculation was made for the base year (2022), construction period (2022-2032) and four future projections – project scenarios (2032 and 2060), for cases if the motorway is (not) constructed.

Calculation of CO_2 emissions for the project area

GHG emissions for the baseline conditions, construction period and project scenarios were calculated based on relevant scientific research to calculate GHG emissions for road construction projects. In order to draw a conclusion of the increase/decrease of emissions in the project area, following scenarios are considered:

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[59] https://www.tportal.hr/vijesti/clanak/vise-pozara-u-hercegovini-najteze-kod-mostara-20200411
[60] https://hms.ba/mostar-i-dalje-aktivan-veliki-sumski-pozar-na-rujistu/
[61] https://www.fhmzbih.gov.ba/latinica/AGRO/pozar.php
[62] Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina, June 2013
[63] Sustainable Energy and Climate Action Plan (SECAP) of Konjic Municipality, 2020
[64] Sustainable Energy Action Plan of Mostar, 2016

> Baseline conditions 2022, which includes the current infrastructure situation (roads, lighting, machinery) that results in vehicle GHG emissions on currently used M17 main road section;
> Construction period 2022-2032, which includes emissions from construction materials and equipment, as well as vehicle GHG emissions on currently used M17 main road section;
> Project scenario 1 – 2032, in case the motorway is not constructed;
> Project scenario 2 – 2032, in case the motorway is constructed;
> Project scenario 3 – 2060, in case the motorway is not construted;
> Project scenario 4 – 2060, in case the motorway is constructed.

The calculation is divided into the construction and operation phase.

Construction phase

The most significant CO_2 emissions during the construction phase of the motorway come from materials and construction equipment (machines).

CO_2 emissions due to material unloading (dust) are negligible compared to the previously mentioned emissions, so they were not considered in the further calculation.

Calculation of CO_2 emissions from construction materials

In order to calculate CO_2 emissions caused by material used for the construction of the motorway, the corresponding input data were taken from the Technical Report of the Preliminary Design (Table 9-7).

Table 9-7: Materials used for the motorway construction

Layer	Thickness, m	Length, m	Width, m
Motorway lines			
Asphalt SMA 11s, PmB 45/80	0,0168	34,250	15
AGNS 22s, PmB 45/80 + limestone aggregate	0,0245	34,250	15
AGNS 32s, B 35/50 + limestone aggregate	0,0245	34,250	15
Cement stabilisation	0,0400	34,250	15
NNS independent bearing layer	0,0275	34,250	15
Stop lines			
BB 11k, B 50/70 + limestone	0,04	34,250	5
AGNS 22s, B 50/70 + limestone	0,07	34,250	5
NNS independent bearing layer	0,52	34,250	5
Loops			
BB 11s, PmB 45/80 + limestone	0,0168	2,040	3,75
AGNS 32s, B 35/50 + limestone aggregate	0,0350	2,040	3,75
NNS independent bearing layer	0,0385	2,040	3,75
Regional roads			
BB 11k, B 50/70 + limestone aggregate	0,04	1,020	6

Layer	Thickness, m	Length, m	Width, m
AGNS 32s, B 35/50 + limestone aggregate	0,07	1,020	6
NNS independent bearing layer	0,30	1,020	6
Local roads 1			
BB 11k, B 50/70 + limestone aggregate	0,04	555	3,50
NNS independent bearing layer	0,30	555	3,50
Local roads 2			
BB 11k, B 50/70 + limestone aggregate	0,04	2,320.5	5,50
NNS independent bearing layer	0,30	2,320.5	5,50

Based on relevant scientific research, the average values of density and emission coefficient for different materials gave been adopted (Table 9-8).

Table 9-8: Average characteristics of materials used for motorway construction

Material	Density, kg/m³	Emission factor, $kgCO_{2e}/kg$[65]
Bitumen	2,450[66]	0,0710
Cement	2,800[67]	0,1320
Bearing layer – stone	2,300[67]	0,0052

Based on the collected input data, the required volume of material as a product of thickness, length and width was first calculated, and then CO_2 emissions were calculated using the formula:

$$E_{material} = Quantity\ (m^3) \cdot Density \left(\frac{kg}{m^3}\right) \cdot Emission\ factor \left(\frac{kg\,CO_{2e}}{kg\ material}\right)$$

The calculation results show that total CO_2 emissions, due to the use of **construction materials** in the construction phase, are **18,353.01 tons**.

