AYGM

HALKALI-ISPARTAKULE-CERKEZKOY RAILWAY LINE

Environmental and Social Impact Assessment



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CLIMATE CHANGE

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14 CLIMATE CHANGE

14.1 INTRODUCTION

14.1.1. This chapter reports the outcome of the assessment of likely significant effects of the Project in relation to climate change, based on data available and gathered during the assessment process. It considers the effects in terms of:

- The contribution of the Project to climate change: the greenhouse gas (GHG) emissions assessment under **Section 14.3**; and
- The assessment of the vulnerability of the Project to climate change (climate change resilience) under **Section 14.4**.

14.1.2. This chapter reports the outcome of the assessment of likely significant effects of the Project in relation to climate change, based on data available and gathered during the assessment process. It considers the effects in terms of:

- The contribution of the Project to climate change: the greenhouse gas (GHG) emissions assessment under **Section 14.3**; and
- The assessment of the vulnerability of the Project to climate change (climate change resilience) under **Section 14.4**.

14.1.3. A collective summary is provided in **Section 14.5**.

14.2 LEGISLATIVE FRAMEWORK, POLICY AND GUIDANCE

14.2.1. This assessment has taken into account the current legislation, policy and guidance relevant to climate change. These items, covering both GHG emissions and climate resilience.

INTERNATIONAL

EIA Directive 2014/52/EU of the European Parliament and of the Council

14.2.2. The requirement to consider climate change as part of EIA process results from the 2014 amendment to the EIA Directive (2014/52). The Directive requires: "A description of the likely significant effects of the Proposed Development on climate (for example the nature and magnitude of GHG emissions) and the vulnerability of the Proposed Development to climate change."[225]

United Nations Framework Convention on Climate Change (UNFCCC)

14.2.3. Turkey became a party to UNFCCC on 24 May 2004 and an official party to the Kyoto Protocol on 26 August 2009. However, Turkey does not have quantified emission reduction or limitation targets. Nevertheless, Turkey undertakes significant activities toward climate resilience and decreasing GHG emissions in the fields of energy efficiency, promotion of renewable energy, transportation and waste management[226].

[225] EC (2014). The Environmental Impact Assessment Directive (2014/52/EU).
[226] UNFCC (2020). Republic of Turkey: Intended Nationally Determined Contribution.

EBRD Environmental and Social Policy

14.2.4. This Policy[227] states that EBRD will support its clients in developing climate adaptation measures and climate resilient investments as well as in managing risks caused by climate change. The potential risks caused by climate change may need to be assessed to identify appropriate climate resilience and adaptation measures to be integrated into the Project design. Furthermore, the Policy states that the EBRD will engage, whenever appropriate, in innovative investments and technical assistance to support no / low-carbon investments, as well as identify opportunities to reduce emissions.

14.2.5. The Project must follow EBRD PR3, which aims to promote the reduction of project related greenhouse gas emissions. The GHG section of the requirements states that:

- The ESIA will consider alternatives and implement technically and financially feasible and cost-effective options to avoid or minimise project related GHG emissions during the design and operation of the Project.
- For projects that currently produce, or are expected to produce post-investment, more than 25,000 tonnes of CO_2e[228] annually, the client will quantify these emissions in accordance with EBRD Protocol for Assessment of Greenhouse Gas Emissions (summarised below). The scope of GHG assessment shall include all direct emissions from the facilities, activities and operations that are part of the project or system, as well as indirect emissions associated with the production of energy used by the project. Quantification of GHG emissions will be conducted by the client annually and reported to the EBRD.

EBRD Protocol for Assessment of Greenhouse Gas Emissions

14.2.6. The Protocol[229] outlines the objectives and basic principles that the EBRD is committed to for estimating the future impacts of GHG emissions of the projects that it finances.

EBRD Green Economy Transition Handbook[230]

14.2.7. The Handbook describes the approaches that the EBRD takes to incentivise the financing of projects that "advance the transition to an environmentally sustainable, low-carbon and climate-resilient economy."

NATIONAL

Republic of Turkey National Climate Change Action Plan 2011–2023[231]

14.2.8. Within the scope of combating climate change, Turkey's main objective is to contribute to the global efforts in line with the sustainable development policies on the basis of common but differentiated responsibilities and within the framework of Turkey's special circumstances. These include

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[227] EBRD (2014). Environmental and Social Policy.
[228] The seven main GHGs defined by the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride. In combination, these GHG emissions are expressed in terms of carbon dioxide equivalents (CO_2e) according to their relative global warming potential.
[229] EBRD (2017). Protocol for Assessment of Greenhouse Gas Emissions.
[230] EBRD (2019). Green Economy Transition Handbook.
[231] Ministry of Environment and Urbanisation (2011). National Climate Change Action Plan 2011-2023.

strengthening the existing information structure on low carbon progress and developing financing models for the transition to a low carbon economy.

Turkey's National Climate Change Adaptation Strategy and Action Plan 2015[232]

14.2.9. The Strategy and Action Plan defines adaptation objectives and describes actions on five vulnerability fields: water resources management; agricultural sector and food security; ecosystem services, biodiversity and forestry; natural disaster risk management; and public health. Time periods, output and performance indicators, responsible or coordinating organisation, and other relevant organisations involved in the delivery of actions are also defined. Policies in relation to climate resilience include:

- Integrating adaptation to the impacts of climate change into water resource management policies;
- Ensure integration of adaptation to climate change into existing strategies, plans and legislation; and
- Strengthening existing systems and establishing new systems to monitor the effects of climate change.

GUIDANCE

14.2.10. The Climate Resilience assessment draws on the following guidance:

- European Commission non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient[233];
- IEMA EIA Guide to Climate Change Adaptation and Resilience[234];
- Climate Action Tracker: Scaling up Climate Action: Turkey[235]; and
- Design Manual for Roads and Bridges (DMRB): LA114 Climate[236].

14.3 GREENHOUSE GAS EMISSIONS

ASSESSMENT METHODOLOGY

Scope

14.3.1. This section details the methods that have been used to undertake the assessment of GHG emissions.

14.3.2. The sources of GHG emissions for the Project were identified following discussions with the Project Team and are presented in **Table 14-1**.

[232] Ministry of Environment and Urbanisation (2015). Turkey's National Climate Change Adaptation Strategy and Action Plan.
[233] EC (2011). Non-paper – Guidelines for Project Managers: Making vulnerable investments climate resilient.
[234] IEMA (2015). Climate Change Resilience and Adaptation.
[235] Climate action Tracker (2019). Climate Action Tracker: Scaling up Climate Action: Turkey.
[236] Highways England (2019). DMRB: LA 114 – Climate.

Table 14-1 – Potential Key Sources of GHG Emissions for the Project

Potential Emissions Source	Assessment Inclusion	Justification
Product stage (including raw material supply, transport and manufacture)	No	In line with PR3, these emissions have been excluded.
Construction processes (including transport and installation)	Yes	Activities of organisations conducting construction work, including fuel / energy consumption by delivery of materials, transportation of waste and construction plant emissions.
Maintenance / repair / replacement / refurbishment	No	The Project will require maintenance. However, this is not expected to result in significant emissions. As such, significant Repair, Replacement and Refurbishment emissions are not anticipated. The process of developing assumptions regarding this data source is highly uncertain, and the burden of developing these assumptions is not proportionate to the anticipated level of emissions. Therefore, the exclusion of this emissions source is considered appropriate, and does not affect the robustness of the assessment.
Electricity consumption	Yes	Expected to be a large source of emissions - which if excluded could materially alter the assessment.
Ventilation / air conditioning electricity consumption	No	Unlikely to be a large emissions source. Furthermore, this data is not available. The process of developing assumptions regarding this data source is highly uncertain, and the burden of developing these assumptions is not proportionate to the anticipated level of emissions.
Water consumption	No	Water consumption has a low emissions rate. It is not expected that large quantities of water will be used to operate the Project. As such this is not expected to be a significant source of emissions, and therefore will not materially alter the assessment.
Land use change	No	The land use change due to the Project is not expected to impact upon any large carbon sinks (areas of forestry, bogs etc). Therefore, the exclusion of this will not materially alter the assessment.
Modal shift (road and rail)	Yes	Expected to be a large source of emissions - which if excluded would materially alter the assessment.

Methodology

14.3.3. The assessment approach considers the likely magnitude of anticipated GHG emissions (or avoided emissions) due to the Project in comparison with the baseline scenario without the Project.

14.3.4. To estimate the GHG emissions as a result of transporting materials to site, the expected mass of materials has been multiplied by transport distance, resulting in tonne kilometres (a unit representing a tonne travelling one kilometre). The tonne kilometres have then been multiplied by an international GHG emissions factor sourced from the GHG Protocol[237].

14.3.5. The total energy and fuel consumption for the construction plant, such as the types of machinery to be used, is currently unknown, as the Contractor has not yet been appointed. Therefore, the construction plant GHG emissions have been estimated using a RICS (2017) emissions factor based on the total construction cost.

14.3.6. Emissions due to the modal shift from road to rail are based on the predicted usage of the railway for freight and by passengers. The end-user vehicle emissions were quantified by multiplying km travelled by an appropriate emissions factor based on published sources, adapted for the Project context. This calculation also includes estimated electricity consumption for traction power and an additional 10% to take into account non-traction related electricity. The figures are included in Appendix R.

14.3.7. The construction phase GHG emissions have been contextualised against the total national and manufacturing / construction emissions for Turkey and operational phase GHG emissions have been contextualised against the total national and transport emissions for Turkey.

