MERSİN GAZİANTEP HIGH STANDARD RAILWAY PROJECT

CLIMATE CHANGE RISK ASSESSMENT REPORT

NOVEMBER 2021

ANKARA

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CLIMATE CHANGE RISK ASSESSMENT REPORT

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TABLE OF CONTENTS

Page

Table of Contents i
List of Tables ii
List of Figures ii
1 INTRODUCTION 1
2 PROJECT BACKGROUND 2
3 METHODOLOGY 3
3.1 Climate Change Risk Assessment 3
3.2 Greenhouse Gases Assessment 5
4 CLIMATE CHANGE RISK ASSESSMENT 6
4.1 Observations 6
4.1.1 Temperature 6
4.1.2 Precipitation 10
4.1.3 Drought 11
4.1.4 Extremes 11
4.2 Climate Projections 18
4.2.1 Temperature 18
4.2.2 Precipitation 20
4.2.3 Other Climate Variables 21
4.3 Risk Evaluation 24
4.3.1 Physical Risks 24
4.3.1.1 Temperature 25
4.3.1.2 Rainfall 26
4.3.1.3 Wind/Storm 26
4.3.1.4 Lightning 27
4.3.1.5 Risk Assessment 27
4.3.2 Transition Risks 30
4.3.2.1 Policy and Legal Risks 30
4.3.2.1 Technology Risks 34
4.3.2.2 Market Risks 34
4.3.2.3 Reputation Risks 34
5 GREENHOUSE GASES EMISSIONS 35
5.1 GHG Emissions Assessment 36
5.1.1 Project Boundaries 36
5.1.2 Mersin-Gaziantep High Standard Train Project 37
5.1.2.1 Construction Phase GHG Emissions 37
5.1.2.2 Operation Phase GHG Emissions 39
5.1.2.3 Annual Total Emissions from the Project 40
6 CONCLUSIONS 42
7 REFERENCES 43

LIST OF TABLES

Page
Table 1. WRF Physics Options 4
Table 2. Last six years' extremes in Turkey (ESWD, 2021) 12
Table 3. Extreme weather events near the project location from 1975 to 2020 13
Table 4. Criteria for magnitude of change 27
Table 5. Physical Climate Impacts 28
Table 6. CO_2 Emissions Under Benchmark (Million Tonnes) 32
Table 7. CO_2 Emissions Under Benchmark (Million Tonnes) 32
Table 8. CO_2 Emissions with the Project (Million Tonnes) 33
Table 9. Cost of carbon emission with different carbon tax levels (Million Euro) 33
Table 10. Impacts of electricity price increases on output prices 33
Table 11. IPCC AR5 global warming potentials 36
Table 12. Machinery lists from construction phase 38
Table 14. Scope 3 GHG emissions from construction phase 39
Table 14. Calculation of energy use GHG emissions 39
Table 15. Scope 3 GHG emissions 40
Table 16. Total annual GHG emissions 40
Table 17. Total annual GHG emissions (Scope 1 and 2) 41

LIST OF FIGURES

Figure 1. Climate change risk assessment methodology steps 1
Figure 2. The project location 2
Figure 3. The study area 4
Figure 4. ERA5 temperature trends over Turkey from 1979 to 2019 7
Figure 5. ERA5 monthly temperature trends over Turkey 7
Figure 6. Observed Average Annual Temperature 8
Figure 7. Average Temperature and Total Rainfall Values for Each Cities. 9
Figure 8. 2021 total rainfall (mm) and rainfall changes 10
Figure 9. SPI drought map October 2020 – September 2021 (TSMS, 2021c) 11
Figure 10. Extreme weather events occurred in 2021, Turkey (ESWD, 2021) 12
Figure 11. Temperature projections RCP4.6 19
Figure 12. Temperature projections RCP 8.5 19
Figure 13. Precipitation projections RCP4.5 20
Figure 14. Precipitation projections RCP 8.5 21
Figure 15. Sea Level Rise - Coastal Risk Assessment under 1.5°C and 4°C Scenarios 21
Figure 16. Warm Spell Duration Index in Turkey for period 2040-2059 22
Figure 17. 5-day precipitation: 10-yr return level in Turkey for period: 2040-2059 23
Figure 18. Drought/Wet-Conditions (SPEI) in Turkey for period: 1986-2099 23
Figure 19. Timeline of climate policy developments 31
Figure 20. Greenhouse gas emissions by sectors (CO_2 equivalent), 1990 - 2018 35
Figure 21. The project scope map 37

1 INTRODUCTION

In line with the agreement signed between The Republic of Turkey State Railways (TCDD) and REC International Construction Investment Industry and Trade Inc. under Rönesans Holding within the scope of the High Standard Railway Line Construction and Electromechanical Systems Installation Project, Mersin Gaziantep High Standard Train (286 km-long railway) is planned to be built between Mersin and Gaziantep (Başpınar) and will reduce the travel time by 1.5 hours. High-standard passenger trains are planned to run at a maximum speed of 200 km/h (120 mph) and freight trains at the speed of 80 – 120 km/h (49 – 74 mph).

In line with the Equator Principles IV (July 2020) and the Recommendations of the Task Force on Climate-related Financial Disclosures, a Climate Change Risk Assessment (CCRA) needs to be prepared. While preparing this CCRA report, six key steps were followed (Figure 1).

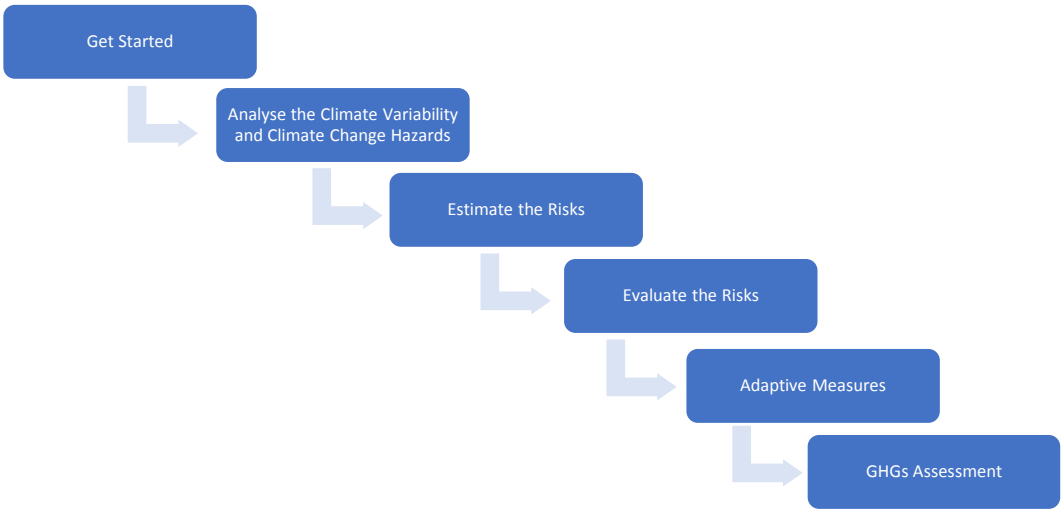

Figure 1. Climate change risk assessment methodology steps

The Climate Change Risk Assessment Report of Mersin Gaziantep High Standard Train Project is organised into the following sections:

Chapter 1: constitutes the introduction to CCRA report

Chapter 2: provides a brief overview of the project

Chapter 3: describes the methodology for the analysis of CCRA and GHGs emissions

Chapter 4: gives the detail analysis of climate patterns and the assessment of climate-related physical and transition risks

Chapter 5: focuses on greenhouse gases and provides a quantification of the project related GHG emissions

Chapter 6: draws the conclusions of CCRA.

2 PROJECT BACKGROUND

The 286 km-long High Standard Train Project will start from Mersin, and pass-through Tarsus, Adana, Incirlik, Toprakkale, Bahçe, Nurdağı, Başpınar stations, and last at Mustafa Yavuz Station. 78 km of this 286 km line is between Mersin and Adana, 79 km between Adana and Toprakkale, 56 km between Toprakkale and Bahçe, 17 km between Bahçe and Nurdağı and the last 56 km between Nurdağı and Başpınar is planned to be. The route of the Project passes through mostly agricultural areas and natural areas such as Nurdağı and Sof Mountain.

Project route and study area were shown in Figure 2.

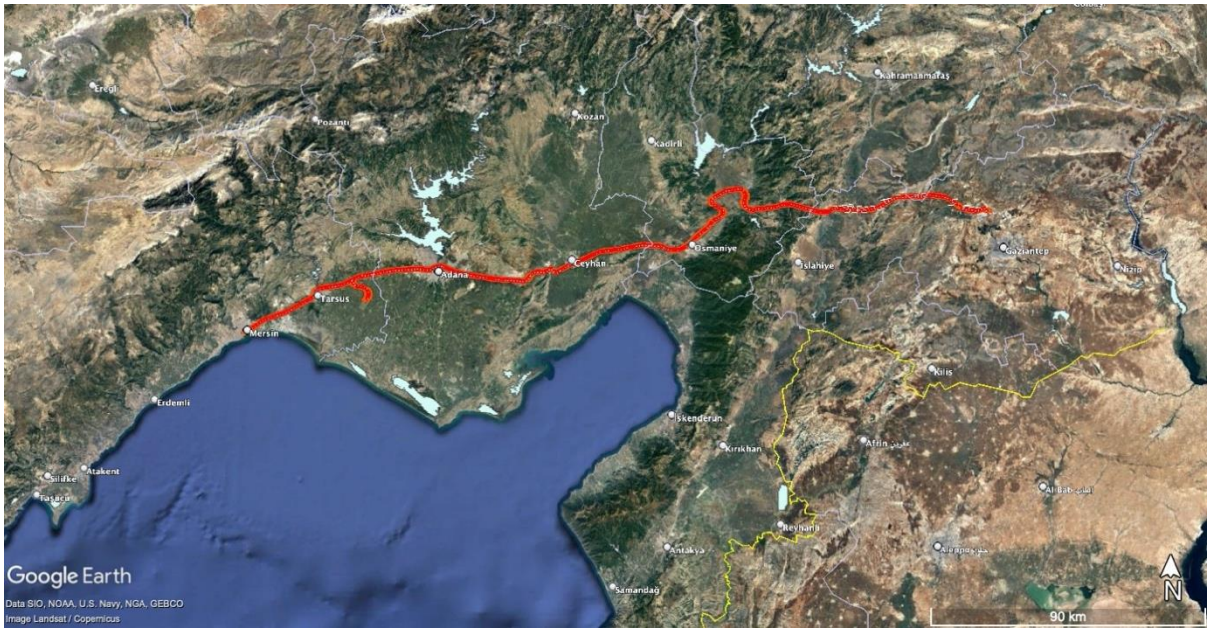

Figure 2. The project location

3 METHODOLOGY

3.1 Climate Change Risk Assessment

Guidance Note on Climate Change Risk Assessment which provides further information of the climate change risk assessment requirements included in the Equator Principles (July 2020) and their implementation was used to assess climate change risks on the project.

Reanalyses data sets provide a numerical description of the recent climate by combining models with observations. For historical climate variables, data were extracted from ERA5 Reanalyses and analysed by using Phyton manuscripts. This data is downloaded from the Climate Data Store (Hersbach *et al.*, 2019)

The Coupled Model Intercomparison Project (CMIP) is serving as a repository of model runs with consistent emission scenarios to standardize some of the output generated by diverse modelling groups. The CMIP climate data are in the form of outputs from atmosphere-ocean general circulation models (AOGCMs), or, in more common and recent usage as global climate models (GCMs). As the spatial scale of GCM output is too large to characterize climate over small and specific areas, and therefore downscaling to a finer resolution is necessary. Statistically downscaled climate variables can be downloaded from the World Bank's CCKP (CCKP, 2021)

The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales. On short timescales, the SPI is closely related to soil moisture, while at longer timescales, the SPI can be related to groundwater and reservoir storage. Drought maps were adopted from the Turkish State Meteorological Service (TSMS, 2021c).

In order to study extremes of climate a number of indices have been created to highlight different aspects of severe weather. The set of indices used are those from the European Severe Weather Database (ESWD, 2021).

As a part of flood risk assessments, extreme precipitation which will directly impact the flood events in the project areas have been obtained from CMIP5 RCP4.5 and RCP8.5 scenarios by using the Weather Research and Forecasting (WRF) model. In the analysis of changes in extreme events, changes above the 90th percentile were examined, and the working area used for the model is given in the Figure 3 WRF model is an open-source regional numerical weather prediction model that is widely used by atmospheric scientist. The WRF model is used for high resolution modelling of regional atmospheric phenomena. WRF is very customizable model, has many physical and dynamic options. More successful results can be achieved by using different options for many situations. The WRF model needs both geographical data and meteorological data inputs, to work.

Figure 3. The study area

WRF version 4.3 was run at 20 km resolution to produce more detailed climate projections. CMIP5 RCP4.5 as the optimistic scenario and CMIP5 RCP8.5 data as the pessimistic scenario were used as meteorological data for the WRF model. The model was operated for 40 years between 2011-2050. Future climate projection change expectations are determined according to the period 2011-2020. The physics options used for the model are given in the Table 3 1.

Table 1. WRF Physics Options

Physics Options	Outer Domain
Microphysics	New Thompson
Cumulus Parameterization	Tiedtke
Longwave Radiation	RRTMG
Shortwave Radiation	RRTMG
Planetary Boundary layer	MYJ
Surface Layer	Eta
Land Surface	NOAH

For transitional risks, analysis decomposes energy consumption data from Turkish Statistical Institute (TurkStat) into 3 sectors according to the input–output (I–O) table. An economic I–O carbon cycle assessment model is constructed to analyze the distribution characteristics of CO_2 emissions among sectors.

The aggregation and decomposition of emission sectors are important aspects of the analysis on CO_2 emissions mitigation due to lack of sectoral details in terms of emissions. To maintain consistency between energy consumption data and TurkStat's emission data, we aggregate the I–O tables into 3 sectors. Thanks to this, we use the accurate carbon emissions at the sectoral level. Fort the railway sector, inputs in production (Energy, Labor, Capital inputs etc.) gathered from Turkey Railway Statistical Yearbook.

In analysis, energy consumption data which is calculated from input output table are allocated based on the sectoral intermediate purchases or demands, and carbon emissions data are allocated based on the sectoral carbon emission intensity.

3.2 Greenhouse Gases Assessment

In order to calculate emissions from the project, the IPCC Guidelines for National Greenhouse Gas Inventories published in 2006, The European Bank for Reconstruction and Development (EBRD), The European Investment Bank (EIB), and UK GHG emission conversion factor by Department for Business, Energy & Industrial Strategy were used (IPCC, 2006; EBRD, 2017; BEIS, 2020; EIB, 2020).