Calculation of CO_2 emissions from construction equipment

Input data related to the construction equipment includes the type of equipment, the number of units in operation and operations hours. The input data for the construction phase (type of equipment, number of units) are assumed based on the experience data of civil engineers, considering that Main Design has not yet been developed. The assumption is that construction equipment works six hours a day, five days a week. In addition, it is assumed that diesel is type of fuel used to drive this equipment[68]. The average consumption of each type of construction equipment is determined from manufacturer's catalogue or on the basis of available scientific research.

[65] M. H. Alzard, M. A. Maraqa, R. Chowdhury, Q. Khan, F. D. B. Albuquerque, T. I. Mauga & K. N. Aljunadi, Estimation of Greenhouse Gas Emissions Produced by Road Projects in Abu Dhabi, United Arab Emirates, 2019
[66] D. Emme & C. Orji, Modifying density and voids properties of bituminous concrete using rubber latex, 2009
[67] https://www.engineeringtoolbox.com/density-solids-d_1265.html
[68] M. H. Alzard, M. A. Maraqa, R. Chowdhury, Q. Khan, F. D. B. Albuquerque, T. I. Mauga & K. N. Aljunadi, Estimation of Greenhouse Gas Emissions Produced by Road Projects in Abu Dhabi, United Arab Emirates, 2019

Table 9-9: Input data for calculating CO_2 emissions as a result of using construction equipment

Equipment used in the construction phase		
Type of equipment	**Number of units**	**Consumption, l/h**
Loader	30	15[69]
Excavator	20	22[69]
Buldozder	15	33,16[69]
Grader	20	8[70]
Rollers	15	4[70]
Steel vibrating roller	20	8[70]
Soil compactor	15	25[71]
Paver	10	10[72]
Dozer	20	25[71]
Dump truck	30	15,2[73]

The CO_2 emission factor per litre of diesel fuel is 2.49[74]. Based on the input data, using the following formula, CO_2 emissions generated as a result of the use of construction machinery were calculated:

$$E_{equipment} = Number\ of\ units\ (-) \cdot Consumption\left(\frac{l}{h}\right) \cdot Number\ of\ working\ hours\ per\ day\left(\frac{h}{day}\right) \cdot Number\ of\ working\ days\ per\ year\ \left(\frac{day}{year}\right) \cdot Emission\ factor\ \left(\frac{kgCO_{2e}}{l}\right)$$

Also, when it comes to indirect emissions, it is assumed that the same number of dump trucks is used to transport materials to the construction site. Based on the empirical data, an average distance of the material collection site to the unloading site of 50 km (in one direction) was assumed, and that material is transported 270 days per year. CO_2 emissions generated as a result of using dump tracks for material transport is calculated as:

$$E_{transport} = Number\ of\ units\ (-) \cdot Number\ of\ working\ days\ per\ year\left(\frac{days}{year}\right) \cdot Distance\ of\ the\ material\ collection\ site\ to\ the\ unloading\ site\ (km) \cdot Emission\ factor\ \left(\frac{kgCO_{2e}}{km}\right)$$

Using these two formulas, the total annual CO_2 emissions, generated as a result of the use of **equipment** during motorway construction, are **13,299.57 tons**.

Considering that CO_2 emissions in BiH from the transport sector in 2016 amounted to 3,363,309.72 tons[75], the use of construction equipment for the construction of

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[69] Mario Klanfar, Tomislav Korman, Tripmir Kujundzic, Fuel consumption and engine load factors of equipment in quarrying of crushed stone, 2016
[70] https://www.scribd.com/document/271103107/Fuel-Consumption
[71] https://static1.squarespace.com/static/58877529414fb5283ed14a6b/t/5888f8df46c3c4d4d976a102/1485371615708/Fuel+Table+-+Compactors.pdf
[72] https://www.scribd.com/document/321246669/Fuel-Consumption-Sheet
[73] https://postconflict.unep.ch/humanitarianaction/documents/02_08-04_06-04_02-22.pdf
[74] https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf
[75] https://www.worldometers.info/co2-emissions/bosnia-and-herzegovina-co2-emissions/

this section would contribute to an increase in total annual emissions from the transport sector by 0.4%.

Operational phase

The main sources of CO_2 emissions in the operational phase are vehicles and lightning.

The reduction of CO_2 emissions due to the planting of trees and the restoration of green areas along the motorway section is neglected in this case, because small values are expected considering the generated amounts of CO_2 emissions from vehicles.