Significance Criteria

14.3.8. There are currently no agreed thresholds for the level of GHG emissions that is considered to be significant in an ESIA. The significance of GHG emissions is assigned with reference to the magnitude of emissions, their context, guidance from IEMA and the use of professional judgement.

14.3.9. As climate change impacts are global in nature, it is not possible to link a specific project, with a specific environmental impact. As such, significance of GHG emissions have been put into context using regional emissions data for Turkey.

14.3.10. A breakdown of $KtCO_2$ emissions from the transport sector in Turkey, the manufacturing and construction sector in Turkey, and total national emissions for Turkey (2018) are presented in **Table 14-2** to **Table 14-4**.

[237] GHG Protocol (2015). Calculation Tools. Available at: https://ghgprotocol.org/calculation-tools#country_specific_tools_id (Accessed 27/07/20).

Table 14-2 - Turkey Total Emissions from Construction and Manufacturing 2018[238]

Greenhouse Gas Source	$KtCO_2$ Emissions
Manufacturing Industries and Construction	59,311.25

Table 14-3 - Turkey Transport Emissions 2018

Greenhouse Gas Source	$KtCO_2$ Emissions
Transport	82,787.84

Note: numbers may not add up due to rounding.

Table 14-4 - Turkey Total National Emissions 2018

Greenhouse Gas Source	$KtCO_2$ Emissions
Total National Emissions for Turkey (excluding Land Use, Land Use Change and Forestry (LULUCF))	520,900

14.3.11. IEMA guidance states that all GHG emissions are significant, however, in the context of the Project the following terms have been used to define the significance of the effects identified and apply to both beneficial and adverse effects:

- **Major effect**: where the Project could be expected to result in substantial improvement or deterioration for receptors;
- **Moderate effect**: where the Project could be expected to result in a noticeable improvement or deterioration for receptors;
- **Minor effect**: where the Project could be expected to result in a perceptible improvement or deterioration for receptors;
- **Negligible**: where no discernible improvement or deterioration is expected as a result of the Project for receptors; and
- **No change**: where no change is expected as a result of the Project for receptors.

Assumptions and Limitations

14.3.12. The following assumptions and limitations are applicable to this GHG emissions assessment:

[238] Turkish Statistical Institute (2020). Turkish Greenhouse Gas Inventory 1990-2018.

- The transport emissions assessment has been based on data provided by TCDD and AYGM. Bulk construction items (such as aggregate, concrete, steel, and plastic) have been included in the assessment of transport emissions where volume and type data were available.
- There is currently no specific guidance or GHG emissions threshold, which, if exceeded, is considered significant. Professional judgement and guidance from IEMA has been used to make this assessment.
- Embodied emissions have not been assessed however mitigation measures are described.
- For the purposes of this assessment the design life of the Project is assumed to be 30 years.
- The assessment of emissions from modal shift, including emissions from traction and non-traction electricity consumption and end-user traffic has been provided an independent specialist as part of the economic analysis of the Project.
- The assessment of modal shift is not based on a full traffic model. The raw data for emissions from modal shift is presented in Appendix R.
- The transportation of materials and waste to and from site (i.e. the source of materials and destination of waste) has been taken from RICS (2017) assumptions for transportation scenarios.
- This assessment does not consider changes to the mix of fuel type over time (i.e. an increase in electric vehicles on the road network) as forecast fuel consumption data for Turkey is not currently publicly available.

BASELINE CONDITIONS

14.3.13. In the baseline (Do Minimum) scenario, without the Project, GHG emissions occur constantly and widely as a result of human and natural activity including energy consumption (fuel, power), industrial processes, land use and land use change. The GHG assessment only considers instances in which the Project results in additional or avoided emissions in comparison to the baseline scenario and its assumed evolution.

Construction

14.3.14. Under baseline conditions, there would not be any emissions from construction, and therefore the construction baseline is zero emissions.

Operational

14.3.15. **Table 14-5** presents the 'Do Minimum' baseline scenario (without the Project) for the opening year of the Project (2026), the average annual emissions and total operational emissions based on a 30-year operational life of the Project (2026-2055).

Table 14-5 - Baseline Operational Emissions from Rail and End-user Traffic

Scenario	Total GHG emissions for rail and end-user vehicles (tCO_2e)		
	2026 (operational year)	**Average per year (2026-2055)**	**Total Lifespan (2026-2055)**
Baseline ('Do Minimum') (tCO_2e)	30,886	52,842	1,585,269

POTENTIAL IMPACTS AND EFFECTS

Construction Phase

14.3.16. The total estimated GHG emissions arising from the transport of materials to/away from site have been quantified as outlined in the Methodology section and are presented in **Table 14-6** and **Table 14-7**. The total GHG emissions arising from the transportation of materials to and from the site and plant use for the construction of the Project are estimated to be approximately 321,580 tCO_2e.

Table 14-6 - Estimated Transport Emissions

Material	Transport to Site (tCO_2e)	Transport away from Site (tCO_2e)	Total (tCO_2e)
Aggregate	67,941	7,700	75,641
Asphalt	578	-	578
Concrete	185,849	27	185,876
Steel	5,755	12	5,767
Plastic	4	-	4
Precast Concrete	11	-	11
Stone	2,848	-	2,848
Iron	3	-	3
Soil	617	38,155	38,772
Total	**263,606**	**45,894**	**309,500**

Table 14-7 - Estimated Plant Use Emissions

Item	Total (tCO_2e)
Plant Use	12,080

14.3.17. The total quantified GHG emissions arising from the construction stage of the Project are presented in **Table 14-8**. Emissions are presented for the construction stage (2021-2026) and placed into the context of Turkey's total national emissions and total emissions from manufacturing and construction.

Table 14-8 - Construction Phase Emissions Context

	Turkey Sector Emissions Construction Phase ($KtCO_2e$ over 6 years)	Project Emissions ($KtCO_2e$ over 6 years)	Percentage Relative to Emissions Sector
Total Project Emissions relative to Total National Emissions	3,125,400	322	(+0.01 %)
Total Project Emissions relative to Emissions from Manufacturing and Construction	59,311.25	322	(+0.54%)

14.3.18. Based on the results presented in **Table 14-8**, the magnitude of GHG emissions from transport of materials to/away from site and plant use for the Project is predicted to be **Moderate Adverse (Significant).**

Operational Phase

14.3.19. The 'Do Something' scenario, with the Project, may result in changes to emissions from traction electricity consumption and emissions from end-user traffic throughout its operational life relative to the 'Do Minimum' scenario. These changes could be increases or decreases depending on the net effect of factors including change in operational energy to power the rail and changes in traffic flows, speeds and vehicle types as a result of the Project.

14.3.20. As described in the methodology section, the calculations for the rail traction and end user traffic assessment were provided by an independent Economic Analyst (please refer to **Appendix A**). A quantitative assessment has been undertaken to estimate emissions from modal shift as presented in **Table 14-9** to **Table 14-11**.

Table 14-9 - Rail Traction Emissions

Scenario	Total GHG Emissions from Rail Traction (tCO_2e)		
	2026 (operational year)	**Average per year (2026-2055)**	**Total Lifespan (2026-2055)**
Baseline ('Do Minimum') (tCO_2e)	6,072	8,195	245,847
Project ('Do Something')	7,600	21,470	644,087
Difference	1,528	13,275	398,240

Table 14-10 - End-user Traffic Emissions

Scenario	Total GHG emissions from End-user Vehicles (tCO_2e)		
	2026 (operational year)	**Average per year (2026-2055)**	**Total Lifespan (2026-2055)**
Baseline ('Do Minimum') (tCO2e)	24,814	44,647	1,339,421
Project ('Do Something')	20,869	3,024	90,711
Difference	-3,946	-41,624	-1,248,711

Table 14-11 - Modal Shift

Scenario	Total GHG Emissions from Modal Shift (tCO_2e)		
	2026 (operational year)	**Average per year (2026-2055)**	**Total Lifespan (2026-2055)**
Baseline ('Do Minimum') (tCO_2e)	30,886	52,842	1,585,269
Project ('Do Something')	28,469	24,493	734,798
Difference	-2,418	-28,349	-850,471

14.3.21. **Table 14-11** demonstrates that there is an anticipated decrease in emissions in the 'Do Something' scenario relative to the 'Do Minimum' scenario, due modal shift (a reduction in vehicle kilometres travelled by road vehicles and increase in rail kilometres travelled).

14.3.22. The total estimated GHG emissions arising from the Operational Stage of the Project is presented in **Table 14-12**. Emissions are presented for the operational stage (2026-2055) and placed into the context of Turkey's total national emissions and Total emissions for transport.

Table 14-12 - Operational (Modal Shift) Emissions Context

	National Sector Annual Emissions ($KtCO_2e$/ year)	Average Operational Emissions per year ($KtCO_2e$/ year)	Percentage Relative to Emissions Sector
Average (per year) Operational Emissions relative to Total National Emissions	520,900	-28.35	(-0.01%)
Average (per year) Operational Emissions relative to Transport Emissions	82,787.84	-28.35	(-0.03%)

14.3.23. Based on the results presented in **Table 14-9** to **Table 14-11**, the magnitude of emissions from the operational phase is expected to be Moderate Beneficial (**Significant**).

Lifecycle

14.3.24. The total estimated GHG emissions arising from the Project are presented in **Table 14-13**. They are presented for the construction stage (2021-2026), the operational stage (2026-2055) and the overall total for the design life (2021-2055).