This guideline aims to support the preparation of the national GHG inventories by the member countries, by providing default values of emission factors for various fuels and sectors, The IPCC Guidelines were refined in 2019, when an updated version of the methodology was issued. Greenhouse gas emission and removal estimates are divided into main sectors. These are:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture, Forestry and Other Land Use (AFOLU)
- Waste
- Other (e.g., indirect emissions from nitrogen deposition from non-agriculture sources)

While calculating emissions, appropriate volumes of guidelines were defined and analysed in detail with the project's emission sources.

4 CLIMATE CHANGE RISK ASSESSMENT

Turkey lies between latitudes 36-42°N and adjacent to the Mediterranean Sea and so might be expected to have a Mediterranean climate which does apply to the southern coastal areas where the project will be operated. In summer-time period, southern coastal areas are mostly dry and sunny. In general, Turkey is warm or hot in summer and cold or very cold in winter. However, coasts are much milder in winter than inland, especially the south and west coasts (Gosling *et al.*, 2011).

4.1 Observations

Highlights:

- There has been a coherent warming trend during summer over Turkey since 1979.
- Since 1979 there have been widespread decreases in the frequency of cool nights and increases in the frequency of warm nights.
- Changes in precipitation are mixed with decreases in winter in the west and increases in autumn in the north.
- In terms of drought, the project area was exceptionally dry from July to December 2020.
- Heavy rainfalls and hails have been highlighted over Turkey, and heavy rains and tornados have been reported for the project areas since 1975.

4.1.1 Temperature

Climate change is not only a challenge for the future, but also it has already affected the many areas. Changes have been observed in Turkey's climate with average temperatures having risen, and warmer winters and hotter summers trends. Based on five different global temperature datasets, it was expected that 2020 will be one of the three warmest years on record and the average temperature will increase by 1.2 °C compared to the 1850-1900 baseline (World Meteorological Organisation [WMO], 2020). In 2020, the third warmest years since 1971, the average temperature (14.9 °C) was above the average of 1981-2010 (13.5 °C).

In the project area, a typical Mediterranean climate is observed, with very hot and dry summers, and warm and rainy winters. In Figure 4, it is clearly seen that between 1979 and 2019 the temperature shows an increasing trend in overall Turkey. The south-east region where the project is located is under the increased trends (Hersbach *et al.*, 2019).

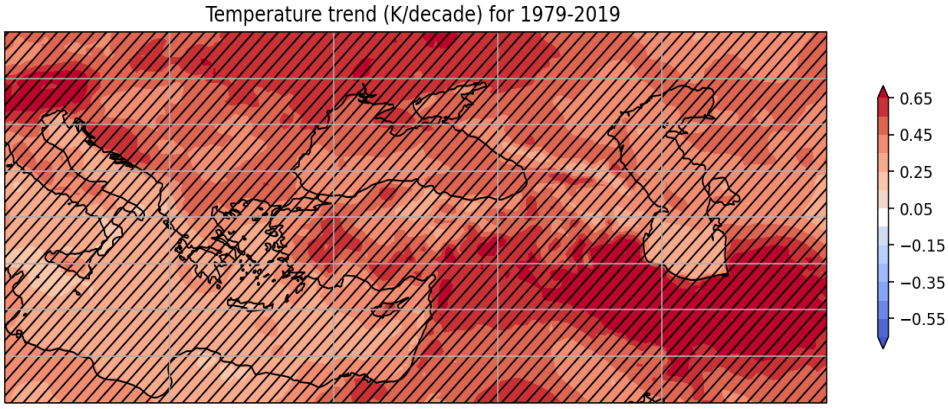

Figure 4. ERA5 temperature trends over Turkey from 1979 to 2019

In order to reveal temperature changes in detail, Figure 5 shows how monthly trends change over Turkey. While there are not much significant trends in winter, significant temperature increase is clearly seen towards the end of spring. In summer-time period, especially in June, the trend for increased temperature is very evident, and this is also true for October, November and December.

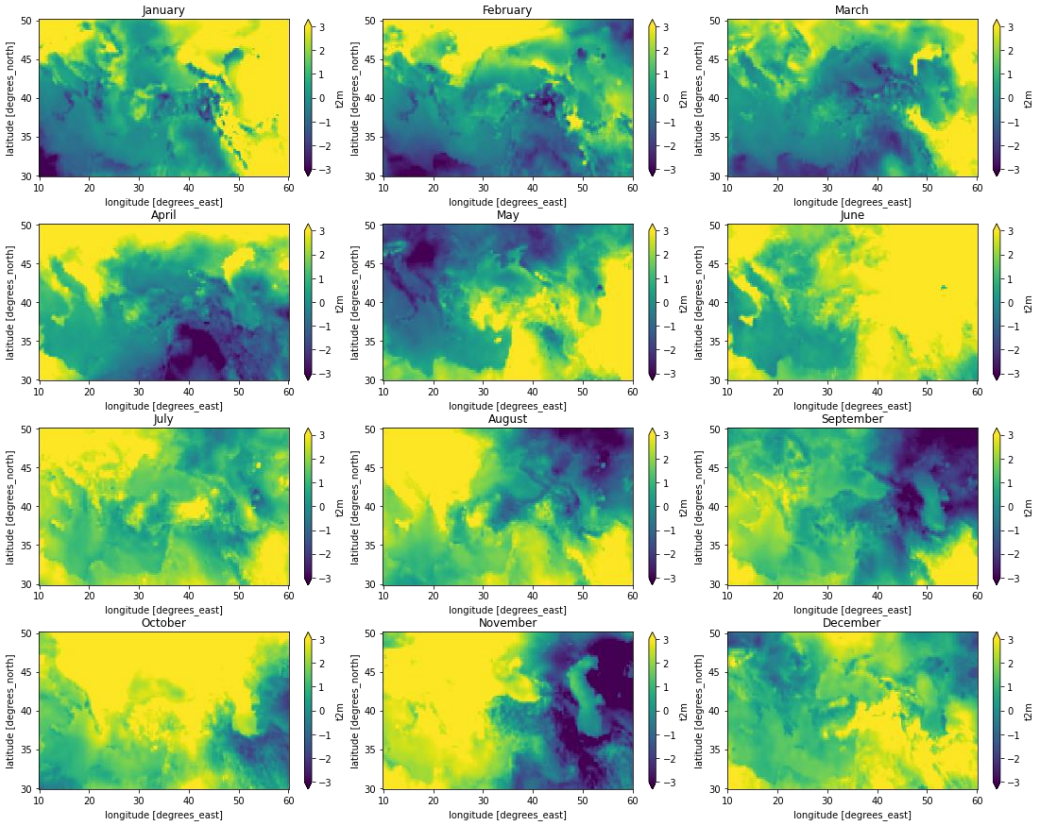

Figure 5. ERA5 monthly temperature trends over Turkey

In addition, night-time temperatures (daily minima) show widespread decreases in the frequency of cool nights and increases in the frequency of warm nights with widespread higher confidence, especially for the increase in warm nights. Day-time temperatures (daily maxima) show a mixed signal in frequency of cool days but a spatially consistent signal for increasing warm days.

In Figure 6, an upward trend in annual temperature has been observed from 1994 onwards, except for 1997 and 2011. 2010 was the warmest year in Turkey. The average temperature increased from 13.2°C in 1971 – 2000 period to 13.5°C between 1981 and 2010.

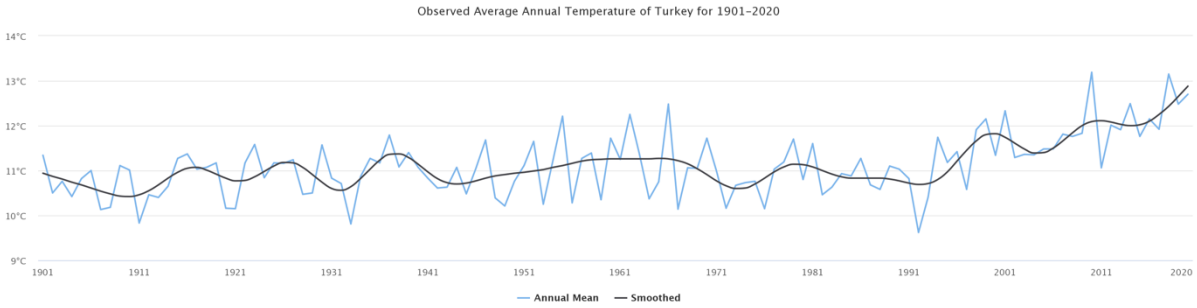

Figure 6. Observed Average Annual Temperature

In the project area, Figure 7 shows how monthly temperature averages and total rainfall values have changed since 1970 (1986 for Osmaniye). There is a clear warming trend in the project area through the year of 1970-2018 by about 1°C. Additionally, it is noted that there is warming by about 2°C over the years in Mersin. The total rainfall values do not show any change, however in detail, there has been an increase in the number of extreme events of over 1000mms since 1990s.

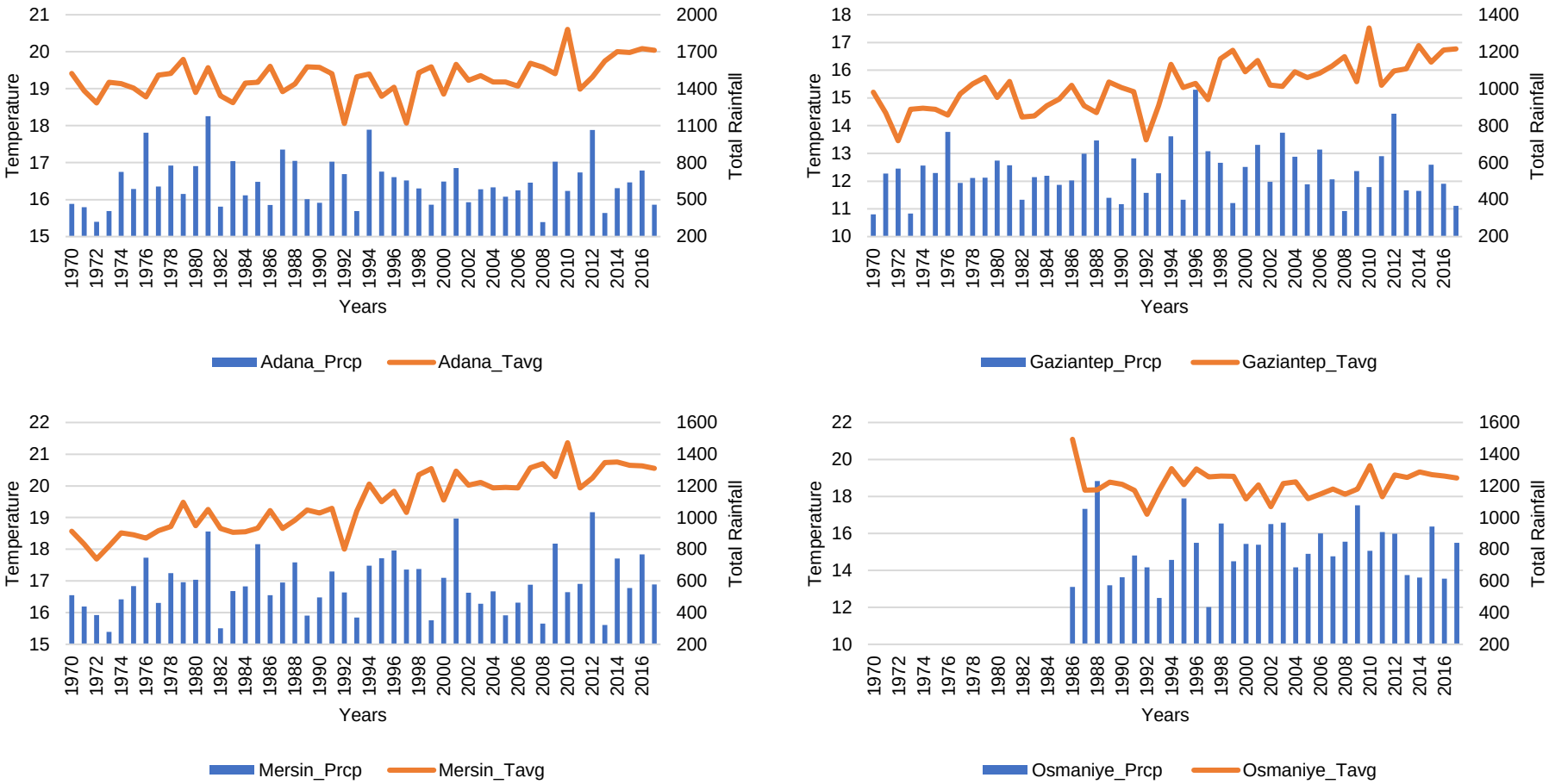

Figure 7. Average Temperature and Total Rainfall Values[1] for Each Cities.

[1] Please note that the axis max and min values are different.

4.1.2 Precipitation

Monthly precipitation in Turkey was above the normal of February, March, April, May and June and was below the normal of other months (Turkish State Meteorological Service [TSMS], 2021). As the Project is located in the south-east of Turkey, the location is dry and do not get many precipitations through the years. Turkey was under very dry period in 2020, and many places faced problems for drinking water reservoir levels. Figure 8 shows how the precipitation over Turkey changed in September 2021 and 2021 summer. In September 2021, Turkey mean areal precipitation in was 29.4 mm, which is 35 % above from 1981-2010's normal (21.8mm). For seasonal changes (Summer) in 2021 compared to long-term averages, Turkey were above the long-term areal precipitation means. The differences between 2021 and the long-term averages in the project location was about 26% (TSMS, 2021b).

