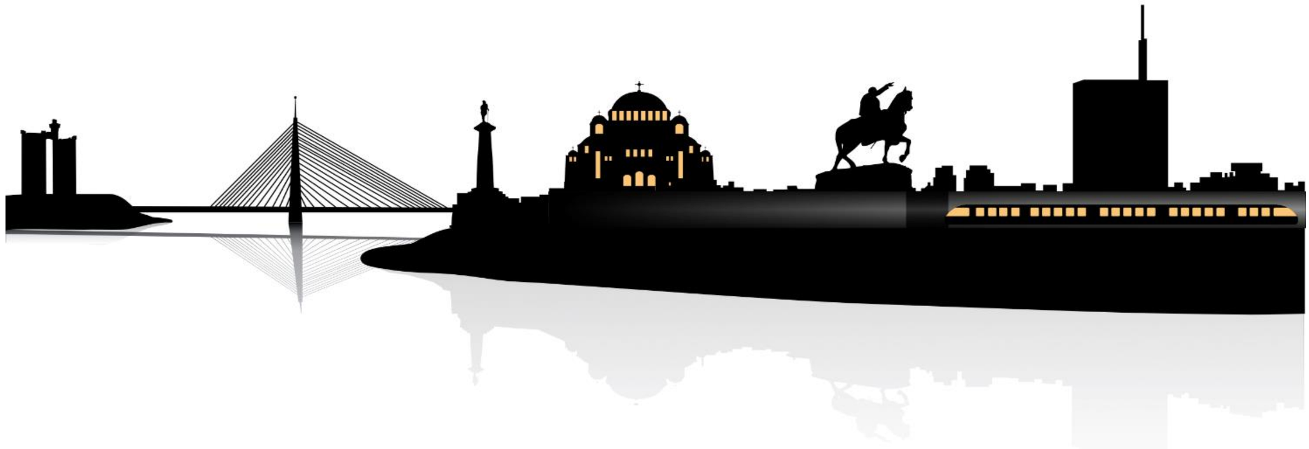
Belgrade Metro Network

Phase 1 Line 1

Climate Change Risk Assessment



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	Prepared by	Reviewed by	Approved by
Name	Yves ENNESSER Camille ESCHENBRENNER Giorgia D'ERRICO	Rémy LAGACHE	François DIGONNET
Position	CCRA & ESIA Specialists	ESIA Leader	Project Director
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Acronyms

BMV	Beogradski Metro i Voz
CoB	City of Belgrade
CRRA	Climate Change Risk Assessment
EP	Equator Principles
EEA	European Environment Agency
EHS	Environmental Health and Safety
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
ESMS	Environmental and Social Management System
EU	European Union
GHG	Greenhouse Gases
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
MDB	Multilateral Development Bank
NCC	National Climate Commitments
OECD	Organization for Economic Cooperation and Development
PS	Performance Standard
RS	Republic of Serbia
SEA	Strategic Environmental Assessment
TBM	Tunnel Boring Machine
TCFD	Task Force on Climate-Related Financial Disclosures
QHSE	Quality, Health, Safety and Environment
WHO	World Health Organization

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1 OBJECTIVES OF THE STUDY

This document is an annex to the ESIA report for the L1P1 Belgrade Metro Project (see project description in the ESIA report). It presents the climate change risk assessment (CRRA) for the Project. The document includes considerations for impacts and risks to the project from climate change-related effects.

The assessment was undertaken in alignment with the applicable Project standards, which includes the Equator Principles (EP) (EP Assoc., 2020) requirements. A summary of applicable Project standards are presented below:

- Guidance Note on Climate Change Risk Assessment. Equator Principles. Ramboll, May 2023.
- Equator Principles (EP) IV (EP Assoc., 2020);
- Organization for Economic Cooperation and Development Recommendation of the Council on Common Approaches for Officially Supported Export Credits and Environmental and Social Due Diligence (OECD Common Approaches) (OECD, 2022);
- International Finance Corporation (IFC) Performance Standards (PSs) on Environmental and Social Sustainability (IFC, 2012);
- World Bank Group General Environmental Health and Safety Guidelines (General EHS Guidelines) (IFC, 2007);
- Other relevant sector-specific World Bank Group Environmental, Health and Safety Guidelines (World Bank, 2007b).