Calculation of CO_2 emissions from vehicles

The calculation of CO_2 emissions from vehicles was done for baseline conditions (2022), construction period (2022-2032) and four project scenarios – 2032 (project scenario 1 in case the motorway is not constructed and project scenario 2 in case the motorway is constructed) and 2060 (project scenario 3 in case the motorway is not constructed and project scenario 4 in case the motorway is constructed).

As a result of vehicle operation, emissions of ultimate CO_2 originate from three sources:

- combustion of lubricant oil,
- combustion of fuel,
- addition of carbon-containing additives in the exhaust.

In order to simplify the calculation, as well as considering that addition of carbon-containing additives in the exhaust is negligible, the procedure for calculating CO_2 emissions resulting from lubricant oil and fuel combustion is presented below.

Data on the number of vehicles in 2022 and the projected number of vehicles in 2060, which are stated in Feasibility Study for Section Konjic–Mostar North, were used as input data for the calculation of CO_2 emissions from vehicles[76]. The assumed number of vehicles that will operate in 2032 was calculated based on data from the Auto-moto Club of Bosnia and Herzegovina on the increase in the number of registered vehicles in 2021 compared to 2020, with the assumption that this growth trend will be maintained until 2032. Data on the share of individual types of vehicles in total number of vehicles are taken from the Traffic Study for Section Konjic – Mostar North. From the Report on number of registered vehicles in 2021[77], the necessary data on the number of registered vehicles on diesel and petrol/gas, as well as the type of engine (conventional, euro 1, euro 2, etc) were taken, in order to establish the value of CO_2 emission factor for each fuel and engine type according to the instruction of the European Environment Agency[78].

[76] Taking into account the presented baseline data on the number of vehicles in 2015 and the predicted traffic growth rate in the period 2020-2025.
[77] BIHAMK, Information on the registered road vehicles in BiH in the period January-December 2021, March 2022
[78] EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 – Update October 2020

CO_2 emissions as a result of lubricant oil combustion

Input data for calculation of CO_2 emissions from vehicles, as a result of lubricant oil combustion, are shown in the Table 9-10.

It is assumed that the percentage in registered diesel and petrol vehicles will remain constant in the period 2022-2032. The fact that in 2050 10% of electric vehicles will be used in BiH[79], i.e., the assumed 13% in 2060, is considered in the calculation of vehicle type number in 2060. Also, it is assumed that the type or proportion of engines will remain approximately the same.

Table 9-10: Input data for calculation of CO_2 emissions from vehicles as a result of lubricant oil combustion

Vehicle type	Fuel type	Engine	Vehicle number per day			Emission factor, gCO_{2e}/km
			2022	2032	2060	
Passenger vehicles (including vehicles with trailers)	Diesel	conventional	746	1.042	2.668	0,663
		euro 1	134	187	480	0,596
		euro 2	352	492	1.259	0,530
		euro 3	1.731	2.418	6.193	0,464
		euro 4	1.716	2.397	6.139	0,398
		euro 5	1.087	1.519	3.889	0,398
		euro 6	529	739	1.892	0,398
	Petrol/gas	conventional	278	389	898	0,663
		euro 1	50	70	161	0,596
		euro 2	131	183	424	0,530
		euro 3	645	902	2.085	0,464
		euro 4	640	894	2.066	0,398
		euro 5	405	566	1.309	0,398
		euro 6	197	275	637	0,398
Buses	Urban buses standard	conventional	14	20	57	2,650
		euro 1	3	4	10	2,050
		euro 2	7	9	27	1,480
		euro 3	33	46	132	0,861
		euro 4	33	46	131	0,265
		euro 5	21	29	83	0,265
		euro 6	10	14	40	0,265
Smaller trucks	Diesel	conventional	13	18	46	0,663
		euro 1	2	3	8	0,596
		euro 2	6	8	22	0,530
		euro 3	30	41	106	0,464
		euro 4	29	41	105	0,398
		euro 5	19	26	67	0,398
		euro 6	9	13	32	98
	Pet	conventional	5	7	15	0,663