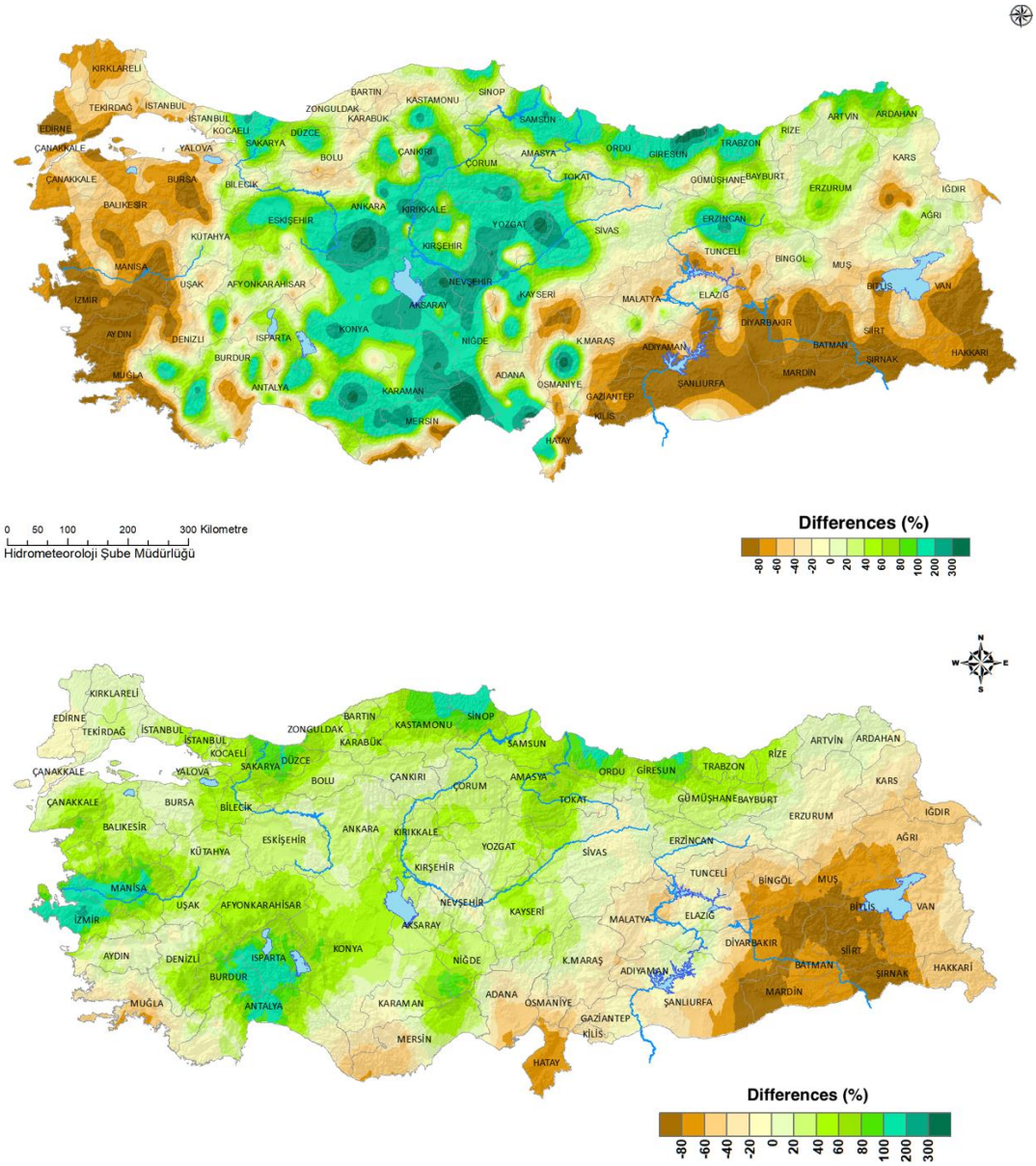

Figure 8. 2021 total rainfall (mm) and rainfall changes

4.1.3 Drought

Drought is a period of drier-than-normal conditions that results in water-related problems, an extended period of decreased precipitation and streamflow (USGS, 2021). Drought is a part of climate change, the frequency and intensity of droughts in several places have been increased recently. The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales. On short timescales, the SPI is closely related to soil moisture, while at longer timescales, the SPI can be related to groundwater and reservoir storage. According to TSMS, Figure 9 shows that Turkey was exceptionally dry over the last 12 months, and the project location was also under exceptionally dry period.

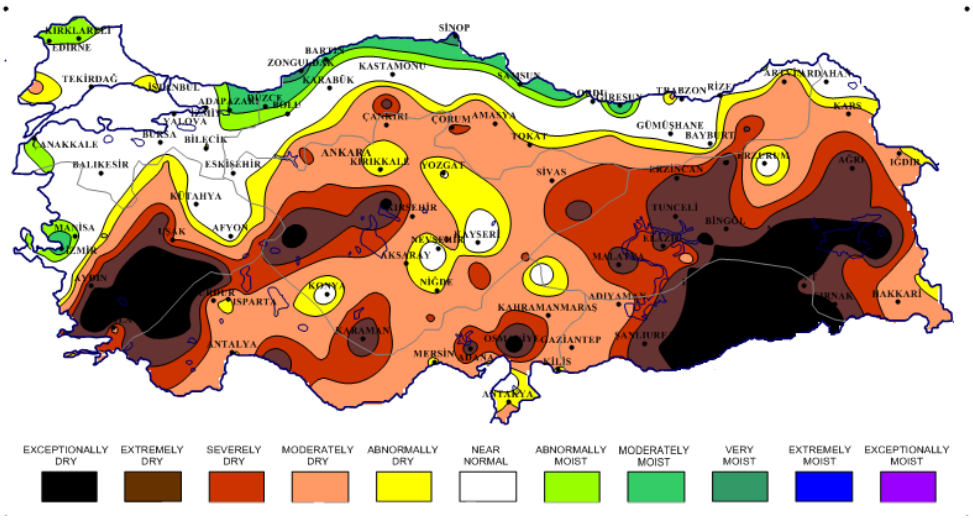

Figure 9. SPI drought map October 2020 – September 2021 (TSMS, 2021c)

4.1.4 Extremes

According to IPCC (2012), extreme events comprise a facet of climate variability under stable or changing climate conditions, which are defined as the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends (‘tails’) of the range of observed values of the variable. Changing climate also leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather. These changes can be linked to changes in the mean, variance, or shape of probability distributions, or all of these.

When looking at the last five years’ extremes in Turkey (see. Table 2) the highest number of extremes were observed in 2020, which almost doubled the 2016’s extremes. While the average of the last ten years’ extremes is 489,4 events/year, the last five years’ average (2016-2020) is 576,4 events/year. Changed average and 2020’s extremes show the increased possibility and frequency of extremes. It is also noted that even if extremes in 2021 are recorded until September, total number of extremes is above the average.

Table 2. Last six years' extremes in Turkey (ESWD, 2021)

Years	2016	2017	2018	2019	2020	2021
Number of Extreme Events	420	306	751	504	901	619

For the geographical distribution of the extreme weather events observed in Turkey, the locations and types of extremes reported by the ESWD in 2021 were presented in Figure 10. It can be seen that heavy rainfalls and hails were highlighted over Turkey, and heavy rains and tornados were reported for the project areas.

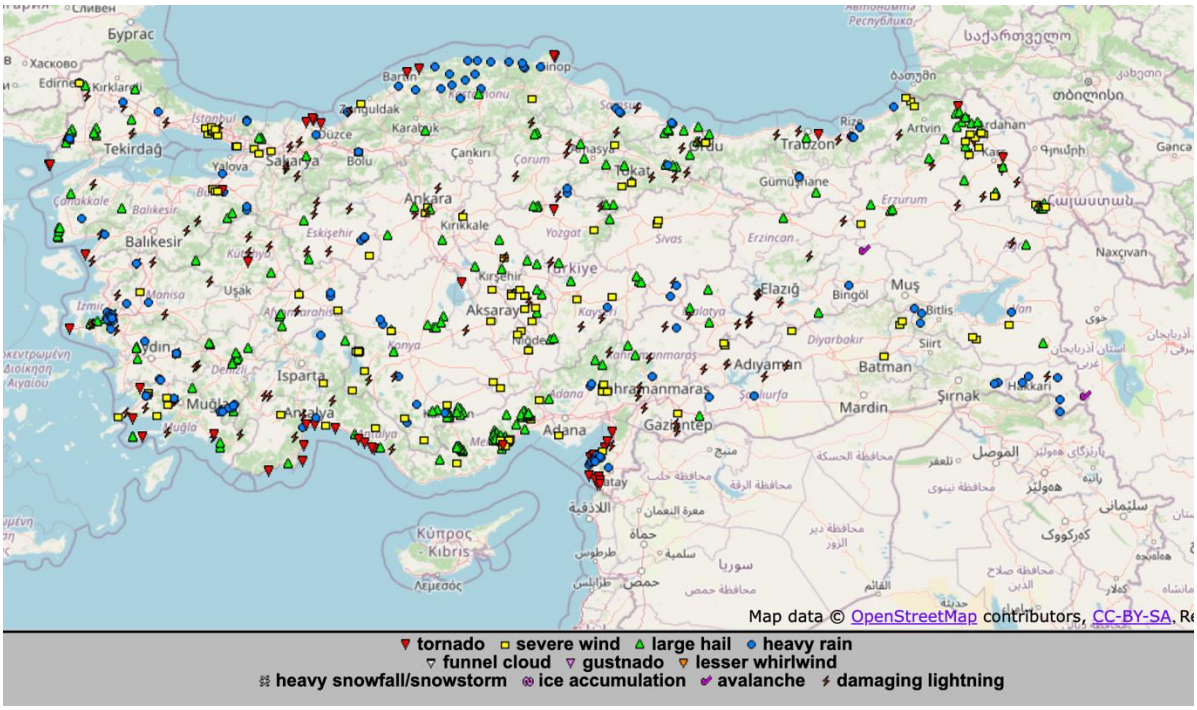

Figure 10. Extreme weather events occurred in 2021, Turkey (ESWD, 2021)

Apart from the ESWD data, extreme events near the project area from 1975 to 2020 were obtained from four different meteorological stations (Adana, Osmaniye, Ceyhan, and Mersin) operated by TSMS. As seen in Table 3, storms and heavy rainfalls were observed frequently near the project area, and many floods were also effective near the project area (TSMS, 2021a).

Table 3. Extreme weather events near the project location from 1975 to 2020

Date	Location	City	Extremes	Date	Location	City	Extremes	Date	Location	City	Extremes
17/04/1975	Mersin	Mersin	Hail	05/11/1994	Adana	Adana	Storm	09/03/2003	Mersin	Mersin	Storm and rain
12/05/1975	Adana	Adana	Rain and flood	18/11/1994	Adana	Adana	Rain and flood	31/05/2003	Osmaniye	Osmaniye	Heavy rain
29/12/1975	Mersin	Mersin	Snow	12/02/1998	Mersin	Mersin	Storm	17/09/2003	Mersin	Mersin	Storm
23/04/1976	Adana	Adana	Rain, flood, and hail	23/03/1998	Mersin	Mersin	Storm	16/12/2003	Ceyhan	Adana	Rain and flood
17/05/1979	Osmaniye	Osmaniye	Rain and flood	06/07/1998	Mersin	Mersin	Rain and flood	17/12/2003	Ceyhan	Adana	Storm
02/11/1979	Osmaniye	Osmaniye	Rain and flood	24/12/1998	Mersin	Mersin	Rain and flood	22/01/2004	Mersin	Mersin	Storm
27/03/1980	Adana	Adana	Rain and flood	19/02/1999	Adana	Adana	Storm	23/01/2004	Mersin	Mersin	Storm
02/04/1980	Adana	Adana	Rain and flood	19/02/1999	Adana	Adana	Storm	13/02/2004	Mersin	Mersin	Storm
15/06/1981	Adana	Adana	Rain, flood, and storm	19/02/1999	Ceyhan	Adana	Storm	14/02/2004	Mersin	Mersin	Storm
17/05/1982	Osmaniye	Osmaniye	Rain, flood, and hail	03/06/2000	Ceyhan	Adana	Storm	21/11/2004	Ceyhan	Adana	Storm
23/05/1983	Osmaniye	Osmaniye	Rain and flood	02/03/2001	Mersin	Mersin	Storm	08/02/2005	Ceyhan	Adana	Storm
30/05/1983	Adana	Adana	Rain and flood	23/03/2001	Mersin	Mersin	Storm	20/02/2005	Mersin	Mersin	Storm
05/03/1987	Osmaniye	Osmaniye	Hail and Storm	28/03/2001	Mersin	Mersin	Fog	28/02/2005	Mersin	Mersin	Storm
10/10/1988	Adana	Adana	Rain, flood, and storm	14/04/2001	Mersin	Mersin	Storm	09/03/2005	Mersin	Mersin	Storm
04/01/1989	Mersin	Mersin	Frost	07/05/2001	Mersin	Mersin	Storm	10/03/2005	Mersin	Mersin	Storm
27/02/1989	Adana	Adana	Frost-drought	20/08/2001	Mersin	Mersin	Heavy rain	31/03/2005	Ceyhan	Adana	Storm
29/04/1992	Osmaniye	Osmaniye	Drought	02/12/2001	Mersin	Mersin	Rain	01/04/2005	Mersin	Mersin	Storm
03/01/1994	Adana	Adana	Rain and flood	07/02/2003	Mersin	Mersin	Storm	21/11/2005	Mersin	Mersin	Storm

Date	Location	City	Extremes	Date	Location	City	Extremes	Date	Location	City	Extremes
15/12/2005	Mersin	Mersin	Hail	09/05/2008	Adana	Adana	Rain and flood	17/03/2010	Osmaniye	Osmaniye	Heavy rain and flood
08/02/2006	Osmaniye	Osmaniye	Storm	18/05/2008	Ceyhan	Adana	Hail	20/03/2010	Osmaniye	Osmaniye	Hail
13/10/2006	Mersin	Mersin	Storm	24/08/2008	Ceyhan	Adana	Storm	24/03/2010	Osmaniye	Osmaniye	Hail
19/10/2006	Osmaniye	Osmaniye	Rain and flood	24/08/2008	Mersin	Mersin	Storm	26/03/2010	Osmaniye	Osmaniye	Heavy rain and flood
26/10/2006	Adana	Adana	Rain and flood	15/10/2008	Mersin	Mersin	Storm	28/03/2010	Osmaniye	Osmaniye	Heavy rain and flood
26/10/2006	Ceyhan	Adana	Rain and flood	22/11/2008	Ceyhan	Adana	Rain and flood	07/04/2010	Adana	Adana	Hail
04/11/2006	Osmaniye	Osmaniye	Rain and flood	23/11/2008	Osmaniye	Osmaniye	Rain and flood	07/04/2010	Mersin	Mersin	Hail
27/12/2006	Ceyhan	Adana	Storm	29/01/2009	Adana	Adana	Lightning	08/04/2010	Osmaniye	Osmaniye	Hail
24/03/2007	Adana	Adana	Storm	10/03/2009	Mersin	Mersin	Storm	29/10/2010	Mersin	Mersin	Storm
24/03/2007	Mersin	Mersin	Storm	13/03/2009	Mersin	Mersin	Hail	19/02/2011	Mersin	Mersin	Storm
28/03/2007	Mersin	Mersin	Rain and flood	05/05/2009	Mersin	Mersin	Storm	10/04/2011	Osmaniye	Osmaniye	Rain and flood
08/04/2007	Adana	Adana	Rain and flood	21/09/2009	Osmaniye	Osmaniye	Storm	11/04/2011	Osmaniye	Osmaniye	Rain and flood
29/04/2007	Ceyhan	Adana	Rain and flood	26/10/2009	Mersin	Mersin	Storm	29/04/2011	Osmaniye	Osmaniye	Hail
15/10/2007	Mersin	Mersin	Storm	04/11/2009	Osmaniye	Osmaniye	Rain and flood	11/06/2011	Osmaniye	Osmaniye	Rain and flood
11/11/2007	Mersin	Mersin	Rain and flood	04/11/2009	Mersin	Mersin	Storm	20/11/2011	Osmaniye	Osmaniye	Rain and flood
06/12/2007	Mersin	Mersin	Rain and flood	12/12/2009	Mersin	Mersin	Rain and flood	16/04/2012	Adana	Adana	Storm
25/03/2008	Mersin	Mersin	Storm	27/01/2010	Mersin	Mersin	Frost	18/04/2012	Adana	Adana	Storm
07/04/2008	Mersin	Mersin	Storm	17/03/2010	Osmaniye	Osmaniye	Hail	18/04/2012	Mersin	Mersin	Storm