This assessment is conducted to align with the IFC PS1 and EP IV (Principle 2, Annex A) standards. It is developed according to the Guidance Note on Climate Change Risk Assessment released in May 2023 available at https://equator-principles.com/app/uploads/Guidance-CCRA_May-2023.pdf, which replaces the earlier EPA Guidance Note on Climate Change Risk Assessment (September 2020, available at https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf).

This document aims to fulfil the following objectives:

- Identify how the Project aligns with national and international climate goals, including the Paris Agreement;
- Identify the potential effects of Climate Change on or from the project;
- Describe how the design phase of the Project considers potential effects of climate change on the Project;
- Outline the required mitigation plans either in place or which need to be developed prior to construction.

This study will be broken down as follows:

- Climate Change Legislation;
- CCRA Applicability;
- Phase 1 - Preliminary NCC Compatibility Review;
- Phase 2 - Physical Climate Risks screening, assessment and management.

2 CLIMATE CHANGE LEGISLATION

2.1 International Treaties and Conventions

Serbia is signatory to a number of international agreements. The following table provides a summary of those that are considered relevant to this study in respect of climate change and GHG emission reduction.

Table 1: Summary of International Agreements Relevant to the Project (Source: Egis)

Agreement	Date (Ratified)	Summary
United Nations Framework Convention on Climate Change (UNFCCC) (1992)	12th March 2001	UNFCCC is the main convention addressing the impacts and causes of climate change and aimed at returning global temperatures to a level which will not cause irreversible significant harm to ecosystem functioning.
The Kyoto Protocol (1997)	19th October 2007	Established to protect wildlife and ecosystems.
Paris Climate Agreement (2015)	25th July 2017	Aims to conduct research and prevent/reverse desertification of natural habitats.

2.2 Serbian Climate Change Legislation and Policy

The Serbian Law on Climate Changes ("Official Gazette of RS", No. 26/2021) regulates the system for limiting greenhouse gas emissions and for adaptation to changed climatic conditions, monitoring and reporting on the strategy of low-carbon development and its improvement, adoption of the strategy of low-carbon development, etc.

By adopting the Law on Climate Change ("Official Gazette of RS", No. 26/2021), the Republic of Serbia has established one of the main components of the institutional and legal framework necessary to combat climate change, which is the establishment of a system for reducing greenhouse gas emissions. The law in question, among other things, envisages the adoption of the Low Carbon Development Strategy of the Republic of Serbia with an Action Plan within two years (with a validity of ten years from the entry into force of this regulation). With its adoption, Serbia is moving towards fulfilling its obligations to the international community, ie the UN Framework Convention on Climate Change (UNCCC) and the Paris Agreement.

3 CCRA APPLICABILITY

3.1 CCRA Implementation Requirements Under EP4

As outlined in EP4 (EP Assoc., 2020), a CCRA is required:

- For all Category A and, as appropriate, Category B Projects, and will include consideration of relevant physical risks as defined by the TCFD.
- For all Projects, in all locations, when combined Scope 1 and Scope 2 Emissions are expected to be more than 100,000 tonnes of CO2 equivalent annually. Consideration must be given to relevant Climate Transition Risks (as defined by the TCFD) and an alternatives analysis completed which evaluates lower GHG intensive alternatives.

The two boxes here below include a reminder of the definition of Projectc Categorisation and of the Scopes for GHG emissions.

Box 2-1: Project Categorisation

EPFI's environmental and social due diligence should be proportionate to the categorised level of environmental and social risks and impacts, including those related to climate change of the Project in review. Such categorisation is based on the IFC environmental and social categorisation process, which divides Projects into the following three categories:

Category A: Projects with potential significant adverse environmental and social risks and/or impacts that are diverse, irreversible or unprecedented

Category B: Projects with potential limited adverse environmental and social risks and/or impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures

Category C: Projects with minimal or no adverse environmental and social risks and/or impacts.

It is highly recommended that the susceptibility of projects to physical climate change risks is considered as part of the categorisation process.

Figure 1: Projectc Categorisation (Source: https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf)

Box 2-2: Greenhouse Gas Quantification and Reporting

The **GHG Protocol** provides guidance for accounting and reporting of seven greenhouse gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF3)). The emissions of each GHG type are calculated separately and then converted into **CO_2 equivalents** ($CO_{2\text{-eq}}$) based on their global warming potential.