[79] UNFCCC, Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina, July 2016

Vehicle type	Fuel type	Engine	Vehicle number per day			Emission factor, gCO_{2e}/km
			2022	2032	2060	
		euro 1	1	1	3	0,596
		euro 2	2	3	7	0,530
		euro 3	11	15	36	0,464
		euro 4	11	15	35	0,398
		euro 5	7	10	22	0,398
		euro 6	3	5	11	0,398
Medium and large trucks	Diesel	conventional	30	41	106	0,486
		euro 1	5	7	19	0,486
		euro 2	14	19	50	0,486
		euro 3	69	96	245	0,486
		euro 4	68	95	243	0,486
		euro 5	43	60	154	0,486
		euro 6	21	29	75	0,486
	Petrol/gas	conventional	11	15	36	1,990
		euro 1	2	3	6	1,990
		euro 2	5	7	17	1,990
		euro 3	26	36	83	1,990
		euro 4	25	35	82	1,990
		euro 5	16	22	52	1,990
		euro 6	8	11	25	1,990

Considering the length of the M17 main road section (approx. 63.7 km) for baseline conditions and construction period and that the length of the motorway section is 34.25 km for project scenarios, as well as that both main road and motorway section are or will be open 365 days a year for traffic, total CO_2 emissions as a result of lubricant oil combustion from vehicle engines can be calculated using the equation:

$$E_{vehicles} = Number\ of\ vehicles\ (-) \cdot Emission\ factor\ \left(\frac{gCO_{2e}}{km}\right) \cdot Section\ length\ (km) \cdot Numberof\ operating\ days\ per\ year\ \left(\frac{days}{year}\right)$$

Results are presented in Table 9-11. For project scenarios (in case the motorway is constructed), emissions are calculated based on data from the Feasibility Study[80] that 70% of vehicles will use the motorway, and 30% will continue to use the main road M17.

[80] Feasibility Study Section: Konjic (loop Ovcari) – loop Mostar North, 2016

Table 9-11: CO_2 emissions as a result of lubricant oil combustion

CO_2 emissions as a result of lubricant oil combustion (tons/year)					
Baseline conditions (2022)	Construction period (2022-2032)	Project scenario 1 (2032) the motorway is not constructed	Project scenario 2 (2032) the motorway is constructed	Project scenario 3 (2060) the motorway is not constructed	Project scenario 4 (2060) the motorway is constructed
55.51	123.75[81]	103.25	77.55	360.01	193.57

CO_2 emissions as a result of fuel combustion

Input data for calculation of CO_2 emissions from vehicles, as a result of fuel combustion, are shown in the Table 9-12. Based on fuel consumption for different engine and fuel types, as well as emission factor for different road transport fossil fuels, emission factor per km section length is calculated as:

$$Emission\ factor\ \left(\frac{gCO_{2e}}{km}\right) = Fuel\ consumption\ \left(\frac{g}{km}\right) \cdot Emission\ factor\ for\ different\ road\ transport\ fossil\ fuels\ \left(\frac{gCO_{2e}}{g\ fuel}\right)$$

Table 9-12: Input data for calculation of CO_2 emissions from vehicles as a result of fuel combustion

Vehicle type	Fuel type	Engine	Vehicle number per day			Fuel consumption, g/km	Emission factor, gCO_{2e}/km
			2022	2032	2060		
Passenger vehicles (including vehicles with trailers)	Diesel	conventional	746	1.042	2.668	63	199,647
		euro 1	134	187	480	55	174,295
		euro 2	352	492	1.259	55	174,295
		euro 3	1.731	2.418	6.193	55	174,295
		euro 4	1.716	2.397	6.139	38	120,422
		euro 5	1.087	1.519	3.889	38	120,422
		euro 6	529	739	1.892	38	120,422
	Petrol/gas	conventional	278	389	898	65	205,985
		euro 1	50	70	161	56	177,464
		euro 2	131	183	424	56	177,464
		euro 3	645	902	2.085	56	177,464
		euro 4	640	894	2.066	49	155,281
		euro 5	405	566	1.309	49	155,281
		euro 6	197	275	637	49	155,281
Buses	Urban buses	conventional	14	20	57	366	1159,854
		euro 1	3	4	10	301	953,869
		euro 2	7	9	27	301	953,869

[81] Average annual value in the period 2022-2032.