Table 14-13 - Total Emissions

Stage / Timing	Total GHG Emissions (tCO_2e)
Construction phase (2021-2026)	321,580
Operational phase traction emissions (2026-2055)	-850,471
Total for lifecycle (2021-2055)	**-528,891**

14.3.25. It should be noted that the magnitude of beneficial effects is related to the length of the Project lifespan (as well as the rate of decarbonisation of road transportation) – the longer the Project is operational, the larger the beneficial effect. The reference lifespan is likely to be in excess of 30 years as some Project elements have a lifespan of 100 years, as described in **Chapter 2: Description of the Project.**

MITIGATION AND ENHANCEMENT MEASURES

Construction

14.3.26. Mitigation and enhancement measures to address the potential construction significant effects identified above are set out below. These mitigation and enhancement measures are also set out in the **ESMP**.

- Design optimisation to reflect the carbon reduction hierarchy (detailed below and found in clause 6.1.4 of PAS:2080:2016):

- Reduce the elements required for the Project;
- Reduce the requirement for construction materials and excavation;
- Substitute construction elements for lower-carbon alternatives (e.g. specifying concrete with a higher portion of ground-granulated blast-furnace slag (GGBS) content which is widely available in Turkey); and
- Use efficient construction processes, such as design for manufacture and assembly.

- Specify materials and products with reduced embodied GHG emissions including through material substitution, recycled or secondary content and from renewable sources;
- Implement the **CESMP** as set out in the **ESMP**, which incorporates a **SWMP** and **MMP**;
- Minimise energy consumption including fuel usage by, for example, reducing the requirement for earth movements to/from and within the construction site;
- Maximise the local sourcing of materials and local waste management facilities;
- Designing, specifying and constructing the Project with a view to maximising the potential for reuse and recycling of materials/elements at the end-of-life stage; and
- Specifying high efficiency mechanical and electrical equipment.

Operation

14.3.27. It is estimated that the Project will lead to a reduction in GHG emissions during the operational phase, therefore operational mitigation is not required. However, to reduce emissions further the following mitigation measures are set out in the **ESMP**, and will be considered:

- Implement energy efficient lighting throughout the Project;
- Use energy meters to monitor energy requirements; and
- Implement efficient water fittings.

RESIDUAL EFFECTS

Whilst the application of the mitigation measures will reduce GHG emissions it will not alter the significance of effects, noting that IEMA guidance states that all GHG emissions are significant. Therefore, with the application of the above mitigation measures the residual effect of GHG emissions during the construction phase will remain **Moderate Adverse (Significant)** and remain **Moderate Beneficial (Significant)** during the operational phase.

14.4 CLIMATE RESILIENCE

ASSESSMENT METHODOLOGY

Scope

14.4.1. The climate variables identified in the baseline (set out **Paragraph 14.4.11** onwards) have a multitude of potential effects with the potential to impact the construction and operation phases. To identify the climate variables to scope in for further detailed risk assessment, a vulnerability assessment has been undertaken. The assessment of risk and vulnerability comprises of the following:

- Identification of climate variables to which the Project is vulnerable to during construction and operation, based on assessment of sensitivity and exposure;
- Identification of mitigation measures already incorporated into the Project design and construction plans;

- Assessment of impacts associated with climate variables the Project is vulnerable to, and identification of their significance; and
- Identification of additional mitigation measures to address any residual climate effects.

Methodology

14.4.2. Vulnerability of the Project to climate change depends on the sensitivity of the Project to a climate variable and exposure of the Project to change in that variable.

14.4.3. The sensitivity and exposure of each element of the Project (i.e. rail track, structures, drainage) to climate variables have been assessed using the following ratings scale:

- High: high climate sensitivity or exposure.
- Moderate: moderate climate sensitivity or exposure.
- Low: no significant climate sensitivity or exposure.

14.4.4. This is a qualitative assessment informed by supporting literature and expert opinion. The sensitivity and exposure ratings have been combined to determine vulnerability of the Project elements to climate variables, using the matrix shown in **Table 14-14**.

14.4.5. The outcome of this stage of the assessment is a list of climate variables for each Project element to take forward for further assessment. 'Low' vulnerabilities were not be considered further. 'High' and 'Moderate' vulnerabilities were assessed further.

Table 14-14 - Vulnerability Matrix

Sensitivity	Exposure		
	Low	**Medium**	**High**
Low	Low Vulnerability	Low Vulnerability	Low Vulnerability
Moderate	Low Vulnerability	Medium Vulnerability	Medium Vulnerability
High	Low Vulnerability	Medium Vulnerability	High Vulnerability

Significance Criteria

14.4.6. For each Project element, the significance of effects associated with the climate variables it is vulnerable to was assessed. This was carried out by considering the likelihood and consequence of potential impacts occurring, taking account of design or construction measures which mitigate the impacts. These design and construction measures were identified through consultation with the Project design team and review of project documentation.

14.4.7. The Project elements which were assessed are:

- Construction:
  - Construction compounds;
  - Materials;
  - Drainage;
  - Workforce;
  - Plant and equipment; and

- Workplace provisions, including worker accommodation.

- Operation:
  - Railway components (including track, sidings, fencing and overhead lines);
  - Structures (including bridges, overpasses, tunnels, underpasses and viaducts);
  - Existing infrastructure;
  - Drainage; and
  - Embankments and planting.

14.4.8. Likelihood and consequence were qualitatively assessed using the descriptions in **Table 14-15** and **Table 14-16**. These descriptions have been developed using experience, professional judgement and informed by relevant guidance[239].

Table 14-15 - Definitions of Likelihood

Measure of Likelihood	Description
Very high	The event occurs multiple times during the lifetime of the project, e.g., usually annually.
High	The event occurs several times during the lifetime of the project, e.g., approximately once every five years.
Medium	The event occurs limited times during the lifetime of the project, e.g., approximately once every 15 years.
Low	The event occurs occasionally during the lifetime of the project, e.g., once in 60 years.
Very low	The event may occur once during the lifetime of the project.

Table 14-16 - Definitions of Consequences

Measure of Consequence	Description
Negligible	No infrastructure damage, minimal adverse effects on health, safety and the environment. No rail/track closure. No financial loss.
Minor Adverse	Localised infrastructure disruption or loss of service. No permanent damage, minor restoration work required: rail/track closure lasting less than one day. Slight adverse health or environmental effects. Repairs cost 2% of rail/track reconstruction cost.

[239] Highways England (2019). DMRB: LA 114 – Climate.

Measure of Consequence	Description
Moderate Adverse	Limited infrastructure damage and loss of service with damage recoverable by maintenance or minor repair. Disruption lasting more than one but less than three days. Adverse effects on health and/or the environment. Repairs cost 25% of rail/track reconstruction cost.
Large Adverse	Extensive infrastructure damage and severe loss of service. Disruption lasting more than three but less than ten days. Early renewal of 50-90% of infrastructure. Permanent physical injuries and/or fatalities. Significant effect on the environment, requiring remediation. Repairs cost 50% of rail/track reconstruction cost.
Very Large Adverse	Permanent damage and complete loss of service. Disruption lasting more than ten days but less than 20 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 rail/track reconstruction cost.

14.4.9. The likelihood and consequence were combined to assess the significance of effects on receptors, as shown in **Table 14-17**. The assessment is qualitative and based on expert judgment and knowledge of similar projects. It also includes engagement with the wider Project Team and a review of Project documentation.

Table 14-17 - Significance Rating Matrix

Likelihood	Consequence of Hazard Occurring				
	Negligible	**Minor Adverse**	**Moderate Adverse**	**Large Adverse**	**Very Large Adverse**
Very High	Not Significant	Significant	Significant	Significant	Significant
High	Not Significant	Significant	Significant	Significant	Significant
Medium	Not Significant	Not Significant	Significant	Significant	Significant
Low	Not Significant	Not Significant	Not Significant	Significant	Significant
Very Low	Not Significant	Not Significant	Not Significant	Significant	Significant

Assumptions and Limitations

14.4.10. This following assumptions and limitations are applicable to this climate resilience assessment:

- There are inherent uncertainties associated with using climate projections and they are not predictions of the future. It is possible that future climate will differ from the assumed future baseline climate against which the resilience of the Project has been assessed, depending on the

extent of global emissions released into the atmosphere over the next century. A worst-case scenario has been used to assess the resilience of the high-speed railway over its lifetime.

- Data on projected climate has been taken from the World Bank Knowledge Climate Change Knowledge Portal which summarises output of the Coupled Model Intercomparison Project, Phase 5 (CMIP5) models included in the IPCC's Fifth Assessment Report (AR5). There are some climate variables which are not available from the World Bank Climate Change Knowledge Portal, including wind and fog, and as such, the assessment does not include detailed information on projections in these variables. However, these climate variables have still been appraised in the assessment but not presented in the projections.
- The assessment of effects and their likely significance takes into account design measures which mitigate impacts. These measures have been identified through engagement with the wider Project Team and a review of Project documentation. The assessment assumes that the measures which have been identified at this stage are incorporated into the final design and that the high-speed railway is designed in accordance with the relevant standards.

BASELINE CONDITIONS

Current Baseline

14.4.11. Information on the current climate of Turkey has been taken from the World Bank Climate Change Knowledge Portal[240]. Turkey is located between the mid-latitude and subtropical climate zones and experiences a number of climate variables due to its differing topographical characteristics. Baseline climate information for Çerkezköy is presented as representative of the climate of the expropriation corridor.