The GHG Protocol categorises GHG emissions into the following three broad scopes:

Scope 1: Direct GHG emissions from owned or controlled sources, i.e. fuel combustion and fugitive emissions;

Scope 2: Indirect GHG emissions from the use of purchased electricity, heat or steam; and

Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

Figure 2: GHG Quantification and Reporting (Source: https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf)

	Transition Climate Change Risk Assessment Thresholds Requirements	
Project Categorization	Project's Scope 1 and Scope 2 GHG emissions are expected to exceed 100kpta CO2-eq	Project's Scope 1 and Scope 2 GHG emissions are expected to be **less than** 100kpta CO2-eq
Category A	GHG Emissions Assessment Physical CCRA Transition CCRA GHG Alternative Analysis	GHG Emissions Assessment Physical CCRA
Category B	GHG Emissions Assessment Physical CCRA Transition CCRA GHG Alternative Analysis	GHG Emissions Assessment Physical CCRA

Table 2: Transition Climate Change Risk Assessment Thresholds Requirements (Source: https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf)

The project has been considered as Category A under EP4 (EP Assoc., 2020) and IFC PS (IFC, 2012) and as such, a CCRA is required under EP4. Furthermore, EP4 requires physical risks are required to be assessed in the CCRA. Physical risks are those resulting from climate change and can be event driven (acute) or longer-term shifts (chronic) in climate patterns.

Based on the GHG emissions calculations performed for the ESIA studies conducted for the Project, referring to the L1P1 Metro operation, the threshold of 100,000 tonnes of CO_2 equivalent annually is not exceeded and therefore Climate Transition Risks not considered further. As such, only physical risks are considered in this assessment.

4 PRELIMINARY NCC COMPATIBILITY REVIEW

4.1 COMPATIBILITY WITH NATIONAL CLIMATE COMMITMENTS

In line with EP4 Annex A, the CCRA should *take "into consideration"* the Project "*compatibility"* with the NCC of the host country. For countries that are party to the 2015 Paris Agreement, the NCC therefore link to commitments made under the agreement, as well as any other nationally developed commitments. Where Projects are located in a country that is not party to the Paris Agreement, and where other NCCs are not available, EPFIs may nonetheless wish to assess the Project for compatibility with the general sectoral objectives set in line with the Paris Agreement.

Box 2-3: Paris Agreement

The **Paris Agreement** is a binding international treaty on climate change adopted in 2015 at the twenty-first Conference of the Parties (COP 21) in Paris. 196 Parties adopted the treaty with the goal to limit global warming to well below 2°C, preferably to 1.5 °C, compared to pre-industrial levels, as well as building climate resilience to adapt to the increased impacts of climate change.

Implementation of the Paris Agreement requires economic and social transformation. In a five-year cycle, each Party is required to submit their increasingly ambitious **national climate commitments.**

Paris Alignment refers, amongst other aspects, to the alignment of public and private financial flows with the goals of the Paris Agreement to strengthen the global response to the threat of climate change. Article 2.1c of the Paris Agreement establishes that financial flows must be consistent with a pathway to low GHG emissions and climate resilient development.

Figure 3: Paris Agreement (Source : https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf)

Box 2-4: National Climate Commitments

Since 2015, countries that are parties to the Paris Agreement are required to submit a national climate action plan known as **Nationally Determined Contribution** (NDC). Countries are also invited to submit **Long-term Strategies** (LTS) towards a low-carbon economy, although these are not mandatory.

NDCs submitted under the Paris Agreement, are the main channel for countries to publicly state their self-defined ambitions in setting long-term decarbonisation targets to keep global temperature rise below 1.5 degrees and to set goals on enhancing climate resilience.

Each country that has ratified the Agreement must submit their NDCs to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat every five years. These must represent a progression compared to the previous NDC and reflect its highest possible ambition.

LTS set long-term deadlines, or concrete timeframes and is a central component of national climate planning.

NDCs and LTSs include targets, measures and policies and are the basis for national climate action plans, programmes and policies.

Figure 4: National Climate Commitments (Source : https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf)

Within this guidance, compatibility against the NCC is assessed by categorising Projects as 'Aligned', 'Not Aligned' or 'Conditional', as shown in the Figure here below.