Vehicle type	Fuel type	Engine	Vehicle number per day			Fuel consumption, g/km	Emission factor, gCO_{2e}/km
			2022	2032	2060		
		euro 3	33	46	132	301	953,869
		euro 4	33	46	131	301	953,869
		euro 5	21	29	83	301	953,869
		euro 6	10	14	40	301	953,869
Smaller trucks	Diesel	conventional	13	18	46	89	282,041
		euro 1	2	3	8	80	253,52
		euro 2	6	8	22	80	253,52
		euro 3	30	41	106	80	253,52
		euro 4	29	41	105	80	253,52
		euro 5	19	26	67	80	253,52
		euro 6	9	13	32	80	253,52
	Petrol/gas	conventional	5	7	15	85	269,365
		euro 1	1	1	3	70	221,83
		euro 2	2	3	7	70	221,83
		euro 3	11	15	36	70	221,83
		euro 4	11	15	35	70	221,83
		euro 5	7	10	22	70	221,83
		euro 6	3	5	11	70	221,83
Medium and large trucks	Diesel	conventional	30	41	106	182	576,758
		euro 1	5	7	19	155	491,195
		euro 2	14	19	50	155	491,195
		euro 3	69	96	245	155	491,195
		euro 4	68	95	243	155	491,195
		euro 5	43	60	154	155	491,195
		euro 6	21	29	75	155	491,195
	Petrol/gas	conventional	11	15	36	182	576,758
		euro 1	2	3	6	155	491,195
		euro 2	5	7	17	155	491,195
		euro 3	26	36	83	155	491,195
		euro 4	25	35	82	155	491,195
		euro 5	16	22	52	155	491,195
		euro 6	8	11	25	155	491,195

Considering the length of the M17 main road section (approx. 63.7 km) for baseline conditions and construction period and that the length of the motorway section is 34.25 km for project scenarios, as well as that both main road and motorway section are or will be open 365 days a year for traffic, total CO_2 emissions as a result of vehicle fuel combustion can be calculated using the equation:

$$E_{vehicles} = Number\ of\ vehicles\ (-) \cdot Emission\ factor\ \left(\frac{gCO_{2e}}{km}\right) \cdot Section\ length\ (km) \cdot Numberof\ operating\ days\ per\ year\ \left(\frac{days}{year}\right)$$

Results are presented in Table 9-13. For project scenarios (in case the motorway is constructed), emissions are calculated based on data from the Feasibility Study[82] that 70% of vehicles will use the motorway, and 30% will continue to use the main road M17.

Table 9-13: CO_2 emissions as a result of fuel combustion

CO_2 emissions as a result of fuel combustion (tons/year)						
Baseline conditions (2022)	Construction period (2022-2032)	Project scenario 1 (2032) the motorway is not constructed	Project scenario 2 (2032) the motorway is constructed	Project scenario 3 (2060) the motorway is not constructed	Project scenario 4 (2060) the motorway is constructed
38,588.69	46,248.54[83]	53,908.40	36,462.22	135,543.77	91,678.24

Although there is an increase in emissions by years due to the increase in the number of vehicles (projected increase of 300.3% in 2060 compared to 2022), it is obvious that the construction of this motorway will have a positive impact on the reduction of GHG emissions compared to the use of the existing M17 main road.

Calculation of CO_2 emissions from lightning

The calculation of CO_2 emissions from lighting was done for two project scenarios – 2032 and 2060 in case the motorway is constructed. CO_2 emissions from lighting on the main road M17 have been neglected because the small length of the section passes through populated areas, where lighting is installed. The rest of the M17 section has no lighting installed. According to the available data, it is assumed that the distance between the two bulbs on the motorway section would be 50 m[84], which for the total section length of 34.25 km, gives 1,370 bulbs on both sides. The power of the light bulb of 150 W was adopted[84], as well as the average number of working hours during the day (10 hours). Electricity is used to drive the light bulbs. The average CO_2 emission factor in 2032 was adopted considering that most electricity is produced from coal, and that by 2060 most electricity will be produced from renewable sources[85].

The input data for the first project scenario (2032) are shown in Table 9-14.

Table 9-14: Input data for the calculation of CO_2 emissions from lighting in 2032

Type of lighting/ bulb	Power per bulb, W	Number of bulbs	Number of working hours per day, h	Emission factor, $kgCO_{2e}/kWh$
LED	150	1,370	10	0,376

[82] Feasibility Study Section: Konjic (loop Ovcari) – loop Mostar North, 2016
[83] Average annual value in the period 2022-2032.
[84] https://www.eneltec-led.com/news/led-street-light-power-pole-and-height-and-road-width.html
[85] http://www.encert-eihp.org/wp-content/uploads/2014/11/0-FAKTORI_primarne_energije.pdf

Total CO_2 emissions from the use of lighting are calculated using the following formula:

$$E_{lighting} = Bulb\ power\ (W) \cdot Number\ of\ bulbs\ (-) \cdot Number\ of\ operating\ hours\ per\ day\ \left(\frac{hours}{day}\right) \cdot Number\ of\ days\ per\ year\ \left(\frac{365\ days}{year}\right) \cdot Emission\ factor\ \left(\frac{kgCO_{2e}}{kWh}\right)$$

The predicted total CO_2 emissions from **lighting** in **2032** are **282,03 tons**.