14.4.12. Çerkezköy is located in the Marmara region which experiences both a Mediterranean and humid subtropical climate. Summers are hot, humid and moderately dry whereas winters are cold and wet and sometimes snowy. The coastal climate keeps the temperatures relatively mild in comparison to the rest of the country.

Temperature

14.4.13. Average monthly temperatures in Çerkezköy are slightly warmer in comparison to the rest of Turkey as presented in **Figure 14-1**. The coldest month is January, with July and August being the warmest months.

[240] World Bank (2020). Climate Change Knowledge Portal. Available at: https://climateknowledgeportal.worldbank.org/ (Accessed 27/06/2020).

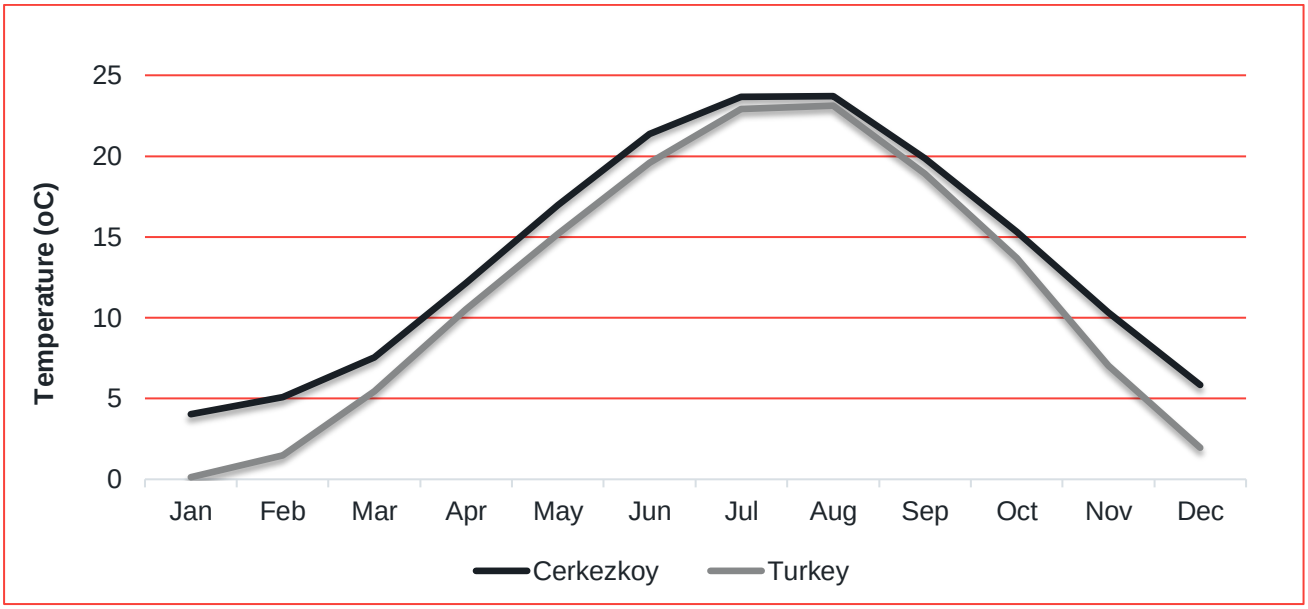


Figure 14-1 - Average Monthly Temperature for Çerkezköy and Turkey (1991-2016)

14.4.14. Temperature records spanning 1901-2016[240] indicate that there have been increases in the annual average temperature of Çerkezköy (Table 14-18), consistent with climate projections. **Table 14-18** shows that from 1991-2016, the average annual temperature in Çerkezköy has been approximately 0.7°C higher than the average for 1961-1990.

Table 14-18 - Çerkezköy Annual Average Temperature (1901-2016)

Year	Average Annual Temperature (°C)
1901-1930	12.9
1931-1960	13.06
1961-1990	13.1
1991-2016	13.8

14.4.15. In July 2017, record temperatures were experienced in Turkey with a heatwave generated from North Africa recording 37.2°C in Istanbul. This was the highest temperature recorded in Istanbul for 106 years[241].

[241] Dailysabah (2017) Record-breaking heat in last 106 years observed in Istanbul. Available at: https://www.dailysabah.com/istanbul/2017/07/02/record-breaking-heat-in-last-106-years-observed-in-istanbul-temperatures-will-soon-drop (Accessed 26/10/2020).

Precipitation

14.4.16. Precipitation records spanning 1901-2016[243] indicate that there have been increases in the annual average precipitation of Çerkezköy (shown in Table 14-19). Table 14-19 shows that from 1991-2016, the average annual precipitation in Çerkezköy has been approximately 1.2mm higher than the average for 1961-1990.

Table 14-19 - Çerkezköy Annual Average Precipitation from 1901-2016

Year	Average Annual Precipitation (mm)
1901-1930	46.4
1931-1960	48.3
1961-1990	48.2
1991-2016	49.4

14.4.17. Incidences of heavy rainfall and flooding have been reported by the Turkish General Directorate of Meteorology to be increasing in frequency. In 2019, 332 incidences of heavy rainfall and flooding occurred, the highest number annually recorded since 1940[242].

Wind

14.4.18. Wind speed data (which is being affected by the energy levels being affected by a warmer climate) is not available from the World Bank Climate Change Knowledge Portal, however, Meteoblue presents observed climate data from weather stations[243]. Data obtained from Tekirdag weather station is the closest to Çerkezköy (approximately 50km away). **Figure 14-2** presents the observed average monthly wind speed for Çerkezköy for 2019.

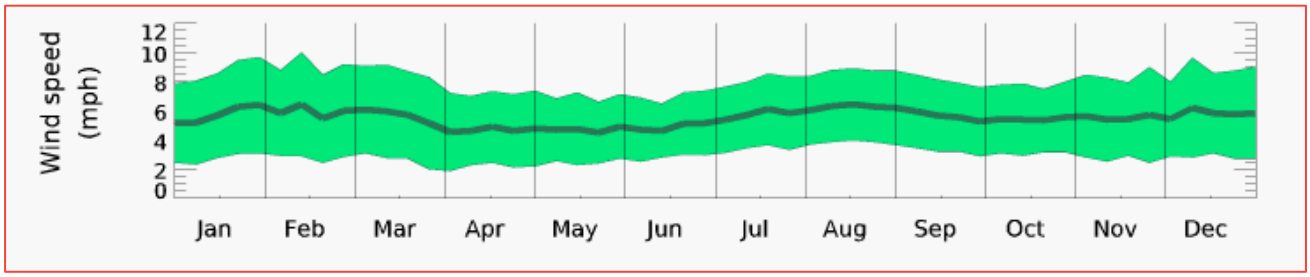


Figure 14-2 - Average Monthly Wind Speed (mph) for Çerkezköy for 2019[243]

[242] Dailysabah (2020) Turkey records highest number of weather disasters in 2019. Available at: https://www.dailysabah.com/turkey/turkey-records-highest-number-of-weather-disasters-in-2019/news (Accessed 26/10/2020).
[243] Meteoblue (2020). Climate observed Çerkezköy. Available at: https://www.meteoblue.com/en/weather/historyclimate/climateobserved/%c3%87erkezk%c3%b6y_turkey_749274 (Accessed 24/07/2020).

14.4.19. Turkey has experienced some severe wind events. In June 2020, Istanbul experienced a rare tornado and severe storm, killing one person and injuring several others[244]. In July 2017, a severe summer storm in Istanbul left people injured with strong winds toppling a large crane that landed on oil barrels at a port, causing an explosion and a fire[245].

Sea Level

14.4.20. Çerkezköy is located approximately 25km and 31km from the sea of Marmara and the Black Sea, respectively. Ispartakule, which will be on the Project alignment, is less than 10km from the coast of the sea of Marmara and 5km from Lake Küçükçekmece. The normal tidal range in the Marmara Sea is reported to be very small with a typical diurnal tidal range of 10-20cm[246].

14.4.21. Further baseline information relating to sea levels are presented in **Section 11.4** of **Chapter 11: Surface Water Environment**.

Future Baseline (Climate Projections)

14.4.22. Climate projections have been derived from the World Bank Climate Change Knowledge Portal[247]. As identified in Chapter 2, the design life of structures such as the rail track, platforms, footbridges and all ancillary structures is approximately 100 years, and it is assumed that maintenance would be required on a 15 to 40-year basis depending on the Project component. The World Bank Climate Change Knowledge Portal provides projections up until the period of 2080-2099 therefore these have been used to develop the baseline against which resilience has been assessed. Projections have been presented for Çerkezköy, which are considered to be representative for the expropriation corridor. Projections for a 'high emissions' scenario (Representative Concentration Pathway 8.5 (RCP8.5)[248] have been used to provide a 'worst case' scenario against which to assess the resilience of the Project, following the precautionary principle.

Temperature

14.4.23. The projected change in monthly temperature for Çerkezköy for 2080-2099 under RCP8.5, compared to the baseline of 1986-2005 is presented in **Figure 14-3** - . This shows an increase in temperature in the range of 3.3°C to 6°C for the 50% percentile 'central estimate' (taken as the median value of predicted change).