Aligned: Project is aligned and contributes to decarbonisation	**Aligned:** Project does not undermine rapid decarbonisation	**Conditional:** Project neither clearly undermines nor contributes to decarbonisation	**Not aligned:** Project undermines rapid decarbonisation

Figure 5: Levels of alignment with national and international climate goals (Source : https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf)

The L1P1 Belgrade Metro project is aligned with the NCC, as it contributes to the decarbonisation of the transport system in Belgrade.

Through the preliminary NCC compatibility review, Projects are also categorised as 'Aligned', 'Not Aligned' or 'Conditional' (refer to the above Figure) based on their inclusion in the 'universally aligned' or 'universally not aligned' lists (https://www.eib.org/attachments/documents/cop26-mdb-paris-alignment-note-en.pdf), as described in the following sections.

4.2 Activities Considered Universally NOT Aligned with the Paris Agreement's Mitigation Goals

According to the current version of the BB1 and BB2 Technical Note drafted in November 2021 by the Joint MDB Assessment Framework for Paris Alignment for Direct Investment Operations (https://www.eib.org/attachments/documents/cop26-mdb-paris-alignment-note-en.pdf), the MDBs consider four activity types to be universally not aligned with the Paris goals:

- Mining of thermal coal;
- Electricity generation from coal;
- Extraction of peat; and
- Electricity generation from peat.

The L1P1 Belgrade Metro project does NOT fall under the above mentioned categories.

4.3 Activities Considered Universally Aligned with the Paris Agreement's Mitigation Goals

According to the current version of the BB1 and BB2 Technical Note drafted in November 2021 by the Joint MDB Assessment Framework for Paris Alignment for Direct Investment Operations (https://www.eib.org/attachments/documents/cop26-mdb-paris-alignment-note-en.pdf), the MDBs consider the following activity types to be universally aligned with the Paris goals:

Table 3: Activities Universally Aligned with the Paris Agreement's Goals
(Source: https://www.eib.org/attachments/documents/cop26-mdb-paris-alignment-note-en.pdf)

Sector	Eligible operation type	Conditions and guidance
Energy	Generation of renewable energy (e.g., from wind, solar, wave power, etc.) with negligible lifecycle GHG emissions.	Includes generation of heat or cooling
	Rehabilitation and desilting of existing hydropower plants, including maintenance of the catchment area (for example, a forest management plan)	Rehabilitation includes work on the water holding capacity of the dam and work on pipes/turbines to increase productivity and bring additional grid stabilization benefits, and for pumped storage
	District heating or cooling systems with negligible lifecycle GHG emissions	Using significant renewable energy or waste heat or cogenerated heat OR Including: a) Modification to lower temperature delta b) Advanced pilot systems (control and energy management, etc.)

	Electricity transmission and distribution, including energy access, energy storage, and demand-side management	
	Cleaner cooking technologies	Cleaner cooking technologies substitute the use of traditional solid biomass fuels in open fires; they include sustainable biomass or electric cookstoves
Manufacturing	Non-energy-intensive industry (excludes chemicals, iron and steel, cement, pulp and paper, and aluminum)	Consider the nature of the product produced (carbon content, lifetime, ability to be reused/recycled)
	Manufacture of electric vehicles; non-motorized vehicles, electric locomotives; non-motorized rolling stock	
	Manufacture of components for renewable energy or energy efficiency	
Agriculture, forestry, land use and fisheries	Afforestation, reforestation, sustainable forest management, forest conservation, soil health improvement	With the exception of operations that expand or promote expansion into areas of high carbon stocks or high biodiversity areas
	Low-GHG agriculture, climate-smart agriculture	With the exception of operations that expand and promote expansion into areas of high carbon stocks or high biodiversity areas and taking into account (international) transport
	Conservation of natural habitats and ecosystems	With the exception of operations that expand or promote expansion into areas of high carbon stocks or high biodiversity areas
	Fishing and aquaculture	
	Non-ruminant livestock with negligible lifecycle GHG emissions	
	Flood management and protection, coastal protection, urban drainage	
Waste	Separate waste collection (in preparation for reuse and recycling), composting and anaerobic digestion of biowaste, material recovery, and landfill gas recovery from closed landfills	
Water supply and wastewater	Water supply systems (e.g., expansion, rehabilitation); water quality improvement; water efficiency (e.g., non-revenue water reduction, efficient process in industries); drought management; water management at watershed level	Desalination plants need to go through specific assessment
	Gravity-based or renewable energy-powered irrigation systems	
	Wastewater treatment (domestic or industrial), including treatment and collection of sewage, sludge treatment (e.g., digestion, dewatering, drying, storage), wastewater reuse technology, resource recovery technologies (e.g., biogas into biofuel, phosphorus recovery, sludge as agriculture input, sludge as co-combustion material)	