The same methodology is used to calculate CO_2 emissions from lighting in 2060.

Table 9-15: Input data for the calculation of CO_2 emissions from lighting in 2060

Type of lighting/ bulb	Power per bulb, W	Number of bulbs	Number of working hours per day, h	Emission factor, $kgCO_{2e}/kWh$
LED	150	1,370	10	0,0042

Total CO_2 emissions from **lighting** in **2060** are **3,15 tons**.

However, considering the expected reduction of traffic on currently used main road section M17 from Konjic to Mostar and the reduction of congestion and delays, as well as shortened travel time, and thus on the other hand the reduction of CO_2 emissions, the positive impacts of construction of this motorway section are justified. A summary of the expected CO_2 emissions is presented in Table 9-16.

Table 9-16: Expected CO_2 emissions for baseline conditions, construction period and project scenarios (tCO_{2e}/year)

Parameter	Baseline conditions (2022)	Construction period (2022-2032)	Project scenario 1 (2032) the motorway is not constructed	Project scenario 2 (2032) the motorway is constructed	Project scenario 3 (2060) the motorway is not constructed	Project scenario 4 (2060) the motorway is constructed
Construction material	0.00	1,835.30	0.00	0.00	0.00	0.00
Construction equipment	0.00	13,299.57	0.00	0.00	0.00	0.00

Parameter	Baseline conditions (2022)	Construction period (2022-2032)	Project scenario 1 (2032) the motorway is not constructed	Project scenario 2 (2032) the motorway is constructed	Project scenario 3 (2060) the motorway is not constructed	Project scenario 4 (2060) the motorway is constructed
Vehicles	38,691.94	46,372.29	54,052.64	36,559.78	135,903.78	91,921.73
Lighting	0.00	0.00	0.00	282.03	0.00	3.15
Total	38,691.94	61,507.16	54,052.64	36,841.81	135,903.78	91,924.88

Although there is an increase in emissions by years due to the increase in the number of vehicles, it is obvious that the construction of this motorway will have a positive impact on the reduction of GHG emissions compared to the use of the existing M17 main road.

A summary of the expected percentage CO_2 emissions reduction in the operational phase, as a result of motorway construction, is presented in Table 9-17.

Table 9-17: Expected CO_2 emissions reduction in the operational phase as a result of motorway construction

CO_2 emissions reduction as a result of the motorway construction		
Year	**tCO_2/year**	**%**
2032	17,013.41	31.48%
2060	43.976.69	32.36%

As presented in Table 9-17, the construction of the motorway section for both project scenarios will result in reduction of operational CO_2 emission of approx. 31%. Considering that reducing traffic speed limit on motorways to 100 kilometres per hour and enforcing it appropriately reduces emissions by about 18%[86], as well as that the carbon emissions of vehicles in congested traffic flow are 10-200% higher than those in free-flow traffic conditions[87], a reduction in CO_2 emissions would be greater. Considering that the section of the M17 main road is characterised by congested traffic flow with occasional traffic jams and taking into account the

[86] Asian Development Bank, Methodology for Estimating Carbon Footprint of Road Projects – Case Study: India, 2010
[87] Y. Dong, J. Xu, X. Liu, C. Gao, H. Ru & Z. Duan, Carbon Emissions and Expressway Traffic Flow Patterns in China, 2019

minimum increase in emissions of 10%, as well as the mentioned reduction of emissions on the motorway, the total cumulative and percentage reduction of emissions in 2032 and 2060 are presented in Table 9-18.

Table 9-18: Expected CO_2 emissions reduction in the operational phase as a result of motorway construction considering reduced traffic speeds on motorway and congested traffic flow on M17 main road section

CO_2 emissions reduction as a result of the motorway construction		
Year	**tCO_2/year**	**%**
2032	24,494.55	41.20%
2060	62,697.46	41.94%

Taking into account that CO_2 emissions in BiH from the transport sector in 2016 amounted to 3,363,309.72 tons[88], the project implementation would contribute to the total emissions from transport in 2032 with about 1.1%, and in 2060 with about 2.7%.