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[244] Dailysabah (2020) 1 killed as heavy rainfall, tornado batters Istanbul. Available at: https://www.dailysabah.com/turkey/istanbul/1-killed-as-heavy-rainfall-tornado-batters-istanbul?gallery_image=undefined#big (Accessed 26/10/2020).
[245] The Guardian (2017) Injuries as hailstones as large as golfballs sweep Istanbul. Available at: https://www.theguardian.com/world/2017/jul/27/people-injured-as-summer-storm-strikes-istanbul-turkey-floods (Accessed 26/10/2020).
[246] Küçükçekmece Lagoon Hydrodynamics and Sediment Transport: Choosing an Appropriate Model. Taner, Mehmet. Cem Şenduran, August 2007.
[247] World Bank (2020). Macedonia Climate Data – Projections.
[248] Representative Concentration Pathways specify the concentrations of greenhouse gases that would result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to preindustrial levels. Four forcing levels have been set: 2.6, 4.5, 6.0 and 8.5 W/m^2. These create four RCPs; RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5.

14.4.24. The projections for temperature rise are greatest in summer. During winter, air temperatures are also expected to increase, though with less intensity.

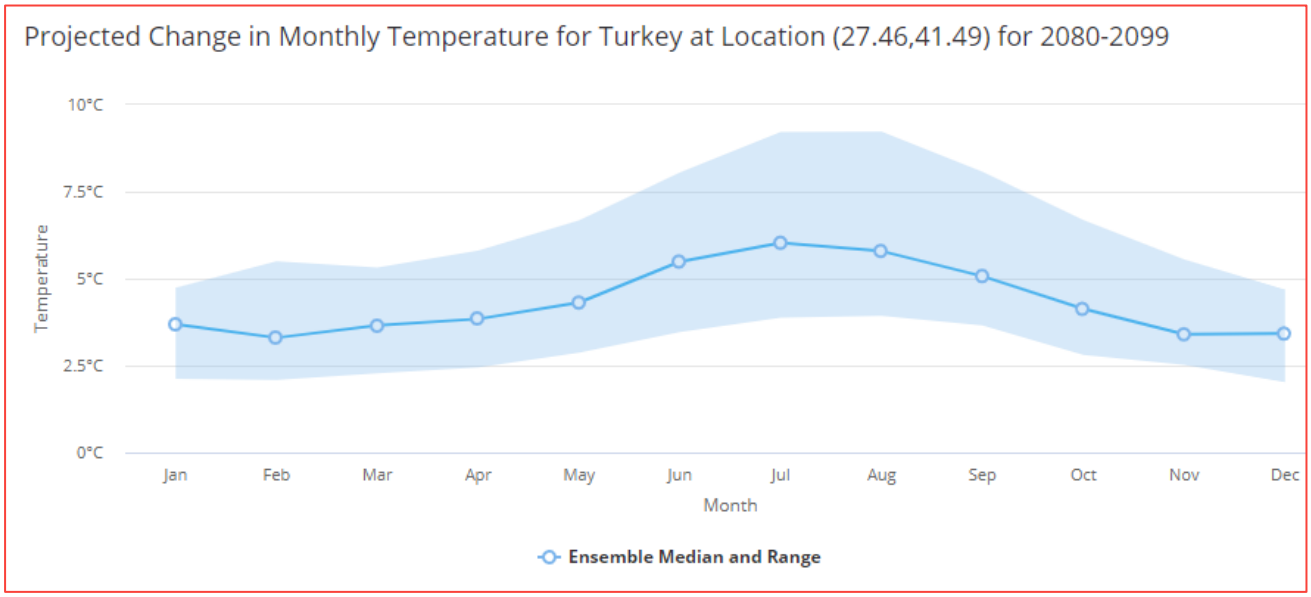


Figure 14-3 - Projected Change in Monthly Temperature of Çerkezköy in 2080-2099 Under RCP8.5 (compared to 1986-2005 baseline)

14.4.25. As well as an increase in average temperatures, projections indicate an increase in extreme temperatures (i.e. the temperature experienced during heatwaves). **Figure 14-4** shows the change in the warmest daily maximum temperature in each of four future time slices relative to the reference period (1986-2005) for Çerkezköy. **Figure 14-4** shows that the hottest day in the period 2080-2099 is projected to be 3°C degrees hotter than the hottest day in 1986-2005.

14.4.26. Periods of extreme temperature can increase the risk of fire outbreak, with high temperatures, low humidity and dry conditions conducive to fire weather[249]. With extreme temperature events likely in the project area, this poses a risk of fire to the Project.

[249] Jones et al., (2020) Climate Change Increases the Risk of Wildfires. Available at: https://tyndall.ac.uk/sites/default/files/wildfires_briefing_note.pdf (Accessed 26/10/2020).

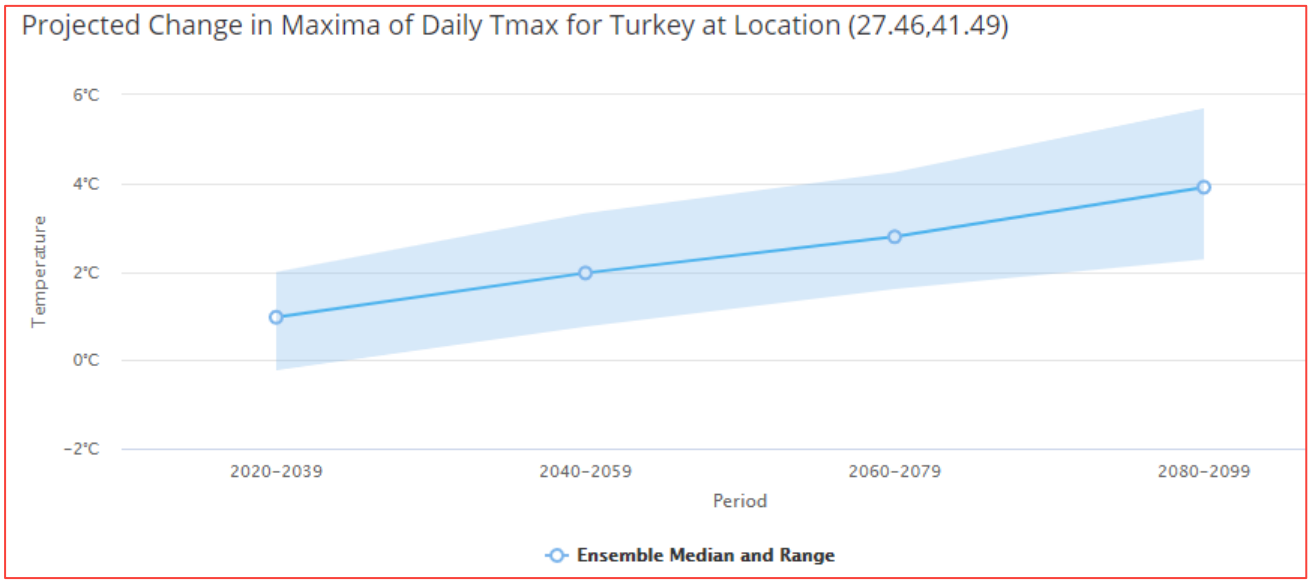


Figure 14-4 - Projected Change in Warmest Daily Maximum Temperature in 2080-2099 Under RCP8.5 (compared to 1986-2005 baseline)

Precipitation

14.4.27. A decrease in annual precipitation is predicted in Turkey for the period 2080-2099. Precipitation reductions are forecast for all four seasons, with the maximum decrease in November. The projected change in monthly precipitation for Çerkezköy for 2080-2099 under RCP8.5 compared to the baseline of 1986-2005 is presented in **Figure 14-5**. This shows a decrease in precipitation in the range of 3mm to 17mm (50th centile value).

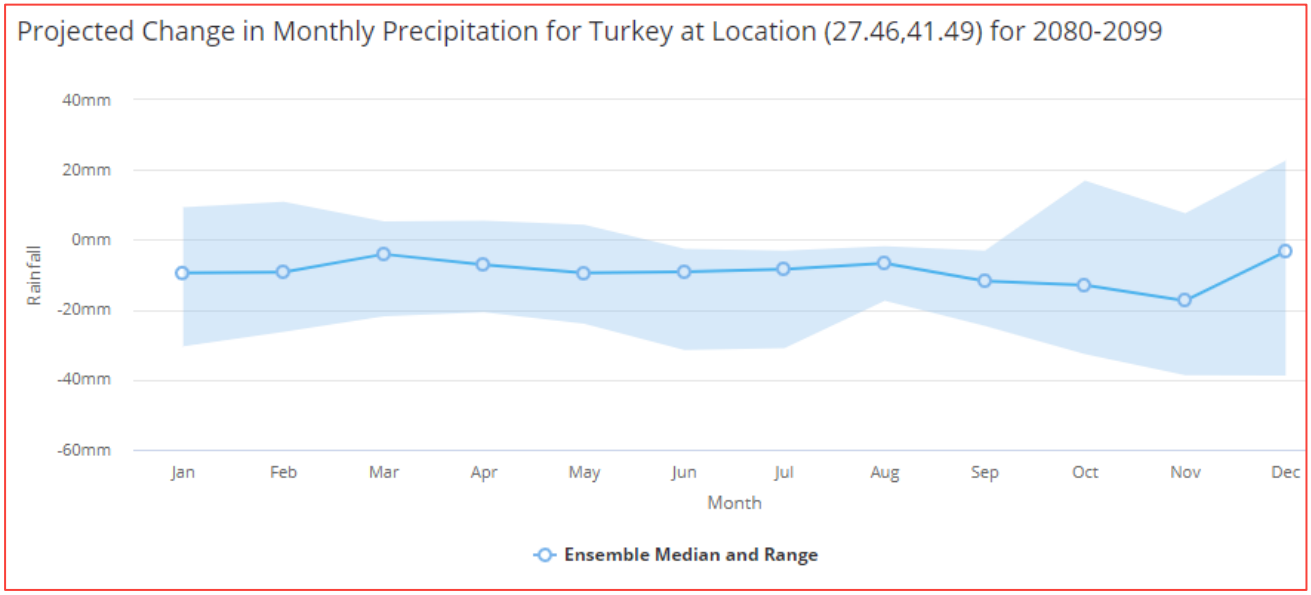


Figure 14-5 - Projected Change in Monthly Precipitation of Çerkezköy in 2080-2099 Under RCP8.5 (compared to 1986-2005 baseline)

14.4.28. In terms of extreme rainfall events, projections for Çerkezköy show little change in the amount of rainfall falling during intense rainfall events, as presented in Figure 14-6. This indicator captures how much of the precipitation sum in an area comes primarily from extreme rainfall events, as opposed to more evenly distributed events. The larger the number, the more the location is dominated by a few heavy rainfall events. Conversely, the smaller the number, the more evenly distributed is precipitation, and the largest rainfall events are not that exceptional overall. **Figure 14-6** shows that in the period 2080-2099, rainfall will be fairly evenly distributed in Çerkezköy.