Transport	Electric and non-motorized urban mobility	
	Roads with low traffic volumes providing access to communities which currently do not have all-weather access (for example, connecting farmers to markets or providing access to a rural school, hospital, or better social benefits)	Except if there is any risk of contributing to deforestation
	Electric passenger or freight transport	
	Short sea shipping of passengers and freight ships	
	Inland waterways passenger and freight transport vessels	
	Port infrastructure (maritime and inland waterways)	
	Rail infrastructure	
	Road upgrading, rehabilitation, reconstruction, and maintenance without capacity expansion	
Buildings and public Installations	Buildings (education, healthcare, housing, offices, retail, etc.)	Needs to meet green building certification criteria as established by each individual MDB[1]
	LED street lighting	
	Parks and open public spaces	Excluding energy- consuming installations[2]
Information and communications technology (ICT) and digital technologies	Information and communication, excluding data centers	
Research, development and innovation	Professional, scientific, research and development (R&D), and technical activities	
Services	Public administration and compulsory social security	
	Education (excluding infrastructure/buildings)	
	Human health and social work activities (excluding infrastructure/buildings)	
	Social protection, cash transfer schemes	
	Arts, entertainment and recreation (excluding infrastructure/buildings)	
Cross-sectoral activities	Conversion to electricity of applications that currently use fossil fuels	

The L1P1 Belgrade Metro project falls under the category “Electric passenger or freight transport”.

[1] MDBs are working on the approach to assess the Paris alignment of buildings and the role of certification schemes. This approach can also take into account the impact of materials on the alignment of buildings with the low-carbon pathways envisioned by the Paris Agreement.
[2] Energy-consuming installations are those beyond lighting and routine maintenance such as watering. Examples are major built- up area (i.e., buildings) or energy-intensive installations (e.g., fountains or playground and recreational equipment that need a non-renewable power source).

Operation types included in the above table will have to go through the specific criteria assessment if they fall under any of the following:

- Operations whose economic feasibility depends on external fossil fuel exploitation, processing, and transport activities (e.g., a railway line that will have a significant income from the transport of coal from a coal mine).
- Operations whose economic feasibility depends on existing fossil fuel subsidies (e.g., a fishing fleet that would be unfeasible in the absence of subsidies to diesel fuel).
- Operations that rely significantly on the direct utilization of fossil fuels (e.g., a pharmaceutical production plant that makes use of diesel pumps).

The L1P1 Belgrade Metro project does NOT fall under the above mentioned criteria.

5 PHYSICAL CLIMATE RISKS

5.1 METHODOLOGICAL FRAMEWORK AND TERMINOLOGY

The term “physical risk” refers to risks to the Project arising from the hazard-exposure-vulnerability concept, as defined by IPCC. Physical risk to the Project is defined as:

Physical Risk = hazard * exposure * vulnerability

The following table shows the definitions of hazard, exposure and ulnerability as set out by the CCRA Guidance Note (https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf), as per IPCC AR6.

Table 4: Definitions related to Physical Climate Risk (Source: https://equator-principles.com/app/uploads/CCRA_Guidance_Note_Sept2020.pdf)

Hazard	The potential occurrence of a natural or human-induced physical event or trend, that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision and environmental resources.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. For example, a community exposed to a drought hazard would have increased vulnerability if it lacked the capacity to bring in water resources from elsewhere or to adapt to reduced water availability.

In compliance with the EP IV guidance on CCRA, the terms “risk” and “impact” are defined as follows: “Climate-related risk refers to the potential negative impacts of climate change on a Project”.

Therefore, impact refers to the consequences of realized risks. Impacts may be considered as consequences or outcomes and can be adverse or beneficial. Impact analysis is based on already available data (observations). Impact analysis is therefore often based on statistical approaches.

Risk is the potential for adverse consequences. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. In more general terms, risk refers to the combination of the probability of an event (e.g. climate hazard) and its consequences. Risks analysis is therefore a probabilistic approach. Risk is what we must protect ourselves against. Therefore, depending on the level of climate risk, adaptation options may be necessary.

The TCFD Recommendations state that ‘Physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns.’