The sensitivity of receptors to greenhouse gas emissions is related to the potential of natural disasters caused by climate change. The main project should address in detail the issues of resilience to climate change, such as motorway construction (culverts, bridges, etc) that can accommodate 100-year flood waters, drainage system capacities, slope protection and stabilisation, application material stabilisation, etc.

Based on the previously presented information, an assessment of the climate risks and impacts of climate change and their significance on the project area was performed (Table 9-19).

Table 9-19: Summary of potential impacts on climate and assessment of their significance before mitigation

Phase	Type of potential impact	Adverse/ Beneficial	Magnitude	Sensitivity	Impact evaluation	Significance (before mitigation)
Climatic factors						
Pre-construction	No impacts	-	-	-	-	-
Construction	**Landslides and rock falls** › Endanger the stability of terrain that is the basis for the construction of the motorway › If the watercourse or part of it is buried by a landslide, an ecological catastrophe can occur	Adverse	Moderate	Medium	Moderate	Significant

[88] https://www.worldometers.info/co2-emissions/bosnia-and-herzegovina-co2-emissions/

Phase	Type of potential impact	Adverse/ Beneficial	Magnitude	Sensitivity	Impact evaluation	Significance (before mitigation)
Construction	**Droughts** › Heat stroke and increased risk of fire › Land subsidence during the construction phase › Ignition of equipment containing hazardous substances › Damage of construction equipment (melting)	Adverse	Moderate	Low	Minor	Not significant
Construction	**Fires** › Ignition of equipment containing hazardous substances › Dense smoke and increased GHG emissions › Damage of construction equipment (melting)	Adverse	Moderate	Medium	Moderate	Significant
Construction	**GHG emissions** › Environmental pollution due to GHG emissions from construction equipment and vehicles	Adverse	Negligible	Negligible	Negligible	Not significant
Operation	**Landslides and rock falls** › Physical damage to the transport infrastructure › Destroyed vehicles › Disruption to traffic flow › Interrupted plumbing roads as well as underground installations	Adverse	Moderate	Medium	Moderate	Significant
Operation	**Droughts** › Increased risk of fire	Adverse	Moderate	Medium	Moderate	Significant

Phase	Type of potential impact	Adverse/ Beneficial	Magnitude	Sensitivity	Impact evaluation	Significance (before mitigation)
	› Depletion of water supplies in the event of a drought, or increased use of groundwater can cause land subsidence › High temperatures can lead to the melting of the road surface mask, which further leads to the formation of ruts that destabilize the movement of vehicles, with an increase of GHG emissions					
Operation	**Fires** › Physical damage to the transport infrastructure › Disruption to traffic flow › Fire smoke reduces the visibility and results in road closure › Rapidly spreading fires along the road can lead to car fires, and injury or even death of road users › Increase in GHG emissions	Adverse	Moderate	Medium	Moderate	Significant
Operation	**GHG emissions** › Environmental pollution due to vehicle traffic on the motorway section	Adverse	Moderate	Medium	Moderate	Significant

9.4 Mitigation and Enhancement Measures

Mitigation and enhancement measures to address potential impacts of landslides and rock falls leading to significant effects in the pre-construction/construction phase identified in Table 9-19 above are:

- Conduct pre-construction rockfall analysis and implement mitigation measures to prevent soil erosion and dewatering, as stipulated in Chapter 13 Soil. Implement the same mitigation measures to prevent negative impacts on terrain stability by intrusion of groundwater and change of surface and groundwater flows, as stipulated in Chapter 7 Geology and Groundwater and Chapter 8 Surface Waters.
- Perform periodic geotechnical monitoring with the aim of landslide control.
- Implement recultivation and restoration as stipulated by **Biodiversity Management Plan** (BMP) and where possible reforest land within the Project area of influence.
- Prepare and implement **Emergency Preparedness and Response Plan (EPRP)** as a part of CESMP for the construction phase. The Plan:
  - Sets out key national and EU policies, laws and standards related to emergency response to reduce negative landslides and fire related impacts on society or the environment;
  - Defines roles and responsibilities;
  - Identifies and classifies potential landslide- and fire- related emergencies in the construction phase, including spill management and fire response;
  - Lists the activities, measures and equipment needed to respond to emergencies;
  - Defines the implementation of trainings for emergency preparedness;
  - Defines media ways of communication in emergency situations;
  - Defines the procedure of mitigation and recovery after emergency situations;
  - Defines the maintenance and control of this plan.
- In case of noticeable wetting of the terrain in the lowest zones, make culverts in places to drain the accumulated waters.
- In case of noticeable torrential flow of water from larger catchment areas on the construction site, collect and channel water through temporary or permanent channels and pipelines.
- In case of rock falls, mark the terrain and set up appropriate traffic signals.