14.4.29. Extreme rainfall events are a primary trigger of rapid-moving landslides[250]. As assessed in **Chapter 12: Geology and Hydrogeology** (**Section 12.5**), there is a potentially high risk of landslides during construction that will be managed though good practice measures in the **ESMP**. There will be a minor adverse operational effect associated with landslides, following the application of mitigation (**Section 12.5**). As the predictions for extreme rainfall are fairly evenly distributed in Çerkezköy, this is not expected to exacerbate the assessed risk of landslides.

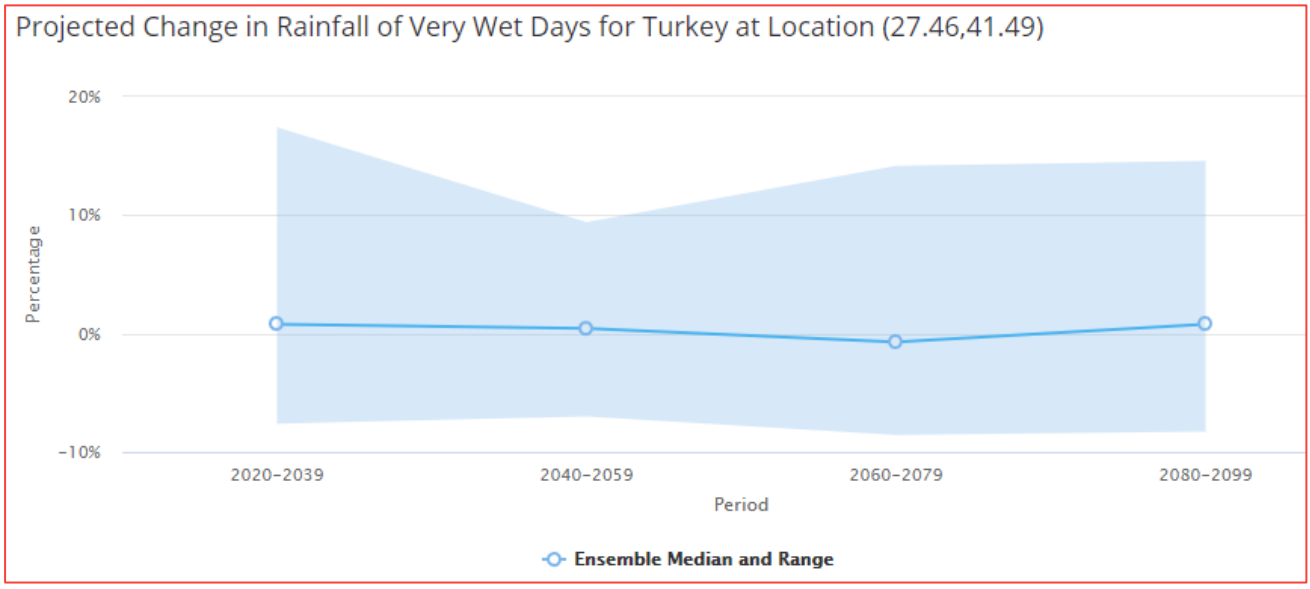


Figure 14-6 - Projected Change in Rainfall of Very Wet Days for Çerkezköy in 2080-2099 Under RCP8.5 (compared to 1986-2005 baseline)

Wind

14.4.30. There is low confidence in the accuracy of the results from existing models of future wind conditions under climate change. The area of Halkali to Çerkezköy is identified as having a 'Low' storm hazard

[250] Gariano, S.L and Guzzetti, F. (2016) Landslides in a changing climate. Earth Science Review, v 162, pages 227-252.

risk[251] however, studies have identified that changes in wind speeds in Turkey are most strongly related to changes in general circulation patterns and air temperatures[252].

Sea Level

14.4.31. Global mean sea level is projected to rise over the coming century. The Intergovernmental Panel on Climate Change (IPCC) global sea level rise projections for RCP8.5 relative to 1986-2005[253] levels are presented in **Table 14-20**. **Figure 14-7** presents the projected change in relative sea level for 2081-2100 for the Turkish coast under the lowest and highest emission scenarios (RCP2.6 and RCP8.5 respectively).

14.4.32. A review of available national data sources indicates a predicted sea level rise within the Istanbul area of between 45-75cm over the next 100 years depending on the modelled climate change scenario[254]. Further baseline information relating to future sea levels is presented in **Section 11.4** of **Chapter 11: Surface Water Environment**.

Table 14-20 - Global Sea Level Rise Projections

Time Period	Global Mean Sea Level Rise (mm/yr)	Global Mean Sea Level Rise Range (mm/yr)
2031-2050	0.20	0.15-0.26
2046-2065	0.32	0.23-0.40
2081-2100	0.71	0.51-0.92
2100	0.84	0.61-1.10

[251] Swiss Re (2020) CatNet – the online natural hazard atlas.
[252] Dadaser-Celik F.and Cengiz, E. (2013) Wind speed trends over Turkey from 1975 to 2006. International Journal of Climatology. V34, Issue 6, pages 1913-1927.
[253] Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari (2019). Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.
[254] Istanbul Climate Change Action Plan, Summary Report 2018, Istanbul Metropolitan Municipality.

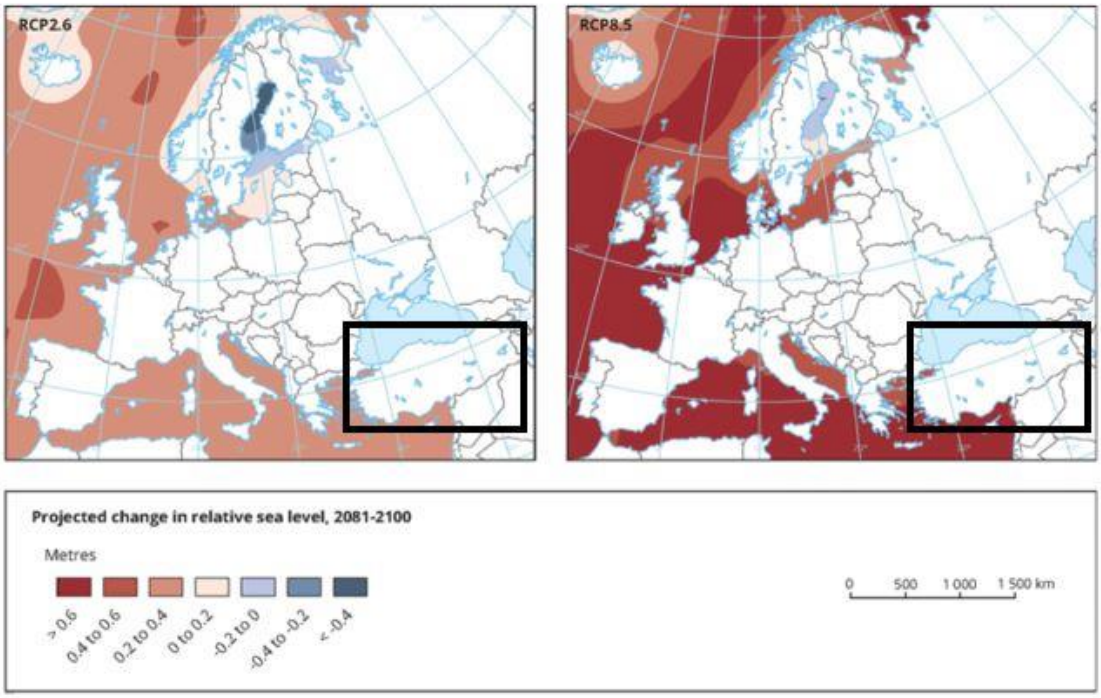


Figure 14-7 - Projected Change in Relative Sea Level, 2081-2100[255]

Inherent Mitigation Measures

14.4.33. The assessment of significance takes into account construction and design measures which mitigate climate impacts. The design measures have been identified through engagement with the Project Team and from the existing project information. It is appropriate to adopt a precautionary approach in future-proofing designs, so that the key assets will perform satisfactorily throughout their design life in the event of climactic changes towards the extreme predictions. These measures for the construction phase are summarised in **Table 14-21** and included in the **ESMP**. **Table 14-22** summarises the measures for the operation phase, which are included in the **ESMP**. Where project information is unavailable, certain best practice measures that would be expected in a project such as this have been assumed. This is set out in the final column of **Table 14-25**.