Date	Location	City	Extremes	Date	Location	City	Extremes	Date	Location	City	Extremes
03/05/2012	Adana	Adana	Rain and flood	12/12/2013	Mersin	Mersin	Frost	21/04/2015	Osmaniye	Osmaniye	Heavy rain and flood
21/05/2012	Adana	Adana	Rain and flood	03/03/2014	Mersin	Mersin	Heavy rain and flood	11/05/2015	Adana	Adana	Hail
21/06/2012	Osmaniye	Osmaniye	Storm	29/03/2014	Osmaniye	Osmaniye	Storm and whirlwind	26/06/2015	Osmaniye	Osmaniye	Heavy rain and flood
03/10/2012	Mersin	Mersin	Rain and flood	30/03/2014	Adana	Adana	Storm and whirlwind	26/06/2015	Osmaniye	Osmaniye	Heavy rain and flood
25/10/2012	Osmaniye	Osmaniye	Rain and flood	24/05/2014	Osmaniye	Osmaniye	Heavy rain and flood	28/06/2015	Mersin	Mersin	Hail
09/11/2012	Mersin	Mersin	Rain and flood	06/06/2014	Adana	Adana	Heavy rain and flood	21/09/2015	Adana	Adana	Storm and whirlwind
10/12/2012	Mersin	Mersin	Rain and flood	05/08/2014	Adana	Adana	Lightning	21/09/2015	Adana	Adana	Heavy rain and flood
28/02/2013	Adana	Adana	Hail	27/09/2014	Adana	Adana	Storm and whirlwind	22/10/2015	Mersin	Mersin	Storm and whirlwind
03/03/2013	Adana	Adana	Storm	27/09/2014	Mersin	Mersin	Heavy rain and flood	29/10/2015	Osmaniye	Osmaniye	Heavy rain and flood
10/04/2013	Adana	Adana	Heavy rain	25/11/2014	Mersin	Mersin	Heavy rain and flood	14/03/2016	Adana	Adana	Storm and whirlwind
15/04/2013	Mersin	Mersin	Hail	05/01/2015	Osmaniye	Osmaniye	Heavy rain and flood	28/04/2016	Osmaniye	Osmaniye	Heavy rain and flood
10/05/2013	Osmaniye	Osmaniye	Hail	06/01/2015	Adana	Adana	Storm and whirlwind	18/05/2016	Adana	Adana	Hail
10/05/2013	Osmaniye	Osmaniye	Hail	06/01/2015	Mersin	Mersin	Storm and whirlwind	19/05/2016	Adana	Adana	Hail
14/05/2013	Adana	Adana	Whirlwind	09/01/2015	Mersin	Mersin	Frost	24/05/2016	Osmaniye	Osmaniye	Heavy rain and flood
14/05/2013	Mersin	Mersin	Storm	10/01/2015	Mersin	Mersin	Frost	29/05/2016	Adana	Adana	Heavy rain and flood
25/05/2013	Osmaniye	Osmaniye	Hail	19/02/2015	Mersin	Mersin	Hail	30/06/2016	Adana	Adana	Heavy rain and flood
09/06/2013	Osmaniye	Osmaniye	Hail	19/03/2015	Adana	Adana	Lightning	21/09/2016	Adana	Adana	Storm and whirlwind
19/07/2013	Adana	Adana	Flood in urban areas at high attitudes	21/03/2015	Osmaniye	Osmaniye	Storm and whirlwind	16/11/2016	Osmaniye	Osmaniye	Lightning

Date	Location	City	Extremes	Date	Location	City	Extremes	Date	Location	City	Extremes
13/12/2016	Mersin	Mersin	Storm and whirlwind	28/10/2017	Adana	Adana	Storm and whirlwind	31/05/2018	Mersin	Mersin	Hail
14/12/2016	Adana	Adana	Storm and whirlwind	05/11/2017	Mersin	Mersin	Heavy rain and flood	05/06/2018	Adana	Adana	Hail
18/12/2016	Mersin	Mersin	Frost	19/11/2017	Mersin	Mersin	Hail	13/06/2018	Adana	Adana	Heavy rain and flood
21/12/2016	Osmaniye	Osmaniye	Snow	19/11/2017	Mersin	Mersin	Heavy rain and flood	15/06/2018	Mersin	Mersin	Hail
29/12/2016	Mersin	Mersin	Heavy rain and flood	03/01/2018	Adana	Adana	Heavy rain and flood	17/06/2018	Mersin	Mersin	Heavy rain and flood
26/01/2017	Mersin	Mersin	Storm and whirlwind	04/01/2018	Mersin	Mersin	Heavy rain and flood	17/06/2018	Mersin	Mersin	Heavy rain and flood
02/03/2017	Mersin	Mersin	Heavy rain and flood	04/01/2018	Mersin	Mersin	Heavy rain and flood	21/06/2018	Mersin	Mersin	Heavy rain and flood
07/04/2017	Adana	Adana	Heavy rain and flood	21/02/2018	Mersin	Mersin	Hail	30/06/2018	Osmaniye	Osmaniye	Storm and whirlwind
23/04/2017	Mersin	Mersin	Storm and whirlwind	24/03/2018	Mersin	Mersin	Storm and whirlwind	20/07/2018	Osmaniye	Osmaniye	Heavy rain and flood
07/05/2017	Osmaniye	Osmaniye	Heavy rain and flood	29/03/2018	Mersin	Mersin	Storm and whirlwind	08/09/2018	Mersin	Mersin	Heavy rain and flood
20/05/2017	Osmaniye	Osmaniye	Heavy rain and flood	29/03/2018	Mersin	Mersin	Heavy rain and flood	20/10/2018	Mersin	Mersin	Hail
20/05/2017	Osmaniye	Osmaniye	Heavy rain and flood	10/04/2018	Osmaniye	Osmaniye	Hail	24/10/2018	Adana	Adana	Heavy rain and flood
23/05/2017	Adana	Adana	Hail	10/04/2018	Osmaniye	Osmaniye	Heavy rain and flood	24/10/2018	Mersin	Mersin	Hail
01/06/2017	Osmaniye	Osmaniye	Heavy rain and flood	10/05/2018	Osmaniye	Osmaniye	Hail	25/10/2018	Mersin	Mersin	Storm and whirlwind
14/06/2017	Adana	Adana	Heavy rain and flood	11/05/2018	Adana	Adana	Hail	25/10/2018	Mersin	Mersin	Storm and whirlwind
21/06/2017	Osmaniye	Osmaniye	Storm and whirlwind	14/05/2018	Osmaniye	Osmaniye	Hail	25/10/2018	Mersin	Mersin	Hail
02/07/2017	Adana	Adana	Severe cold weather and high temperatıre	30/05/2018	Osmaniye	Osmaniye	Heavy rain and flood	25/10/2018	Osmaniye	Osmaniye	Heavy rain and flood
06/09/2017	Mersin	Mersin	Heavy rain and flood	30/05/2018	Mersin	Mersin	Hail	29/11/2018	Mersin	Mersin	Heavy rain and flood
06/12/2018	Mersin	Mersin	Heavy rain and flood	26/12/2018	Adana	Adana	Heavy rain and flood	04/01/2019	Osmaniye	Osmaniye	Heavy rain and flood
18/12/2018	Mersin	Mersin	Heavy rain and flood	04/01/2019	Adana	Adana	Heavy rain and flood	05/01/2019	Osmaniye	Osmaniye	Heavy rain and flood

Date	Location	City	Extremes	Date	Location	City	Extremes	Date	Location	City	Extremes
14/01/2019	Adana	Adana	Heavy rain and flood	14/06/2019	Osmaniye	Osmaniye	Heavy rain and flood	31/01/2020	Mersin	Mersin	Storm and whirlwind
15/01/2019	Mersin	Mersin	Storm and whirlwind	18/06/2019	Mersin	Mersin	Heavy rain and flood	06/02/2020	Mersin	Mersin	Heavy rain and flood
30/01/2019	Mersin	Mersin	Storm and whirlwind	18/06/2019	Mersin	Mersin	Heavy rain and flood	21/02/2020	Mersin	Mersin	Landslide
09/02/2019	Mersin	Mersin	Snow	18/06/2019	Osmaniye	Osmaniye	Heavy rain and flood	17/03/2020	Mersin	Mersin	Storm and whirlwind
09/02/2019	Mersin	Mersin	Landslide	18/06/2019	Mersin	Mersin	Lightning	28/03/2020	Mersin	Mersin	Hail
03/03/2019	Mersin	Mersin	Storm and whirlwind	20/06/2019	Mersin	Mersin	Heavy rain and flood	29/03/2020	Mersin	Mersin	Hail
23/03/2019	Mersin	Mersin	Heavy rain and flood	20/06/2019	Mersin	Mersin	Heavy rain and flood	29/03/2020	Mersin	Mersin	Hail
30/03/2019	Osmaniye	Osmaniye	Heavy rain and flood	20/06/2019	Mersin	Mersin	Heavy rain and flood	09/04/2020	Mersin	Mersin	Hail
09/04/2019	Osmaniye	Osmaniye	Heavy rain and flood	12/07/2019	Osmaniye	Osmaniye	Heavy rain and flood	01/05/2020	Mersin	Mersin	Hail
09/04/2019	Osmaniye	Osmaniye	Heavy rain and flood	20/08/2019	Mersin	Mersin	Hail	02/05/2020	Mersin	Mersin	Hail
09/04/2019	Mersin	Mersin	Hail	15/09/2019	Mersin	Mersin	Heavy rain and flood	15/05/2020	Mersin	Mersin	Severe cold weather and high temperatıre
16/04/2019	Mersin	Mersin	Hail	20/10/2019	Osmaniye	Osmaniye	Heavy rain and flood	22/05/2020	Mersin	Mersin	Storm and whirlwind
17/04/2019	Adana	Adana	Heavy rain and flood	26/11/2019	Mersin	Mersin	Storm and whirlwind	18/06/2020	Mersin	Mersin	Heavy rain and flood
18/04/2019	Mersin	Mersin	Hail	26/11/2019	Mersin	Mersin	Hail	19/06/2020	Mersin	Mersin	Heavy rain and flood
18/04/2019	Mersin	Mersin	Hail	23/12/2019	Adana	Adana	Heavy rain and flood	19/10/2020	Mersin	Mersin	Hail
19/04/2019	Mersin	Mersin	Hail	23/12/2019	Mersin	Mersin	Snow	03/11/2020	Mersin	Mersin	Lightning
19/04/2019	Mersin	Mersin	Hail	30/12/2019	Mersin	Mersin	Heavy rain and flood	14/12/2020	Mersin	Mersin	Storm and whirlwind
21/04/2019	Mersin	Mersin	Snow	06/01/2020	Mersin	Mersin	Snow	14/12/2020	Mersin	Mersin	Hail
03/05/2019	Mersin	Mersin	Hail	07/01/2020	Mersin	Mersin	Heavy rain and flood	14/12/2020	Mersin	Mersin	Heavy rain and flood

4.2 Climate Projections

The climate science community sources a suite of global climate models to help decision makers understand the projections of future climate change and related impacts, among the most widely used are the Coupled Model Intercomparison Project, Phase 5 (CMIP5) models included in the IPCC's Fifth Assessment Report (AR5). Climate projections can be presented via individual models or through multi-model ensembles. The Climate Change Knowledge Portal (CCKP) supports the analysis of climate impacts using multi-model ensembles, as they represent the range and distribution of the most plausible projected outcomes when representing expected changes.

- The trend of decreasing in the amount of rainfall throughout Turkey particularly in the southern and inner parts of Anatolia.
- Increasing in temperature especially in winter season, which may cause to turn the precipitation type from snow to rain during the winter.

4.2.1 Temperature

One of the problems from climate change over Turkey is increased temperature especially in winter season. The increase in temperature may cause additional effects on rainfall patterns by turning the precipitation type from snow to rain during the winter (Demircan *et al.*, 2017). In order to look at the project location, the outcomes of CIMP5 ensemble model for RCP 4.5 and RCP 8.5 were used.

Under the RCP4.5 scenario, Figure 11 shows the projected temperature patterns compared to the reference period (2011-2020). For the period 2021-2030; between 0 and 0.5 °C decrease is expected, for the period 2031-2040; between 0 and 0.5 °C increase is expected, and for the period 2041-2050; between 0.5 and 1.2 °C increase is expected for all the months.

Under the RCP8.5 scenario (Figure 12), for the period 2021-2030; between 0 and 0.5 °C increase is expected, for the period 2031-2040; between 0.25 and 1 °C increase is expected, and for the period 2041-2050; between 1 and 1.5 °C increase is expected for all the months.