Proposed mitigation and enhancement measures to address potential impacts of fires in the construction phase identified in Table 9-19 above are:

- Regularly control the state of fires in the project area by visual inspection and monitoring of news in local media, including monitoring of the index of danger from the occurrence and spread of forest fires on the website of Federal Hydrometeorological Institute[89].
- Store flammable materials in special heat-resistance containers.

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[89] https://www.fhmzbih.gov.ba/latinica/AGRO/pozar.php

- In case of least fire danger, suspend works.
- Prepare and implement **Emergency Preparedness and Response Plan** (EPRP), as specified under item above.

Landslides and rock falls can lead to significant effects in the operational phase, as identified in Table 9-19 above. Proposed mitigation and enhancement measures are:

- Perform periodic geotechnical monitoring with the aim of landslide control.
- In case of reconstruction, implement recultivation and restoration as stipulated by **Biodiversity Management Plan** (BMP) and where possible reforest land within the Project area of influence
- Prepare and implement **Operational Emergency Preparedness and Response Plan** (OEPRP) for the operational phase. The Plan:
  - Sets out key national and EU policies, laws and standards related to emergency response to reduce negative landslide- and fire- related impacts on society or the environment;
  - Defines roles and responsibilities;
  - Identifies and classifies potential emergencies in operation phase, including landslide occurrence, spill management and fire response;
  - Lists the activities, measures and equipment needed to respond to emergencies (e.g., The following protection measures should be applied: in case of minor landslides in the Project area, carry out a risk assessment and, if necessary, stop and/or diverse traffic; in case of traffic accidents and spillage of hazardous substances – suspend and/or diverse traffic, catch leaking liquid into intervention vessels, use special sorbents and others substances for decontamination of the terrain and remediation of consequences at the place of spillage of hazardous substances, use fire-protection equipment);
  - Defines the implementation of trainings for emergency preparedness;
  - Defines media ways of communication in emergency situations;
  - Defines the procedure of mitigation and recovery after emergency situations;
  - Defines the maintenance and control of this plan.
- Regular inspection of plumbing installations to prevent leaks.
- Regularly check the drainage system for the management of surface and rainwater from the road in order to prevent overflow in the form of concentrated torrents.
- In case of noticeable torrential flow of water from larger catchment areas, collect and channel water through temporary or permanent channels and pipelines.
- In case of rock falls, mark the terrain and set up appropriate traffic signals.
- Establish an appropriate program of regular maintenance and inspection of road infrastructure.

Droughts or high temperatures can cause negative impacts in the operational phase as identified in Table 9-19 above. Proposed mitigation and enhancement measures are:

- Prepare **Operational Emergency Preparedness and Response Plan** (OEPRP).

- In case of reconstruction, use high quality road construction materials, which are resistant to high temperatures.
- Set appropriate signals or motivating messages to help drivers adapt to driving conditions on the road and according to their psychophysical abilities.
- Control water leakage, to prevent its disappearance in extremely dry periods, which can cause land subsidence.
- Restrict the movement of vehicles transporting dangerous substances during periods of high temperatures.
- Establish an appropriate program of regular control maintenance and inspection of road infrastructure.

In case of fires, fire smoke can reduce the visibility and cause physical damage to transport infrastructure. Mitigation and enhancement measures to address potential impacts are:

- Regularly control the state of fires in the project area by visual inspection and monitoring of news in local media, including monitoring of the index of danger from the occurrence and spread of forest fires on the website of Federal Hydrometeorological Institute[90].
- Prepare **Operational Emergency Preparedness and Response Plan** (OEPRP) for the operational phase.
- Install fire extinguishers in tunnels.
- Restrict the movement of vehicles transporting dangerous substances in the period possible for fire.
- Avoid planting resinous trees along road section.
- In case of least fire danger, divert traffic.

With the commissioning of the motorway section, a significant increase in GHG emissions is expected. Proposed mitigation and enhancement measures include:

- Implement recultivation and restoration as stipulated by **Biodiversity Management Plan** (BMP) and where possible reforest land within the Project area of influence.
- Encourage drivers with motivational messages on electronic displays to maintain a consistent speed of 110 km/h for the benefit of reducing GHG emissions

[90] https://www.fhmzbih.gov.ba/latinica/AGRO/pozar.php