[255] European Environment Agency (2019). Global and European sea-level rise Available at: https://www.eea.europa.eu/data-and-maps/indicators/sea-level-rise-6/assessment (Accessed 13/07/20).

Table 14-21 - Construction Phase: Inherent Mitigation Measures

Project Element	Design Measures	Where Committed To
Construction Compounds	During construction activities, trucks will be covered when they carry excavation materials in order to prevent dispersion of dust. Construction walls will be provided in all locations where strong winds could cause the blowing of dust and debris. Spray / water unpaved surfaces which are exposed to winds and erosion, as often as necessary (several times a day) using watering trucks to ensure a high humidity level of the soil, thus minimizing dust. To prevent dusting during the construction works; the land and in-site roads will be regularly watered prior to works when needed.	**ESMP**
Materials	Ensure that materials stored in piles retain a high level of humidity by frequently spraying them during dry periods (approximately twice a day). Materials to be stored at the station storage units will be stored in separate areas by their contents, according to the applicable legislation. All long-term topsoil material stockpiles will be located outside the active construction site and away from drainage ditches.	**ESMP**
Drainage	River crossings, beds and banks will be restored to their original state, and banks and adjacent upland areas will be stabilised immediately after final grading; the watercourse crossings will be designed to avoid affecting the stability and long-term performance of riverbanks and flood defences. Not carry out landscaping or excavation work near watercourses during high water periods or during heavy rains. Drainage from higher areas will be diverted around stockpile areas to prevent erosion. As required, sediment controls will be installed downstream of stockpile areas to collect any run-off.	**ESMP**
Workforce	Drinking water for construction workers will be provided by bottled water to be purchased from private companies. The amount of water required for the construction will be calculated to ensure capacity is met.	**ESMP**
Plant and Equipment	Engines of all vehicles will be turned off when they are not in operation. The maintenance of construction vehicles will be carried out regularly, unnecessary use of the vehicles will be avoided.	**ESMP**
Workplace Provisions	The Contractor will ensure all dirt and debris are cleaned on sites without delay (approved by the Construction Supervision Officer). The Contractor will clean all public roads and surfaces immediately in the event of contamination / spillage caused by vehicles under the authority of the Contractor or subcontractors. Materials stored on site will be stored neatly and safely.	**ESMP**
Embankments and Planting	The Contractor will: ▪ Stabilise the soil in places where there is risk of erosion. ▪ Restore ditches damaged by machinery (damage to the gradient, shoulder construction of the embankments, etc.). Planting specifications and maintenance regimes for the public realm will be important in reducing the impact of long periods of drought and waterlogging on ground conditions. Planting plans to emphasise use of locally common native species - tolerant of local conditions, e.g. soil type, microclimate, habitat type, which would tend to be tolerant of the varying weather conditions, including drought, that may be experienced in the future.	**ESMP** and **BMP**

Table 14-22 - Operational Phase: Inherent Mitigation Measures

Project Element	Design Measures	Committed / Good Practice
Railway Components (including track, sidings, fencing and overhead lines)	Rail tracks will be designed to withstand temperature increases up to 6ºC from the baseline levels (average monthly temp around 14ºC, summer temperatures approx. 23ºC). Overhead railway lines to be designed for resilience to strong wind events, in compliance with the 'Infrastructure TSI'. Track circuits (for signalling) will work uneventfully and safely under climate conditions of the areas they will be installed and in temperatures ranging from -40°C to 70°C. The uninterrupted power supply will operate in the temperature range of 0-40°C. Technical buildings will have air conditioning systems to eliminate the effect of condensation due to temperature differences or very cold/hot air. A lightning rod line will be established along with the energy line that will be used by the railroad line.	**ESMP** **Technical Specification** (for signalling and telecommunication works and signalling systems)

Project Element	Design Measures	Committed / Good Practice
	The sub-ballast used for the layer of crushed stone material, will be able to resist loads from the ballast and transmit these loads to the subbase. Sub-ballast material will: ▪ Be permeable enough to transfer a significant part of the water from the line to the side ditches to prevent the subbase from becoming saturated and weakening under load; and ▪ Be built thick enough to resist freezing and thawing. Fencing will comprise galvanised steel wire and galvanised steel fence posts, installed on concrete foundations. Protecting fencing from deterioration through exposure to precipitation and winds by monitoring condition of the fencing following extreme weather events, is required in the **ESMP**.	
Structures (including bridges, overpasses, tunnels, underpasses and viaducts)	Rubber or PVC water trap tapes will be compatible for storage, preservation, installation in the temperature range from 0° C to 50° C. Pressure cells will be made up of corrosion-resistant stainless steel in order to remove temperature affects. Crackmeters[256] will be made up of corrosion-resistant material which will not be affected by temperature changes. Permanent and temporary loads that will be taken into account for designing the bored tunnels and cross passages will also include temperature and shrinkage. Materials will be selected to withstand temperature increases up to 6ºC from the baseline levels (average monthly temp around 14ºC, summer temperatures approx. 23ºC). Consideration of design foundation and ground movements in regard to their resilience to flooding or heavy rainfall events. Structures will be designed with wind loading factored into design life and materials.	**ESMP** **Technical Specification** (for general infrastructure requirements)
Existing Infrastructure	Materials will be selected to withstand temperature increases up to 6ºC from the baseline levels (average monthly temp around 14ºC, summer temperatures approx. 23ºC). Concrete Travers (B70 Reinforced Concrete) is the main building material to be used. This is resistant to humidity when necessary measures taken and is resistant to fire. Considering projections of increases in temperature up to 6ºC when specifying materials.	**ESMP** **Technical Specification** (for general infrastructure requirements)
Drainage	Drainage ditches will be the best quality without any casting defects and beads and showing no cracks or other faults and be in firm and homogenous condition Drainage infrastructure will include an allowance for climate change. The design of drainage will minimise the need for drain cleaning, the possibility of clogging and the consequent flooding of the track work subgrade. The drainage will be achieved by open ditches based on 50 year, and culverts based on 100-year rainfall intensities published by the State Meteorological Service. The drainage of all areas of depots and sidings will be such as to prevent pounding, flooding and consequent weakening of the supporting track structure. Access roads will be located at least 60m from surface watercourses, where practical. Drainage infrastructure will be inspected regularly to identify any deterioration, and additional inspections following extreme weather events and/or persistent high temperatures. Pipe materials will be able to withstand temperature changes and climate conditions.	**ESMP** **Technical Specification** (for general infrastructure requirements)
Maintenance and Safety Practices	Risk of fire: ▪ Vocal and visual warning systems will be established for a fire event that can occur at stations and rolling stock. ▪ Regular maintenance and controls of fire extinguishing equipment will be undertaken.	**Emergency Response Framework**

[256] To measure movement across joints.

Project Element	Design Measures	Committed / Good Practice
	▪ Necessary training will be given regarding correct usage of the equipment. Within the Project, regulations on preventing and tackling forest fires provisions will be adopted. Ensure that the railway tracks are regularly inspected and maintained. Ensure emergency response procedures are in place in the event that tracks buckle. Ensure that emergency response measures such as back-up power sources are in place in the event that overhead lines experience power loss. Ensure that the structures are regularly inspected and maintained.	

POTENTIAL IMPACTS AND EFFECTS

14.4.34. **Table 14-23** shows the assessment of the potential impacts associated with the climate vulnerabilities (set out in **Appendix S**) during the construction phase, taking into account the design measures identified in **Table 14-21**.

Table 14-23 - Construction Phase: Assessment of Climate Resilience Impacts and Effects

Project Element	Climate Variable	Potential Impact	Likelihood of Impact Occurring	Consequence of Effect	Significance of Effect
Construction Compound	Extreme Temperature	Drying out and cracking of ground and access road surfaces leading to slower vehicle movements and repair work, resulting in construction delays.	Medium	Minor Adverse	Not Significant
Materials	Average Temperature Extreme Temperature	Shorter drying times of materials.	High	Minor Adverse	Significant
	Extreme Temperature	Deformation and melting of materials.	Low	Moderate Adverse	Not Significant
Plant and Equipment	Average Temperature Extreme Temperature	Overheating of machinery leading to delay.	Low	Minor Adverse	Not Significant
Workforce	Average Temperature Extreme Temperature	Health and safety risks from heatstroke and UV radiation.	Low	Moderate Adverse	Not Significant
Workforce Provisions	Extreme Temperature	Buildings vulnerable to overheating, risk to users.	Medium	Moderate Adverse	Significant

14.4.35. Table 14-24 shows the assessment of the potential impacts associated with the climate vulnerabilities (set out in set out in Appendix S) during the operation, taking into account the design measures identified in Table 14-19.