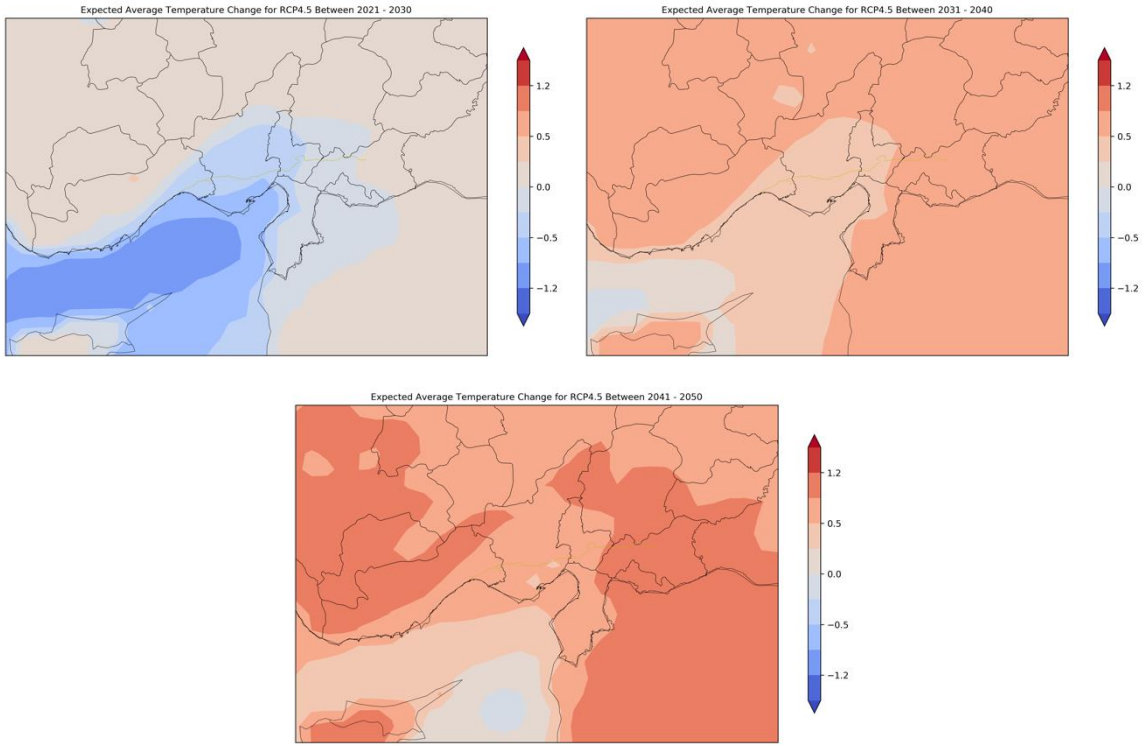

Figure 11. Temperature projections RCP4.6

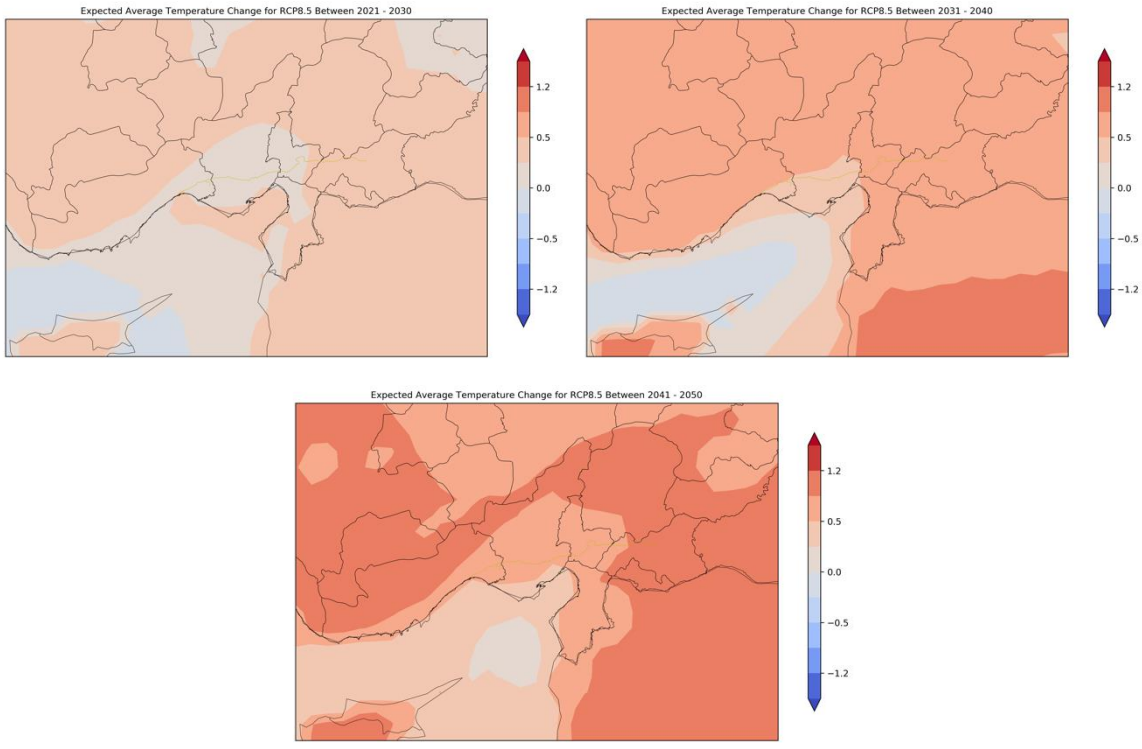

Figure 12. Temperature projections RCP 8.5

4.2.2 Precipitation

Other concern of climate change in Turkey is the trend of decreasing the amount of rainfall particularly in the southern and inner parts of Anatolia (Demircan *et al.*, 2017). By using the outcomes of CIMP5 ensemble model for RCP 4.5 and RCP 8.5, the precipitations patterns in the project location were assessed and Figure 13 and Figure 14 show how the rainfall will change over the years. According to CMIP5 model outputs, it is expected that rainfall will increase by 25% near the project areas under the RCP 4.5 scenario; however, there will be increase and decrease by 25% under the high emission scenario (RCP8.5).

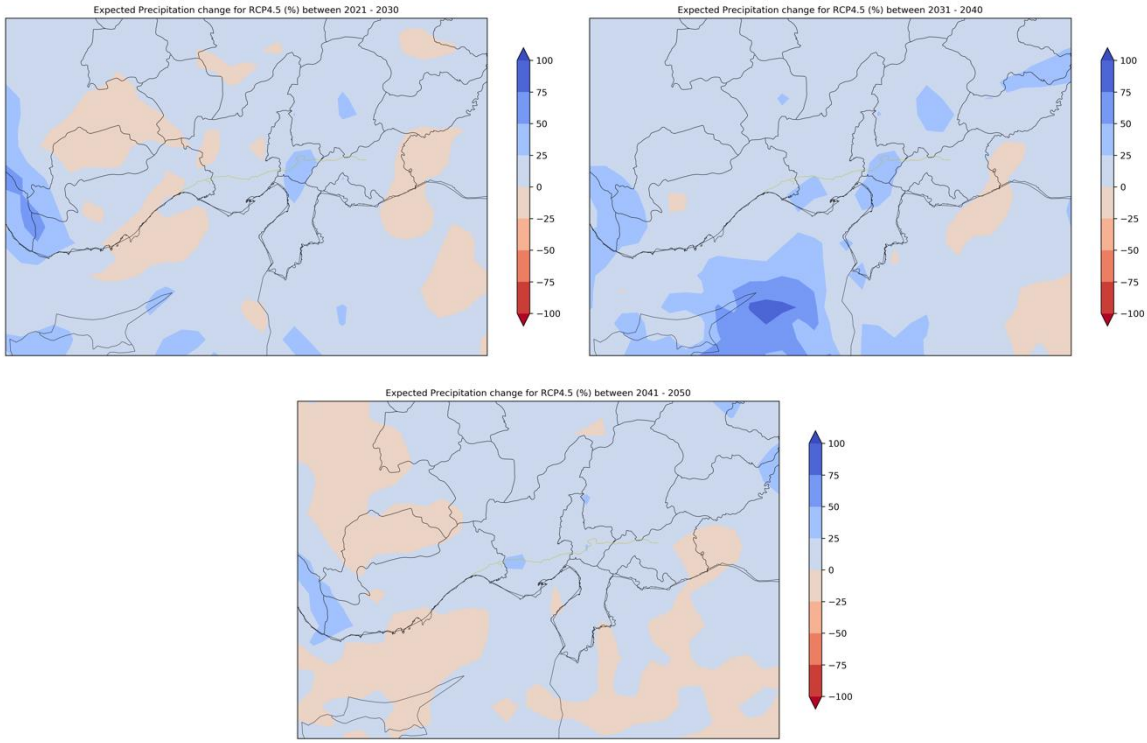

Figure 13. Precipitation projections RCP4.5

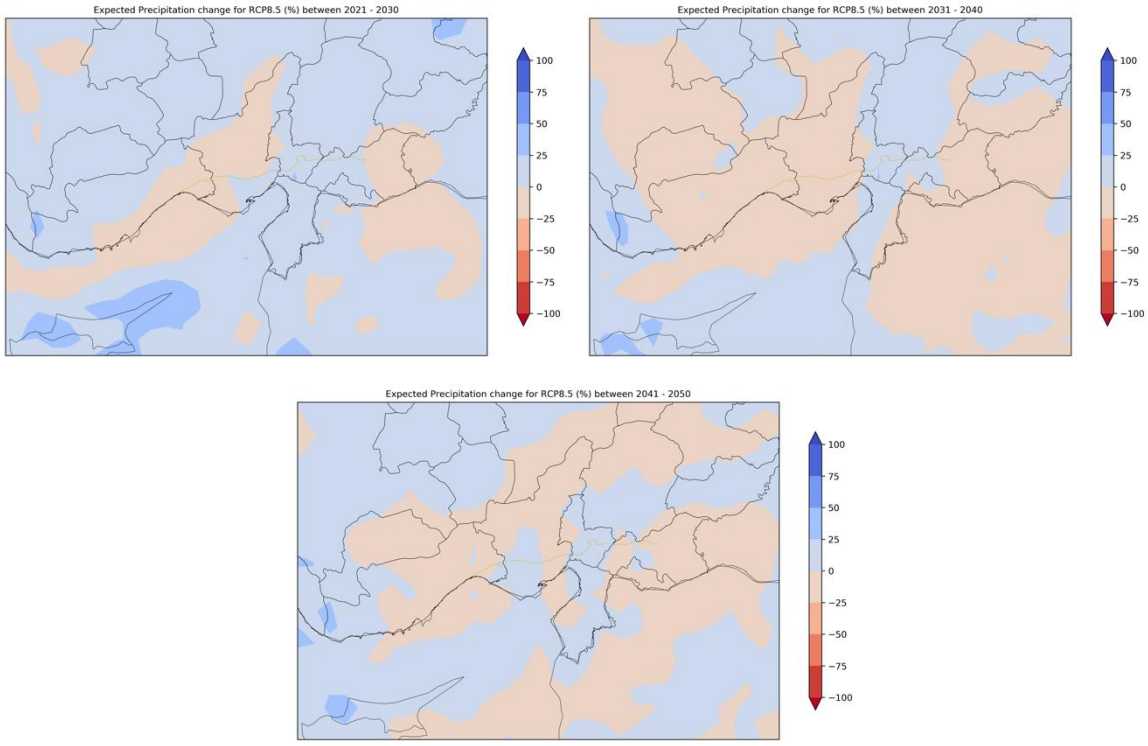

Figure 14. Precipitation projections RCP 8.5

4.2.3 Other Climate Variables

Changes in sea level are due to a complex interaction of climatic and geologic factors. Sea levels are rising largely because global temperatures are rising, besides this global trend, regional changes are also occurring in climate patterns affecting sea level. According to Climate Central Coastal Risk Assessment, coastal areas near the project will be under the threat of being flooded by sea (Climate Central, 2021). Figure 15 shows which part of the coast will be affected near the project area. It is not expected to the route will be under the flood threat. However, as Mersin Station of the railway will be very close to coastal areas, it is important to follow the regulations from the government and local authorities.

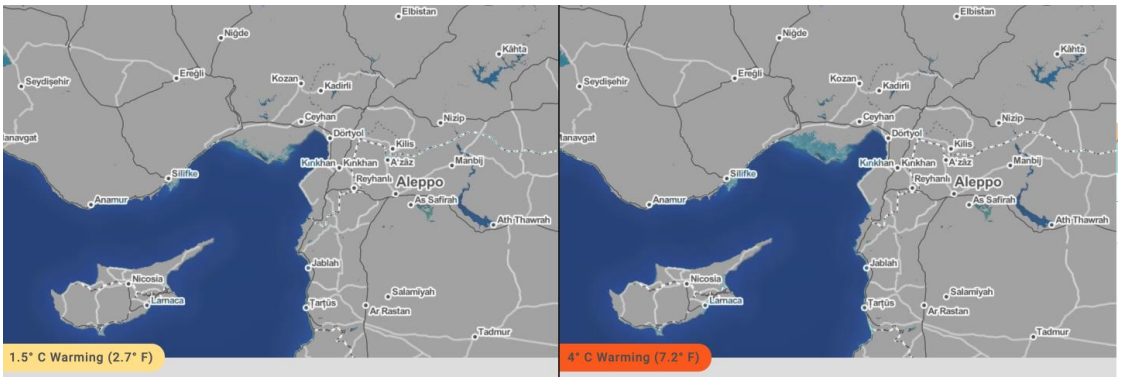

Figure 15. Sea Level Rise - Coastal Risk Assessment under 1.5°C and 4°C Scenarios

In addition, Warm Spell Duration Index (WDSI) is defined as count of days with at least 6 consecutive days when daily Tmax > 90th percentile of the reference period (1986-2005). The cumulative nature of a sequence of multiple days with high temperatures can raise the impact on the human body and lead to health issues in broad segments of the population. Many studies have reported associations between temperature extremes and mortality rates of circulatory diseases (WHO, 2009). Figure 16 shows Warmspell Duration Index in Turkey for period 2040-2059.

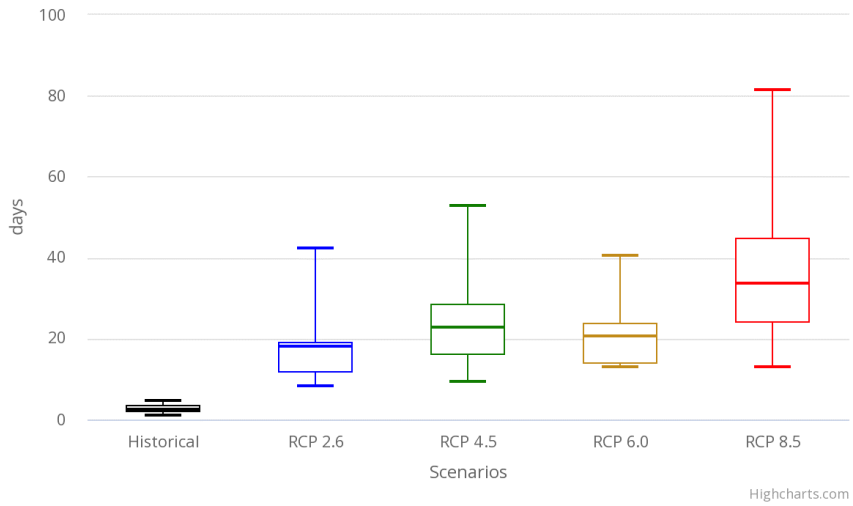

Figure 16. Warm Spell Duration Index in Turkey for period 2040-2059

As warmer air has a higher capacity to carry moisture in form of water vapor, future climate raises the likelihood for strong rainfall events and particularly towards extremes. The 10-year return period rainfall episodes, such as the 5-day cumulative rainfall, is a good measure of these extremes. 10-yr return events are rare enough to warrant special analysis based on extreme value theory. Here, monthly maxima of the 5-day cumulative rainfall over any 20-year window were calculated and the values used to derive the extreme value parameters. Figure 17 shows recorded 5-Day Cumulative Rainfall for 1986-2005 and projected 5-Day Cumulative Rainfall 10-yr Return Level by 2050 under all RCPs of CIMP5 ensemble modelling.