- Acute physical climate risks can include increased severity and frequency of droughts, storms, floods, heat waves and wildfires.

- Chronic physical climate risks can include sea level rise, longer-term temperature/precipitation/wind increase/decrease.

According to the TCFD, the physical climate related scenarios are relevant for organizations exposed to acute or chronic climate change, such as those with:

- Long-lived, fixed assets;
- Locations or operations in climate-sensitive regions (e.g., coastal and flood zones);
- Reliance on availability of water; and
- Value chains exposed to the above.

Being a linear infrastructure developed over the wide area of the city of Belgrade, the L1P1 Belgrade Metro project can be considered as a "long-lived, fixed assets".

According to EP IV Annex A, the depth and nature of the CCRA depend on the type of Project, as well as the nature and severity of the risks. Materiality of risks should form an essential part of the CCRA process. For the purposes of the EP IV guidance on CCRA, a climate-related risk is material for the Project, and requires to be considered within the CCRA, if there are associated significant financial risks or if it poses impacts in terms of either: the risk that climate change may have on the financial performance of the Project; the climate-related impacts to society and the environment posed by the Project in terms of GHG emissions and any incompatibilities with the NCC (i.e. Impact Materiality).

5.2 Identification of Climate Hazards

This first step of the study focuses on the identification of climatic events (climate hazards) that could impact the study area. This is done through an inventory of intense climate events in the project area during the 1995-2014 period . The mains source of information is "Climate change adaptation action plan and vulnerability assessment, City of Belgrade Secretariat for Environmental Protection, 2015". Other sources are mentioned in Chapter 5.4.4. of the ESIA.

5.2.1 Heat waves

According to data of the Republic Hydrometeorological Service of Serbia, there were several heat waves on the territory of Belgrade in the 1995-2014 period, specifically:

- The heat wave of the summer of 2013: The mean, maximum and minimum air temperatures exceeded the multi-annual average; it was an extended heat wave – high temperatures (above 39°C) for more than 6 consecutive days, with 52 "tropical" days and 27 "tropical" nights (minimum air temperature exceeding 20°C); the heat wave was accompanied by extreme lack of precipitation (over 25% relative to the normal). The whole territory of Belgrade was affected.
- The heat wave of August 2012: Extended heat wave with high temperatures (above 39°C) for more than 6 consecutive days; 62 "tropical" days and 52 "tropical" nights (minimum air temperature exceeding 20°C); mean summer temperature 4.9°C higher than the average for 1960–1991. The whole territory of Belgrade was affected.
- High temperatures (above 40°C) in July and August 2009.

- The heat wave of July 2007: Extreme temperatures for more than 22 consecutive days; absolute maximum ever recorded in Belgrade (43.6°C); mean summer temperature between 4 and 5°C higher than the average for 1960–1991. The whole territory of Belgrade was affected.
- The heat wave of June/July 2006: 12 "tropical" days and 9 "tropical" nights in June (8 days and 8 nights above the 1961–1990 average); 21 "tropical" days and 12 "tropical" nights In July (12 days and 9 nights above the 1961–1990 average), only 35% of the average amount of precipitation. The whole territory of Belgrade was affected.
- The heat wave of June 2003: 18 "tropical" days and 12 "tropical" nights; only 37% of the average amount of precipitation.

5.2.2 Extreme cold

According the Republic Hydrometeorological Service of Serbia data, there were several cases of extreme cold on the territory of Belgrade in the 1995-2014 period, specifically:

- The extreme cold of the winter of 2012, with extremely low temperatures (average daily ambient temperature from 30 January to 11 February ranged from -6.6°C to -12°C), 17 consecutive ice days (from 29 January to 14 February), followed by high snowfall (52cm).
- The extreme cold of the winter of 2008/2009 with 20 consecutive ice days (from 26 December to 14 January).
- The extreme cold of the winter of 2007/2008 with 15 consecutive ice days (from 19 December to January 2).
- The extreme cold of the winter of 1998, with 14 frost days in March (8 days above the 1961–1990 average), 12 ice days in December (7 days above the 1961–1990 average), 18 days with snow cover (7 days above the 1961–1990 average).

5.2.3 Droughts

There were several droughts on the territory of Belgrade in the 1995-2014 period, specifically:

- The drought of the summer of 2012: lack of rainfall from late June to the end of August; extreme heat over a prolonged period of time (above 35°C).
- The drought of August 2000: lack of rainfall, only 15% of the average amount of precipitation (7.8 mm).