Table 14-24 - Operational Phase: Assessment of Climate Resilience Impacts and Effects (taking into account design measures in Table 14-9, but not mitigation)

Project Element	Climate Variable	Potential Impact	Likelihood of Impact Occurring	Consequence of Effect	Significance of Effect
Railway Components (including	Drought	Prolonged dry periods may lead to drying out and cracking of earthworks and soils, increased repair costs and slower journey times.	Low	Moderate Adverse	Not Significant
		Increase in dust on the railway tracks leading to reduced visibility.	Medium	Minor Adverse	Not Significant

Project Element	Climate Variable	Potential Impact	Likelihood of Impact Occurring	Consequence of Effect	Significance of Effect
track, sidings, fencing and overhead lines)	Increase in average Temperature	More rapid deterioration of materials and associated infrastructure such as signage.	Low	Minor Adverse	Not Significant
		Deformation of tracks leading to increased repair costs and slower journey times.	Low	Moderate Adverse	Not Significant
	Extreme Temperature (heatwave)	Rail tracks buckling or deforming under extreme heat.	Low	Moderate Adverse	Not Significant
		More rapid deterioration of materials and associated infrastructure such as signage.	Low	Minor Adverse	Not Significant
		Occurrence of track fires.	Low	Moderate Adverse	Not Significant
	Wind (increase in wind events)	Destabilisation of overhead lines.	Low	Moderate Adverse	Not Significant
		Power loss of overhead lines.	Low	Moderate Adverse	Not Significant
	Sea Level	Flooding of railway tracks resulting in disruption to service.	Low	Moderate Adverse	Not Significant
Structures (including bridges, overpasses, tunnels, underpasses and viaducts)	Decrease in average Precipitation	Drying out and cracking of substrate leading to damage to foundations and destabilisation of structure.	Low	Moderate Adverse	Not Significant
	Drought	Drying out and cracking of substrate leading to damage to foundations and destabilisation of structure.	Low	Moderate Adverse	Not Significant
	Increase in average Temperature	Increase in expansion of materials leading to structural damage.	Low	Moderate Adverse	Not Significant
		Increase in earth pressure.	Low	Moderate Adverse	Not Significant
	Extreme Temperature	Increase in expansion of materials leading to structural damage.	Low	Moderate Adverse	Not Significant
		Increase in earth pressure.	Low	Moderate Adverse	Not Significant
		Melting/deformation of materials.	Low	Moderate Adverse	Not Significant
	Wind	Increase in wind loading leading to destabilisation or safety risks to users.	Low	Moderate Adverse	Not Significant
		Wind-driven rain infiltration into materials and surfaces which can increase maintenance costs and operational disruption.	Low	Minor Adverse	Not Significant
	Sea Level	Flooding of underpasses and tunnels.	Low	Moderate Adverse	Not Significant
		Scour of structures, weakening and degrading materials.	Low	Moderate Adverse	Not Significant
Drainage	Drought	Dust and debris clogging drainage channels and requiring clearing.	Low	Minor Adverse	Not Significant
	Wind	Windborne dust and debris clogging drainage channels and requiring clearing.	Low	Minor Adverse	Not Significant
	Sea Level	Drainage infrastructure overwhelmed leading to surface water flooding.	Low	Moderate Adverse	Not Significant
Embankments and Planting	Decrease in average Precipitation	Drying out of soils, death of vegetation due to lack of moisture, increased maintenance requirements.	Low	Minor Adverse	Not Significant
	Drought	Shrinking and cracking of soils.	Low	Moderate Adverse	Not Significant
	Increase in average Temperature	Drying out of soils, death of vegetation due to scorching.	Low	Moderate Adverse	Not Significant
	Extreme Temperature	Drying out of soils, death of vegetation due to scorching.	Low	Moderate Adverse	Not Significant

Project Element	Climate Variable	Potential Impact	Likelihood of Impact Occurring	Consequence of Effect	Significance of Effect
	Sea Level	Waterlogging and erosion leading to destabilisation.	Low	Moderate Adverse	Not Significant
		Death of planting due to waterlogging.	Low	Moderate Adverse	Not Significant

MITIGATION AND ENHANCEMENT MEASURES

14.4.36. Additional mitigation and enhancement measures to address the potential impacts leading to significant effects identified in **Table 14-23** and **Table 14-24** above are set out in **Table 14-25** below.

Table 14-25 - Mitigation and Enhancement Measures

Phase	Project Element	Climate Variable	Potential Impact	Mitigation / Enhancement Measures
Construction	Materials	Average temperature	Shorter drying times of materials.	Selection of construction materials which do not have rapid-drying properties (such as CEM 3 cement, which contains cement replacement, and this reduces the speed of set, compared to CEM 1 cement, which is 100% cement, and dries faster). Planning and consideration of temperature and material use during the construction process, such that in extreme temperatures, materials which may be susceptible to shorter drying times are used during cooler periods.
		Extreme temperature	Deformation and melting of materials.	
	Workforce Provisions	Extreme temperature	Buildings vulnerable to overheating, risk to users.	Ensure that buildings are equipped with cooling and ventilation systems, with the ability to cope with extreme temperatures.

RESIDUAL EFFECTS

14.4.37. Following the adoption of the climate resilience mitigation and enhancement measures identified in **Table 14-25** and the embedded mitigation outlined in **Table 14-21** and **Table 14-22**, there are considered to be Not Significant effects for climate resilience.

14.5 SUMMARY

Table 14-26 - Summary of Potential Impacts, Effects and Mitigation (Climate Change)

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
GHG	No GHG emissions as no construction activities would be undertaken.	Construction	GHG emissions are anticipated to occur due to construction of the Project.	Moderate Adverse (Significant)	As listed in Mitigation section.	Moderate Adverse (Significant)
	Baseline emissions would occur from the operation of the existing rail and end-user traffic.	Operation	Changes in GHG emissions are anticipated to occur due to modal shift (road to rail).	Moderate Beneficial (Significant)	As listed in Mitigation section.	Moderate Beneficial (Significant)
Climate Resilience	▪ Increase in average temperature. ▪ Increase in extreme temperatures. ▪ Decrease in annual precipitation. ▪ Little change in extreme precipitation events. ▪ Increase in wind speed ▪ Sea level rise.	Construction	Drying out and cracking of ground and access road surfaces leading to slower vehicle movements and repair work, resulting in construction delays.	Not Significant Adverse	Inherent mitigation measures (Table 14-21). Additional mitigation measures (Table 14-25).	Not Significant Adverse (all potential effects)
			Shorter drying times of materials.	Significant Adverse		
			Deformation and melting of materials.	Not Significant Adverse		
			Overheating of machinery leading to delay.	Not Significant Adverse		
			Health and safety risks from heatstroke and UV radiation.	Not Significant Adverse		
			Buildings vulnerable to overheating, risk to users.	Significant Adverse		
		Operation	Drought: Prolonged dry periods may lead to drying out and cracking of earthworks and soils, increased repair costs and slower journey times.	Not Significant Adverse	Inherent mitigation measures (Table 14-22). Additional mitigation measures (Table 14-25).	Not Significant Adverse (all potential effects)
			Drought: Increase in dust on the railway tracks leading to reduced visibility.	Not Significant Adverse		
			Increase in Average Temperature: More rapid deterioration of materials and associated infrastructure such as signage.	Not Significant Adverse		
			Increase in Average Temperature: Deformation of tracks leading to increased repair costs and slower journey times.	Not Significant Adverse		
			Extreme Temperature (heatwave): Rail tracks buckling or deforming under extreme heat.	Significant Adverse		

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
			Extreme Temperature (heatwave): More rapid deterioration of materials and associated infrastructure such as signage.	Not Significant Adverse		
			Extreme Temperature (heatwave): Occurrence of track fires.	Not Significant Adverse		
			Wind: Destabilisation of overhead lines.	Not Significant Adverse		
			Wind: Power loss of overhead lines.	Significant Adverse		
			Sea Level: Flooding of railway tracks resulting in disruption to service.	Not Significant Adverse		
			Decrease in Average Precipitation: Drying out and cracking of substrate leading to damage to foundations and destabilisation of structure.	Significant Adverse		
			Drought: Drying out and cracking of substrate then damaging foundations and destabilisation of structure.	Significant Adverse		
			Average Temperature: Increase in expansion of materials leading to structural damage.	Not Significant Adverse		
			Average Temperature: Increase in earth pressure.	Not Significant Adverse		
			Extreme Temperature: Increase in expansion of materials leading to structural damage.	Significant Adverse		
			Extreme Temperature: Increase in earth pressure.	Not Significant Adverse		
			Extreme Temperature: Melting/deformation of materials.	Not Significant Adverse		
			Wind: Increase in wind loading leading to destabilisation or safety risks to users.	Not Significant Adverse		
			Wind: Wind-driven rain infiltration into materials and surfaces which can increase maintenance costs and operational disruption.	Not Significant Adverse		
			Sea Level: Flooding of underpasses and tunnels.	Not Significant Adverse		
			Sea Level: Scour of structures, weakening and degrading materials.	Not Significant Adverse		
			Average Precipitation: Drying out of soils and cracking of materials.	Not Significant Adverse		

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
			Drought: Drying out of soils and cracking of materials.	Not Significant Adverse		
			Dust and debris clogging drainage channels and requiring clearing.	Not Significant Adverse		
			Dust and debris clogging drainage channels and requiring clearing.	Not Significant Adverse		
			Windborne dust and debris clogging drainage channels and requiring clearing.	Not Significant Adverse		
			Drainage infrastructure overwhelmed leading to surface water flooding.	Not Significant Adverse		
			Drying out of soils, death of vegetation due to lack of moisture, increased maintenance requirements.	Not Significant Adverse		
			Shrinking and cracking of soils.	Not Significant Adverse		
			Average Temperature: Drying out of soils, death of vegetation due to scorching.	Not Significant Adverse		
			Extreme Temperature: Drying out of soils, death of vegetation due to scorching.	Not Significant Adverse		
			Waterlogging and erosion leading to destabilisation.	Not Significant Adverse		
			Death of planting due to waterlogging.	Not Significant Adverse		