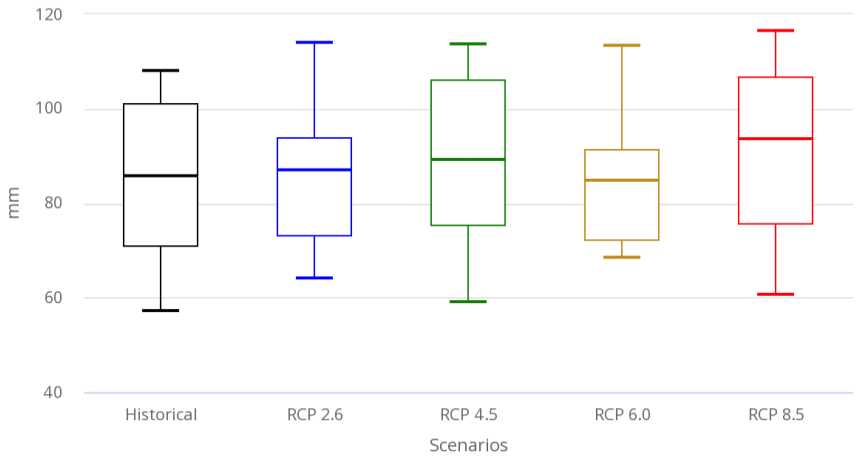

Figure 17. 5-day precipitation: 10-yr return level in Turkey for period: 2040-2059

In addition, dry conditions might also come along with higher temperatures and thus heightened cooling needs and an increase in demand for water pumping, particularly in regions where, water consumption is intense. The projections of Drought/Wet-Conditions (SPEI) under the low (blue) and high (red) emissions scenarios were given in Figure 18.

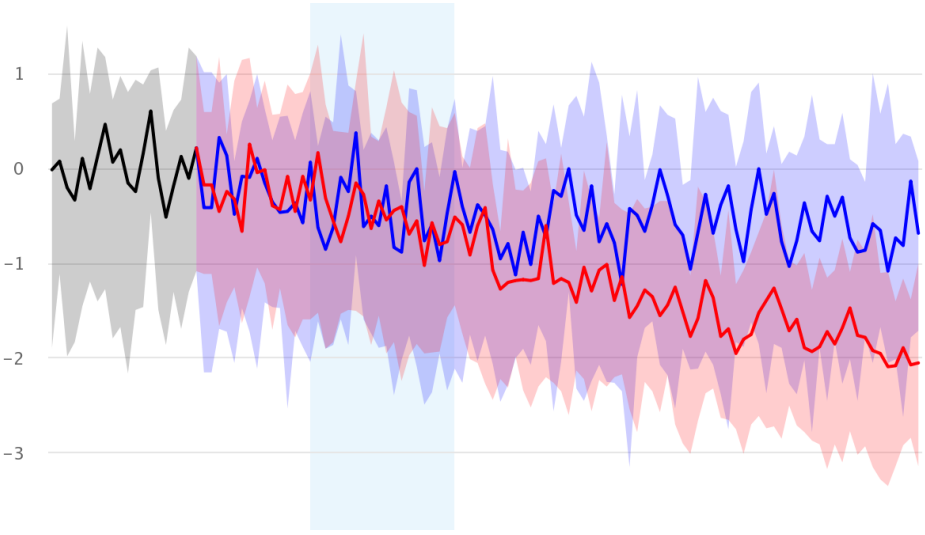

Figure 18. Drought/Wet-Conditions (SPEI) in Turkey for period: 1986-2099

Climate change has been a key factor in increasing the risk and extent of wildfires in the world. Wildfire risk depends on a number of factors, including temperature, soil moisture, and the presence of trees, shrubs, and other potential fuel. All these factors have strong direct or indirect ties to climate variability and climate change. Climate change enhances the drying of organic matter in forests (the material that burns and spreads wildfire). In July and August 2021, a series of more than two hundred wildfires burnt 1,700 square kilometres of forest in Turkey's Mediterranean Region in the worst-ever wildfire season in the country's history.

4.3 Risk Evaluation

The central objective of the Task Force's recommendations is to encourage organizations to evaluate and disclose, as part of their financial filing preparation and reporting processes, the material climate-related risks and opportunities that are most pertinent to their business activities.

The Task Force divided climate-related risks into two major categories:

- (1) risks related to the physical impacts of climate change.
- (2) risks related to the transition to a lower-carbon economy and

The Task Force identified certain subcategories under each of these categories. Depending on intensity of the change, exposure of project and area of influence and the vulnerability or resilience of the project, the area and the society, the impacts of the natural hazards may be extreme, significant, moderate or low. In context of climate change, serious risks in Turkey, and especially in the project area, are foreseen to occur due to possible new climate conditions in the future.

4.3.1 Physical Risks

Extreme weather events in the last few years have shown that the rail industry has insufficient understanding of weather effects on infrastructure and rolling stock, passengers and staff. This hinders the industry in making informed judgements about any adaptation policy that will deliver a reliable railway into the future. In order to achieve reliability of the railway system into the future, information is needed about the impacts of climate change. This information will be used to plan and provide for the adaptation of infrastructure and rolling stock at a reasonable cost. An effective method for assessment of the future impact of climate change will allow the industry to develop options for managing railway assets in the longer-term.

In order to achieve a reliable transport system into the future, the rail industry needs to know how the current and future climate will affect the ability to achieve and deliver:

- A safe railway
- A highly reliable railway
- Increased capacity
- Value for money
- A 'predict and prevent' ethos

While assessing the physical risks from climate change, each climate patterns were considered, and potential risks were identified. Physical risks were summarized in Table 5.

In its “Fifth Assessment Report” published in 2014, the Intergovernmental Panel on Climate Change (IPCC) has already predicted that risks associated with extreme events will continue to increase as the global mean temperature rises. There is evidence that some extremes have changed because of anthropogenic influences, including increases in atmospheric concentrations of greenhouse gases. It is likely that anthropogenic influences have led to warming of extreme daily minimum and maximum temperatures at the global scale.

4.3.1.1 Temperature

According to the Intergovernmental panel on Climate Change Report (IPCC, 2013), continued emissions of greenhouse gases will cause further warming, and it is virtually certain that there will be more frequent hot temperature extremes over most land areas during the next fifty years. Warming will not be regionally uniform. In the project area, the temperature increase in the next fifty years will be slightly higher than the worldwide average based on model outputs.

Increasing temperature is a complex issue that cuts across a number of policy areas, including health, planning, transport, energy, and the environment. Workers, heavy outdoor manual labour, are likely to be at the greatest risk of heat stress. Sustained periods of higher temperatures, for example the 2003 heatwave, resulted in large economic losses and thousands of deaths. However, there is considerable uncertainty about the magnitude of impacts. For the adaptation measure, these impacts of higher temperatures could be prevented by management plans, autonomous adaptations, and workplace guidance. Extreme heat hazard is classified as medium based on modelled heat information currently available, which means that there is more than a 25% chance that at least one period of prolonged exposure to extreme heat, resulting in heat stress, will occur in the next five years. Project planning decisions, project design, and construction methods should take into account the level of extreme hazard and could be followed in different phases of the project to help reduce the risk to the project.

Standards state that suitable personal protective equipment (PPE) should be provided to protect workers from cold weather. However, no guidance was found as to what PPE or welfare facilities are considered ‘suitable’. It is recommended that this informal good practice for PPE and welfare facilities is collected and disseminated in the form of consistent guidance. This applies to all adverse or extreme weather conditions, not just cold weather. There are several tracks working instructions which refer to the safety and welfare of workers during hot weather. However, there are no specific thresholds and related guidance for the protection of outdoor engineering workers from heat and other extreme weather. This can have implications for heat-induced fatigue, effective performance and ultimately the health and safety of staff and contractors. Therefore we suggest that consideration is given to the value of developing such guidance for staff and contractors.

Many design standards for different assets include a maximum temperature, and these values may need to be reviewed to check they will still be high enough in the future.

4.3.1.2 Rainfall

Flooding and coastal erosion can lead to loss of the project location, or access to them, and disrupt infrastructure provision. The possible realignment or retreat of coast protection structures due to increasing erosion and flood risks may have an impact on the project area in affected areas. There is the potential for lengthy disruption and high costs of repair.. More intense rainfall under climate change will also increase sewer flooding and combined sewer overflow (CSO) events. Periods of rainfall increase the risk of slope and embankment instability. These risks are most significant for road and rail infrastructure. These project specific flood risks are considered further in the Project's **Flood Risk Assessment Report**.

Reduced water availability is a risk which is likely to impact on water-intense industries with implications for other sectors across their supply chains. The impact of drought must be considered in all phases of the project, in particular its effect on personnel and stakeholders, and during the design of buildings and infrastructure. Project planning decisions, project design, and construction methods must consider the level of water scarcity. Medium confidence in an increase in drought tendency and a consistent increase in the physical area of drought hazard, which influences water scarcity. The present hazard level may increase in the future because of climate change.

4.3.1.3 Wind/Storm

Wind and storm damage and disruption are the biggest risk for disruption to overhead cables, particularly for energy distribution infrastructure. The impact of such lightning strike events is relatively low, compared to events such as flooding, as damage can usually be repaired quickly, and services restored. Wind currently causes problems with 'blow-off' of overhead lines (OHL). While future projections for wind are uncertain, it is likely that more local monitoring and increased prediction of wind conditions will be needed. Alternatively, or in parallel, vulnerability mapping of assets could reveal the most sensitive locations to wind. This would allow more targeted use of available information and forecasts for monitoring of wind risks. We suggest reviewing standards and management procedures for the installation of earthing arrays and high voltage cables.

High winds can increase leaf fall and bring down branches and trees. These problems can be mitigated by more investment in vegetation management where this vegetation is within the boundary of the railway.

High winds can also impact overhead line equipment (OHLE) and provide a risk of overturning. Given the large uncertainty in the projected changes to wind speeds in the projections, there is little evidence for changing the Turkey wind maps. The most important wind-related actions for the railway should be about understanding present day vulnerabilities to high winds, and how to reduce those vulnerabilities. It should be noted that some leaf fall is from vegetation belonging to third parties. Other climate and non-climate variables also contribute to these risks.

Removing vegetation can mean removing shading and this can lead to a risk of asset failure. Such vegetation clearance also has the potential to increase flood risks caused by heavy rainfall, and impact on slope stability, and these risks need to be considered before any vegetation is cleared from embankments and cuttings.

4.3.1.4 Lightning

Lightning strikes can cause problems for the railway. However, there were limitations to what could be done operationally to prevent the effects of a lightning strike, as these effects are predominantly mitigated through design. It is recommended that the industry includes reference to lightning protection in relevant design standards. There is a lack of rail-specific design guidance on the subject of reducing impacts of lightning on equipment and buildings. We suggest that railway guidance is extended to apply this standard explicitly to rail-related equipment and structures. Better mitigation of impacts can be achieved by understanding where lightning strikes have previously occurred. This may help to identify equipment and structures which are potentially at risk.

4.3.1.5 Risk Assessment

The physical risks of climate change that may have an impact on the project have been described above. To determine the effects of these risks on the project, the magnitude of the change was defined and the size of the change in physical risks was determined. The criteria for the magnitude of change component of the overall magnitude is presented in Table 4. Criteria for magnitude of change .

Table 4. Criteria for magnitude of change

High	Medium	Low	Negligible
Permanent damage and complete loss of service. Disruption, including transmission lines lasting more than ten days. Early renewal of infrastructure >90%. Severe health effects and/or fatalities. Very significant loss to the environment requiring remediation and restoration. Repairs cost 100% of reconstruction cost.	Limited infrastructure or asset damage and loss of service with damage recoverable by maintenance or minor repair. Disruption lasting more than one but less than ten days. Adverse effects on health and/or the environment. Repairs cost 25% of reconstruction cost.	Localised infrastructure or asset disruption or loss of service. No permanent damage, minor restoration work required: Operation closure lasting less than one day. Slight adverse health or environmental effects. Repairs cost 2% of reconstruction cost.	No infrastructure or asset damage, minimal adverse effects on health, safety and the assets. No operation closure. No financial loss. No transport difficulties, supply chain interruptions. No power outages. No water shortage.

The potential physical impacts, proposed mitigation measures and residual impact significances are summarized in

Table 5. Physical Climate Impacts .

Table 5. Physical Climate Impacts

Climate Variable	Potential Impact	Frequency	Design Measures	Overall Magnitude	Notes/Comments
Temperature	More rapid deterioration of materials and associated infrastructure such as signage.	Permanent	• Railway lines will be installed for resilience to temperatures ranging from -40°C to 70°C in accordance with **bid specification**. • Rail tracks will be designed to withstand temperature increases up to 6ºC from the baseline levels	Low	Overall magnitude was selected as low because of the bid specification can companse heat changes in the future
	Deformation of tracks leading to increased repair costs and slower journey times.			Low	
	Increase in expansion of materials leading to structural damage.			Low	
Heat Waves	Rail tracks buckling or deforming under extreme heat.	Temporary	• Railway lines will be installed for resilience to temperatures ranging from -40°C to 70°C in accordance with **bid specification**. • Rail tracks will be designed to withstand temperature increases up to 6ºC from the baseline levels	Low	Overall magnitude was selected as low because of the bid specification can companse heat changes in the future
	More rapid deterioration of materials and associated infrastructure such as signage.			Low	
	Increase in expansion of materials leading to structural damage.			Low	
	Melting/deformation of materials.			Low	
	Power outages due to increased energy demand, transmission line damages and power supply damages		-	Medium	Please refer to Criteria for magnitude of change table
Extreme Rainfall	Flooding at stations	Temporary	-	Low	Please refer to Criteria for magnitude of change table
	Flooding at depots		-	Low	Overall magnitude was selected as low because of the bid specification can companse extreme rainfalls in the future
	Flooding affecting plant and equipment rooms		-	Low	Please refer to Criteria for magnitude of change table
	Flooding caused by poor drainage and high-water levels		The project is designed to withstand the Q500 flow.	Medium	
	Flooding at bridges — scour/ pressure/ obstruction damage		The project is designed to withstand the Q500 flow.	Low	Overall magnitude was selected as low because of the bid specification can companse extreme rainfalls in the future

Climate Variable	Potential Impact	Frequency	Design Measures	Overall Magnitude	Notes/Comments
	Flooding in tunnels		The project is designed to withstand the Q500 flow.	Low	Overall magnitude was selected as low because of the bid specification can companse extreme rainfalls in the future
	Increased rainfall causing high surface run-off		-	Medium	Please refer to Criteria for magnitude of change table
	Cabinets		-	Low	Please refer to Criteria for magnitude of change table
	Safety of workforce in extreme flood conditions — watchmen at flood sites		-	Negligible	Please refer to Criteria for magnitude of change table
Cold Wave	Broken Rails	Temporary	-Railway lines will be installed for resilience to temperatures ranging from -40°C to 70°C in accordance with **bid specification**.	Low	Overall magnitude was selected as low because of the bid specification can companse heat changes in the future
Sea level rise and increased storminess	Sea defences	Permanent	-	Negligible	No sea level rise forecasted through railway route

4.3.2 Transition Risks

Transition risks refer to political and regulatory changes aimed at fostering low-carbon transition. Transitioning to a lower carbon economy may require extensive policy, legal, technology and market changes to address climate change mitigation and adaptation requirements. The TCFD Recommendations identify the Transition Risks as,

- Policy and Legal Risks
- Technology Risks
- Market Risks and
- Reputation Risks.

4.3.2.1 Policy and Legal Risks

Various policies are being developed for the transition to a low carbon economy such as carbon-pricing mechanisms to reduce GHG emissions, shifting energy use toward lower emission sources, adopting energy-efficiency solutions, encouraging greater water efficiency measures, and promoting more sustainable land use practices.

In addition to policy risks, litigation or legal risks are another important risk in terms of transition to low carbon economy.

In this section, these risks were determined and assessed.

4.3.2.1.1 Legal Framework

a. National Level Legal Framework

The Ministry of Environment and Urbanization (MoEU) is responsible for the formation and implementation of environmental policy in Turkey, and is also the focal point for the UNFCCC. In this context, climate change policies are determined and executed by Climate Change and Air Management Coordination Board (CCAMCB) under the coordination of the MoEU with the participation of relevant ministries and institutions.

Turkey's main climate change policy documents (see Figure 19 for timeline of climate policy developments in Turkey) are 10th Development Plan, National Climate Change Strategy (2010-2023), National Climate Change Action Plan (2011-2023) and National Climate Change Adaptation Strategy and Action Plan (2011-2023).

The Paris Agreement is a legally binding international treaty aims to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. Turkey signed the Paris Agreement on 22 April 2016. At the 76th session of the UN General Assembly, it was announced that Turkey will ratify Paris Agreement within October 2021 by President. Turkey's intended Paris Agreement target (INDC) specifies emissions cuts of up to

21% by 2030, compared to a business-as-usual scenario. Following a business-as-usual scenario, this target allows emissions growth (excluding LULUCF emissions) of up to 80% above 2018 levels. Such a trajectory is not yet aligned with a science-based approaches for keeping warming below at least 2°C. Moreover, projections indicate the Covid-19 pandemic to have had only a small impact on Turkey's emission trajectory, with emissions expected to have troughed at only 3-5% below 2019 levels by the end of 2020, and expected return to 2019 levels by 2021. As such, additional mechanisms – and significant financial resources from both national and international sources – will be needed to align Turkey's low carbon transition with global ambitions.

Turkey is taking steps to prepare its economy for closer ties with EU legislation. One important step towards this integration has been the preparation of new legislation to monitor and verify emissions across a range of sectors. Regulation on "Greenhouse Gases Emission Monitoring" went into force on April 25, 2012 with the publication of 28274 numbered official gazette, implements key parts of the EU Monitoring Mechanism Decision 280/2004/EC. Following some amendments on several articles, the regulation has been revised and republished on May 17, 2014 on 29003 numbered official gazette. Within the scope of the legislation, industries mentioned in Appendix-1 of the regulation are subject to annual monitoring, reporting and verification processes. The monitoring plans, which are prepared within the legislation scope, are delivered to Ministry via Environmental Information System.

Partnership for Market Readiness (PMR), launched by the World Bank in 2011, is a technical assistance program that aims to support the efforts of developing countries, which have an important place in the global fight against climate change, to reduce their greenhouse gas emissions, through the effective use of the market. A synthesis report outlining carbon market policy options for Turkey was submitted to the Climate Change and Air Management Coordination Board in November 2018. The (PMR) First Phase Closure Meeting was held at the end of 2018 and the PMR Second Phase officially began in February 2019. With additional funding under the PMR Second Phase, Turkey has developed draft legislation as well as improved technical and institutional capacity to prepare the groundwork for piloting a suitable carbon pricing policy.

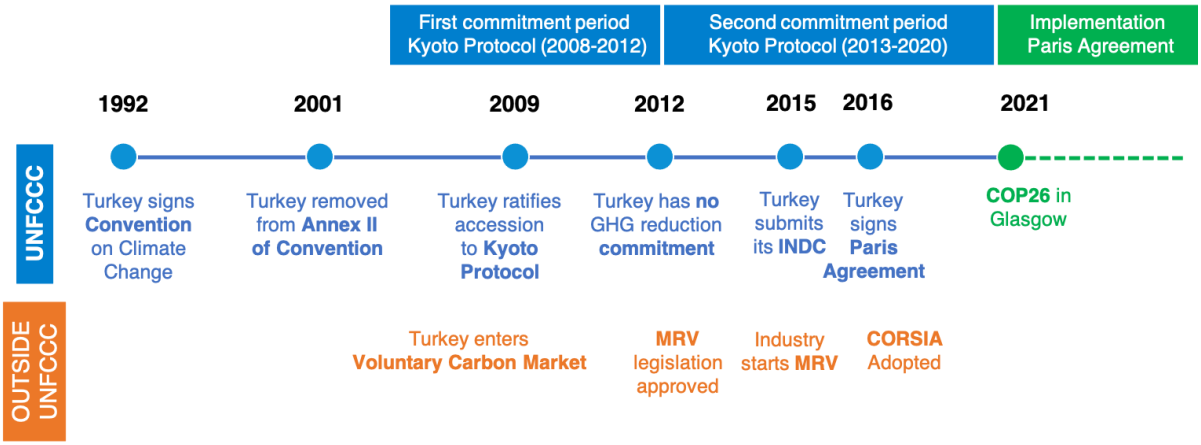

Figure 19. Timeline of climate policy developments

4.3.3. Risks

The project will not cause direct GHG emissions. Therefore, it is not expected to be effected directly from policy and legal changes. Neverthless, because of the energy dependency of the project, policy and legal changes such as transition to carbon trading system on electricity generation wil cause increased prices on energy supply.

Here, using an Input-Output Carbon Cycle technique, we explore the cumulative CO_2 emissions of new HSR route between Mersin and Gaziantep. Within the framework of Input-Output Carbon Cycle assessment model, we assess the carbon cost of this new route in railway network. And lastly, we present the impact of possible electricity price increases on railway sector. Since energy is one of the most fundamental input in railway service sector, any price increases in energy prices will impact the cost and profitability of the sector.

I–O carbon cycle assessment model under benchmark situation (without Mersin-Gaziantep High Speed Railway route) indicates that CO_2 emissions of railway sector in Turkey produces 0.43 million tonnes CO_2 (see Table 6)

Table 6. CO_2 Emissions Under Benchmark (Million Tonnes)

Sector	Emissions
Agriculture	3.34
Other Sectors	360.59
Railway	0.43

High Speed Railway network with new route between Mersin and Gaziantep adds 286 km to the network, and this additional investment can be translated into a capacity increase of 5.2%.

Table 7. CO_2 Emissions Under Benchmark (Million Tonnes)

Years	High Speed Rail Lines	Conventional Rail Lines	Electrified Lines
2014	1213	11272	3748
2015	1213	11319	3854
2016	1213	11319	4350
2017	1213	11395	4660
2018	1213	11527	5467

The capacity impact of this new route on railway sector was give as a shock to the I–O carbon cycle assessment model. Results indicates that new route will increase total CO_2 emissions of sector more than the capacity increases of the railway sector. This means that CO_2 emissions is not the linear function of production in economic system. When we include all the spill over CO_2 impacts of this new route, CO_2 emissions of increases from 0.43 million tonnes in initial situation to 0.51 million tonnes with new route in railway network (see Table 8).

On the other hand, this new route decreases CO_2 emissions of other sectors from 360.59 mt to 358.3 mt. This impact indicates that new route will decrease the CO_2 emissions of other sectors almost 0.64%.

Table 8. CO_2 Emissions with the Project (Million Tonnes)

Sector	Emissions
Agriculture	5.53
Other Sectors	358.3
Railway	0.51

Cost of carbon emissions of additional route in railway network under different scenarios indicated at table 9. If we assume that carbon tax or price will be around 55 euros, total cost of carbon emission railway sector with Mersin-Gaziantep HSR is 28.05 million euros. Additional carbon cost is 5.61 million euros.

Table 9. Cost of carbon emission with different carbon tax levels (Million Euro)

Scenarios	55 Euro	75 Euro	100 Euro
Under benchmark simulation	23.67	32,28	43,04
With New HSR line	28.05	38,25	51

And lastly, we assess the impact of possible electricity price increases on railway sector. Energy input in railway sector constitutes 24.7% of the total output. And any price fluctuations in energy sector will impact the cost and profitability of the railway sector. According to Input-Output Leontief price model results, cost increase in electricity input will result substantial cost increases in railway services. According to simulation of 100% price increases in electricity will impact of the railway service prices almost 16.37% (see Table 10). This at the end can be a risk factor which will impact the profitability of the new investment.

Table 10. Impacts of electricity price increases on output prices

Sectors/Scenarios	10%	50%	100%
Agriculture	0,13%	1,08%	3,21%
Food	0,32%	2,51%	7,70%
Textile	0,56%	4,35%	13,41%
Construciton	0,24%	1,94%	5,90%
Railway	**0,56%**	**5,35%**	**16,37%**
Other Transport	0,13%	1,01%	3,03%
Machinary and Equipment	0,22%	1,80%	5,40%
Water	1,97%	16,30%	51,89%
Petrol	0,17%	1,41%	4,19%
Metal Related Manufacturing	0,63%	4,98%	15,19%
Chemical industry	0,17%	1,40%	4,16%
Other Industry	0,40%	3,26%	9,85%
Tourism	0,47%	3,70%	11,32%
Services	0,28%	2,30%	6,89%

4.3.2.1 Technology Risks

Technological improvements or innovations that support the transition to a low-carbon, energy-efficient economic system may pose investment risk on the project. Even though the best available technologies handled within the scope of the EIA, operator must be aware the importance of the new low carbon technologies.

4.3.2.2 Market Risks

Markets can be affected by climate change. One of the main ways is through changes in supply and demand for certain goods, products and services as climate-related risks and opportunities are increasingly taken into account.

The return on climate change resilience projects is most likely to be in conventional benefits, principally the impact on the reliability of the network. This means that we do not see a case for treating these projects differently to any other investment.

In accordance with a 'system of systems' approach, it is recommended that encouraging the development of integrated solutions on a cross-sector basis, covering all modes of transport is undertaken. This would account for the possible changes (and resulting low or high demand) to rail services during extreme weather. The main resulting recommendation is that the rail industry considers adopting Turkey's approach to appraising investments that offer increased climate change resilience. This uses the level of protection to define the scheme being appraised.

4.3.2.3 Reputation Risks

Climate change has been identified as a potential source of reputational risk due to changing customer or community perceptions of an organization's contribution to or away from the transition to a lower carbon economy. Potential reputation risks can be listed as below.

- Growing expectations for responsible conduct from stakeholders, including investors, lenders and consumers.
- Opportunity to enhance reputation and brand value
- Risk of loss of trust and confidence in management

As the project is public transportation investment and causes less GHG than personal transportation, it is considered as more desirable solution in terms of climate change. Consequently reputation risks will be negligible.

Transition risks, responsibilities and management recommendations are summarized in **Hata! Başvuru kaynağı bulunamadı.**.

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5 GREENHOUSE GASES EMISSIONS

Turkey was included in Annex I and Annex II lists at the very beginning of the UNFCCC process in 1992 due to her OECD membership. The 7th Conference of Parties (COP) of UNFCCC in 2001 adopted a decision regarding the delisting of Turkey's name from Annex-II. Consequently, Turkey currently takes place only in Annex-I list. However, Turkey had no historical responsibility for greenhouse gas emissions in 1992 despite being included in Annex-I. Indeed, by that time, Turkey was in the last row of the Annex I list among 36 countries in terms of greenhouse gas emission with per capita ratio of 3,88 tCO_2e (less than 1% of the global total), while the average greenhouse gas emission of the Annex I countries was 14,37 tCO_2e per capita. The proposal (dated 28 April 2021 by the Republic of Turkey) of amendment to the list in Annex I to the Convention by deleting the name of Turkey will be the included in the provisional agenda of the twenty-sixth session of the Conference of the Parties. Delisting of Turkey from Annex I of the Convention, will be a comprehensive solution which will enable Turkey to contribute to combating climate change in a much efficient way.

Latest Greenhouse Gas Emissions Statistics for the period of 1990 – 2018 was published on March 2020 (TurkStat, 2020). According to the report, total greenhouse gas emission in 2018 was 520,9 $MtCO_2e$ in Turkey, and Energy-related emissions had the largest share in 2018 emissions with 71.6%, followed by industrial processes and product use with 12.5%, agricultural activities with 12.5% and waste with 3.4%, respectively. Change compared to 1990 was almost %140 in 2018, and this change went hand in hand with energy related emissions trend (Figure 20). Next report for GHGs in Turkey will be published in late March 2021.

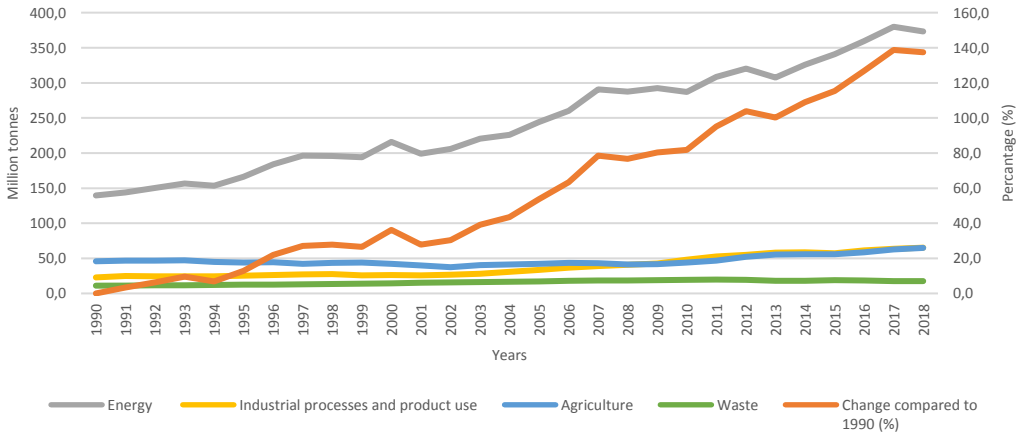

Figure 20. Greenhouse gas emissions by sectors (CO_2 equivalent), 1990 - 2018

According to the NDC, in a BAU scenario Turkey's emissions would nearly triple in the coming decades, from 430 $MtCO_2e$ in 2012 up to 1,175 $MtCO_2e$ in 2030. Its Paris climate target, therefore, means bringing emissions in 2030 down to 929 $MtCO_2e$.

According to Climate Action Tracker (CAT), Turkey's Paris pledge is rated as "critically insufficient", meaning it is not at all consistent with the Paris Agreement's goal to limit warming to "well below" 2C, let alone 1.5C. CAT's rating means that if all government targets were akin to Turkey's, warming would breach 4C. CAT also notes that the 2030 target in the NDC is equivalent to 348% emission increase from 1990 levels.

Today, CO_2 emissions from the chemical sector are approximately 1.5 $GtCO_2$ of carbon dioxide per year globally, or 18% of industrial CO_2 emissions. The sector's emissions stem from two key sources, which are energy-related emissions (1.3 $GtCO_2$ or 85%) like combustion to generate heat, both directly and for the production of steam on-site, and process CO_2 emissions (0.2 $GtCO_2$ or 15%) between the feedstock and the product.

5.1 GHG Emissions Assessment

A review of the available data on the existing operations and proposed project has been undertaken. Information on the construction phase of the Project is limited as the development of designs is still at feasibility stage. Data for the operational phases has been taken from the most up-to-date information available at the time of writing and supplemented with assumptions where necessary.

There is no agreed-upon method for which to determine the exact contribution of these indirect greenhouse gases (NMVOCs, NO_x, CO, SO_2) to global warming. This is due to the short lifetime of these gases in the atmosphere, their spatial variability, or their indirect effects that are hard to quantify. Therefore, there is not a precise global warming formulaic potential for NMVOCs, NO_x, CO, and SO_2 (Satein, 2009). However, IPCC published literature values for CO in AR5 WG1 – Chapter 8, and this will help to calculate total emissions from the project (Myhre *et al.*, 2013). Table 11 gives the Global Warming Potential for CO, CH_4, and N_2O.

Table 11. IPCC AR5 global warming potentials

Greenhouse Gases	Formula	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Carbon monoxide	CO	2 – 3,3

5.1.1 Project Boundaries

The project boundary separates the entities (in other words, the facilities and operations) whose emissions are included in the assessment from those that are not. Construction phase emissions are normally not included in the assessment as they are typically not considered to be significant compared with operational emissions. However, construction related emissions will be included in the assessment. Scope 1 and Scope 2 of emissions for the Construction and Operation of the Mersin Gaziantep High Standard Train will be assessed. For all Projects, in all locations, while combined Scope 1 and Scope 2 emissions are required in the Equator

Principles (July 2020), Scope 3 emissions are not taken into account. However, Scope 3 emissions will be quantified for both plants. As the Equator Principles (July 2020) only requires Scope 1 and Scope 2 emission, total emissions will be given in tables by separating from Scope 3 emissions.

5.1.2 Mersin-Gaziantep High Standard Train Project

Mersin Gaziantep High Standard Train (286 km-long railway) is planned to be built between Mersin and Gaziantep (Başpınar) and will reduce the travel time by 1.5 hours. Figure 23 shows the installation works of construction and electromechanical systems if high standard railway line.

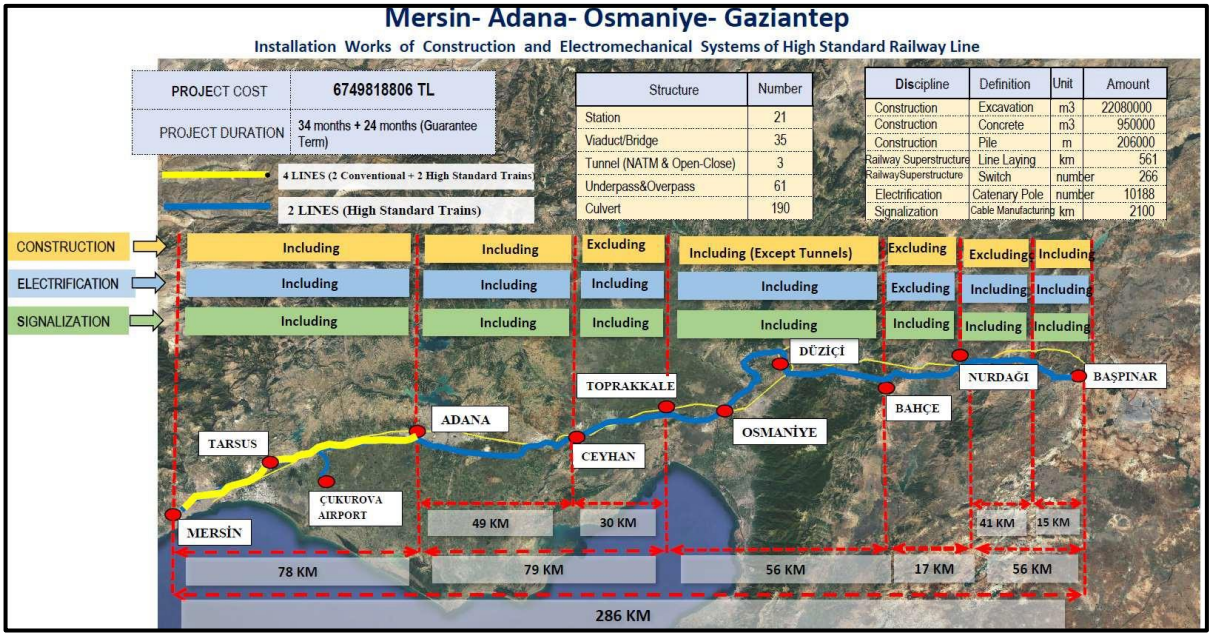

Figure 21. The project scope map

5.1.2.1 Construction Phase GHG Emissions

The construction of the railway system is scheduled to be completed in 34 months, and it is followed by period of 24-month guarantee. There may be shifts in the work schedule due to the site delivery of the companies currently working in the field and the place delivery dates to Rönesans by TCDD and AYGM. According to information supplied by the project owner, different types of machinery equipment will be used (see. Table 12 for maximum number of machinery equipment at peak construction time). During the construction period, when infrastructure, superstructure and excavation operations were carried out, the maximum number of employees in March-April is 385 personnel. For the construction on the route, 3 construction sites will be installed and the structures in these sites are planned to be prefabricated.

While calculating GHG emissions from construction phase, UK Government GHG Conversion Factors for Company Reporting 2020 Version 1.0 were used (BEIS, 2020).

During the construction phase, It is planned that 315 vehicles for excavation, 91 for filling, 17 for foundation excavation, 29 for asphalt production, 87 for granular fillings, 11 for asphalt paving, 35 for basalt paving, 61 for basalt line paving, 15 for non-basalt line paving, scissors paving 13 vehicles for line dismantling, 5 for scissor removal, 14 for sleeper production, 8 for basalt quarry, 8 for panel production and 58 for the support team, total of 767 vehicles will be used for all operations.

Table 12. Machinery lists from construction phase

Purpose	Vehicle Qty
Excavation	315
Filling	91
Foundation excavation	17
Plenty production	29
Granular fillings	87
Asphalt paving	11
Basalt paving	35
Basalt line paving	61
Non-basalt line paving, scissors paving	15
Line dismantling	13
Scissor removal	5
Sleeper production	14
Basalt quarry	8
Panel production	8
The support team	58

In the scope of the project, diesel fuel will be used to provide energy for construction machinery. Usage of total diesel fuel (diesel density is 1189.54 tonnes/litres) for each section are listed below;

- between Mersin and Adana ; 20000 tonnes/year
- between Adana and Toprakkale ; 11200 tonnes/year
- between Toprakkale and Bahçe ; 23200 tonnes/year
- between Bahçe and Nurdağ ; 2300 tonnes/year
- between Nurdağ and Gaziantep ; 4800 tonnes/year

Total fuel consumption from machineries is around 174300 tonnes diesel, and total machinery GHG emissions were calculated as **527900 TCO_2e** (tonnes).

Under the construction phase of the project, Scope 3 emissions were given in Table 13 (GHG Protocol, 2021). Emissions from category 3 and category 7 defined in EPA (2021) calculated as 26600 **TCO_2e** (tonnes/year).

Table 13. Scope 3 GHG emissions from construction phase

Scope 3 Categories	CO_2e (tonnes/year)
Category 3 Fuel- and Energy-Related Activities, Not Included in Scope 1 or Scope 2	**26395**
Category 7 Employee commuting	**204**
TCO_2e (tonnes/year)	**26600**

As the construction period will not last for more than 4 years (including guarantee months), and the operational phase is designed for 100 years unless unforeseen event occurs, total GHG emissions from the construction of Mersin Gaziantep High Standard Train are calculated as **6033 tCO_2e/y.**

5.1.2.2 Operation Phase GHG Emissions

5.1.2.2.1 Scope 1 Direct GHG Emissions

Scope 1 emissions are direct greenhouse (GHG) emissions that occur from sources that are controlled or owned by an organization (e.g., emissions associated with fuel combustion in boilers, furnaces, vehicles). It is expected that construction phase air pollutants and GHG emissions will significantly be reduced during the operation phase, as the train will use electricity only and no fuel will be consumed. The only possible releases from the operation are during the transport of staff and passengers to the stations by vehicles. As there are not many details of these minor releases, it was not possible to calculate Scope 1 emissions.

5.1.2.2.2 Scope 2 Indirect GHG Emissions

Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, heat, or cooling. Although scope 2 emissions physically occur at the facility where they are generated, they are accounted for in an organization's GHG inventory because they are a result of the organization's energy use (EPA, 2021a). Scope 2 emissions are calculated using below formula:

$$CO_2\,(t) = Energy\ use * Country\ Specific\ Emissions\ Factor\ for\ Electricity\ Consumption$$

It is calculated that net electricity consumption in the current plant is 330 GWh yearly. While calculation Scope 2 emissions, country specific emissions factors were used (EIB, 2020).

Table 14. Calculation of energy use GHG emissions

Energy Use (GWh/y)	Country Specific Emissions Factor (gCO_2/kWh)	CO_2e
60.49	326	**107580**
	TCO_2e	**107580**

5.1.2.2.3 Scope 3 Other indirect GHG Emissions

Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain. During the operation period, there will be 20 employees working at stations in each city and 10 employees working at stations in each district.

While calculating Scope 3 emissions (see. Table 15), The Scope 3 Evaluator Tool were used (GHG Protocol, 2021). Emissions from category 3 and category 7 defined in EPA (2021) calculated as **5328.61 TCO_2e** (tonnes/year).

Table 15. Scope 3 GHG emissions

Scope 3 Categories	CO_2e (kg/year)
Category 3 Fuel- and Energy-Related Activities, Not Included in Scope 1 or Scope 2	**5318.20**
Category 7 Employee commuting	**10.41**
TCO_2e (tonnes/year)	**5328.61**

5.1.2.3 Annual Total Emissions from the Project

Construction emissions were calculated as **6033 tCO_2e/y**. With emissions from Scope 1 and Scope 2, the total GHG emissions from the project are, therefore, calculated as **107580 tCO_2e/y** (see. Table 16). It is expected that Scope 2, electricity consumption will be the largest GHG emission source of the operations phase. Scope 3 emissions were calculated as **5328.61 tCO_2e/y**.

Table 16. Total annual GHG emissions

Emissions	Activity	CO_2e
Construction	Construction activities (trucks, forklifts, tower cranes etc.)	**527900**
	Scope 3	**75400**
	TCO_2e of Construction	**618877256**
	TCO_2e (yearly basis for 100-year operation)	**6188772.56**
Scope 1	Operational Process	-
Scope 2	Electricity Consumption	**107580**
	TCO_2e of Scope 1 and Scope 2	**107580**
Scope 3	Transportation and Distribution Category 3 - Fuel- and Energy-Related Activities, Not Included in Scope 1 or Scope 2 Category 7 – Employee commuting	**5328.61**
	TCO_2e of Scope 3	**5328.61**

For all projects, while combined Scope 1 and Scope 2 emissions are required in the Equator Principles (July 2020), Scope 3 emissions are not considered. As the train will use electricity only and no fuel will be consumed, Scope 1 emissions are not calculated. With Scope 2 emissions from Mersin Gaziantep High Standard Train Project are **107580 tCO_2e/y**. The total GHG emissions are, therefore, calculated as **107580 tCO_2e/y** and given in Table 17.

Table 17. Total annual GHG emissions (Scope 1 and 2)

Plant	Emissions	Activity	CO_2e
Mersin Gaziantep High Standard Train Project	**Scope 1**	Operational Process (plant units)	**-**
	Scope 2	Electricity Consumption	**107580**
		TCO_2e of the project	**107580**

6 CONCLUSIONS

This report provides a summary of the methods and information needed to perform a climate change risk assessment, specifically tailored to the project of Mersin Gaziantep High Standard Train. This Climate Change Risk Assessment (CCRA) Report was prepared in line with the Equator Principles IV (July 2020) and the Recommendations of the Task Force on Climate-related Financial Disclosures.

As mentioned in **Chapter 4**, Turkey is under a coherent warming trend during summer, and there have been widespread decreases in the frequency of cool nights and increases in the frequency of warm nights since 1979. Drought is very effective over the project area which has been exceptionally dry since September 2020. Heavy rainfalls, storms and floods have been reported for the project area since 1975. From the projections, it is expected that there will be decreasing trend in the amount of rainfall throughout Turkey particularly in the southern and inner parts of Anatolia, and increased trends in temperature especially in winter season.

Detail explanation of physical and transition risks were identified in **Chapter 4**. It is expected that higher temperature will likely affect workers and productivity and give extra pressures on electricity consumption, which may cause temporary shortages in electricity supply. Due to extremes near project location, delays will likely be occurred. Floods may be occurred due to heavy rainfalls, which will cause delays, water shortages, lengthy disruption and high costs of repairs.

For transition risks, the biggest impacts would be from policy and legal, if the new regulations such as carbon taxes, forcing lower emissions had announced. As Turkey does not have a carbon tax and does not operate an emissions trading system for CO_2, the project might face the challenges in the near future, especially by taking concrete steps after COP26 in Glasgow, should be prepared for any unexpected expenditures, which will be fastened by the one of the aims of The Green Deal Action Plan prepared by the Ministry of Trade “limiting carbon emissions”. Some project specific recommendations of actions for the short, medium and long-term were given in this chapter, and it is important to consider all these action in the project management plans.

In **Chapter 5**, GHGs emissions from the projects were calculated under the scope 1, 2, and 3 for both construction and operation phases. As the train will only use electricity during the operation phase (no usage of fossil fuels etc.). GHG emissions including construction, Scope 1, 2, and 3 from the project were quantified as **6301681.17 tCO_2e/y**. However, as the Equator Principles (July 2020) only requires Scope 1 (not calculated) and Scope 2 emissions, Scope 2 emissions from the Mersin Gaziantep High Standard Train are **107580 tCO_2e/y**. The total GHG emissions from Scope 1 and Scope 2 of the project are, therefore, calculated as **107580 tCO_2e/y**. It is noted that while the Mersin Gaziantep High Standard Train exceed the threshold of 100,000 tCO_2e/y, project’ emissions are higher than the thresholds of 25,000 tCO_2e/y. These thresholds obligate the project owners to report GHGs emission annually and to carry out a Climate Change Alternatives Analysis and cover Transition Risks, respectively.

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