5.2.4 Heavy precipitation and floods

There were several heavy precipitation and flooding events on the territory of Belgrade in the 1995-2014 period, specifically:

- The flood of May 2014: the catastrophic floods were caused by heavy rainfall in Western and Central Serbia (more than 200 mm of rain in a week, i.e. the equivalent of 3 months' rain under normal conditions). This resulted in the rapid and substantial increase of water levels of the main rivers that partly cross the territory of Belgrade (Sava, Tamnava, Kolubara), and the discharge of groundwater to surface streams. The floods have had a devastating effect:
  - widespread flooding in urban and rural areas, particularly in the City Municipality of Obrenovac.;
  - 51 fatalities, of which 23 by drowning (not all of them in Belgrade);
  - 25,000 people were evacuated from Obrenovac, of which 5,000 required temporary shelters in camps established in Belgrade;

  - 114 individual houses were completely destroyed and more than 3,000 damaged;
  - significant infrastructure damage in Obrenovac (bridges, roads, embankments)
- The floods of April 2006: flooding was caused by the melting of snow and heavy rainfalls in the Danube, Sava, Velika Morava and Tisa river basins in December 2005 and March 2006 (rainfall in Belgrade in March was 104 mm; in April 97 mm). This resulted in the rapid rise of the Danube and Sava river water levels (at the maximum rate of 1 cm per hour).
  - The Danube water levels exceeded the historical maximum (783 cm in Zemun) and the Danube spilled over its banks in the City Municipalities of Zemun and Novi Beograd, and in the suburban area of Veliko Selo;
  - The Sava spilled over its banks in urban areas (New Belgrade wharf; Sajam; Kula Nebojša – Kalemegdan; City Municipality of Čukarica; Ostružnica);
- The extreme precipitations of 2001 (April, June and September): extreme rainfall was recorded for April (157.9 mm) and September (183.7 mm), with 17 wet days in June.
- The extreme precipitations of July 1999: extreme rainfall was recorded for July (265 mm).

5.2.5 Storms

The intensity and frequency of storms on the territory of Belgrade is increasing. Storms have been occurring frequently in summer during the 2010-2014 period. This has had a particularly damaging impact on the transport infrastructure, and on the green infrastructure, downing trees and branches. The electricity network, water supply and sewerage systems also sustained damage.

5.2.6 Conclusion

Extreme weather events frequently affected Belgrade in the last decades and caused serious and sometimes disastrous consequences.

Heat waves in the summer seriously affected the entire administrative territory of Belgrade, (most severely in densely populated urban structures – urban core), due to the shortage of vegetation combined with the proliferation of tarmac and concrete surfaces and reduced air ventilation. The most affected areas of Belgrade include the central municipalities of Stari Grad, Savski Venac and Vračar, and the densely populated areas of Novi Beograd, Zemun, Voždovac and Čukarica.

The droughts were somewhat less frequent and intense compared to heat waves, but also had consequences for the entire administrative territory of Belgrade.

However, the intensity and severity of floods rose. The most vulnerable parts of Belgrade are the flood prone areas near the Sava river (Obrenovac, including Ostružnica and Barič, the Lazarevac municipality, embankments of the Sava River in the Belgrade inner city, particularly the lower plateaus in the Stari Grad municipality from Sajam to the Sava-Danube estuary and Ada Ciganlija), the Danube (Zemun, Pančevacki Rit and Veliko Selo) and lower areas of the municipalities of Savski Venac and Čukarica. These areas are below the maximum elevation of the Sava and Danube and are at risk of flooding. They are protected by embankments, but in some places these are old and not sufficiently high. On the administrative territory of Belgrade there are about 160 small torrential streams, which pose a threat of flooding to populated areas, with short–term but highly dangerous effects. The small watersheds of the Topčider and Barič River, Kumodraž Stream and other, are particularly vulnerable to floods and stormwater.

5.3 Exposure of the Metro Line Project to the Climate Hazards

Exposure is analyzed based on the the mapping of the climatic hazards for the city of Begrade, as presented in the report on "Climate change adaptation action plan and vulnerability assessment, City of Belgrade Secretariat for Environmental Protection, 2015". The following map and its zoom on the project area shows the exposure of the Line 1 Project to the main climatic hazards identified in Belgrade.

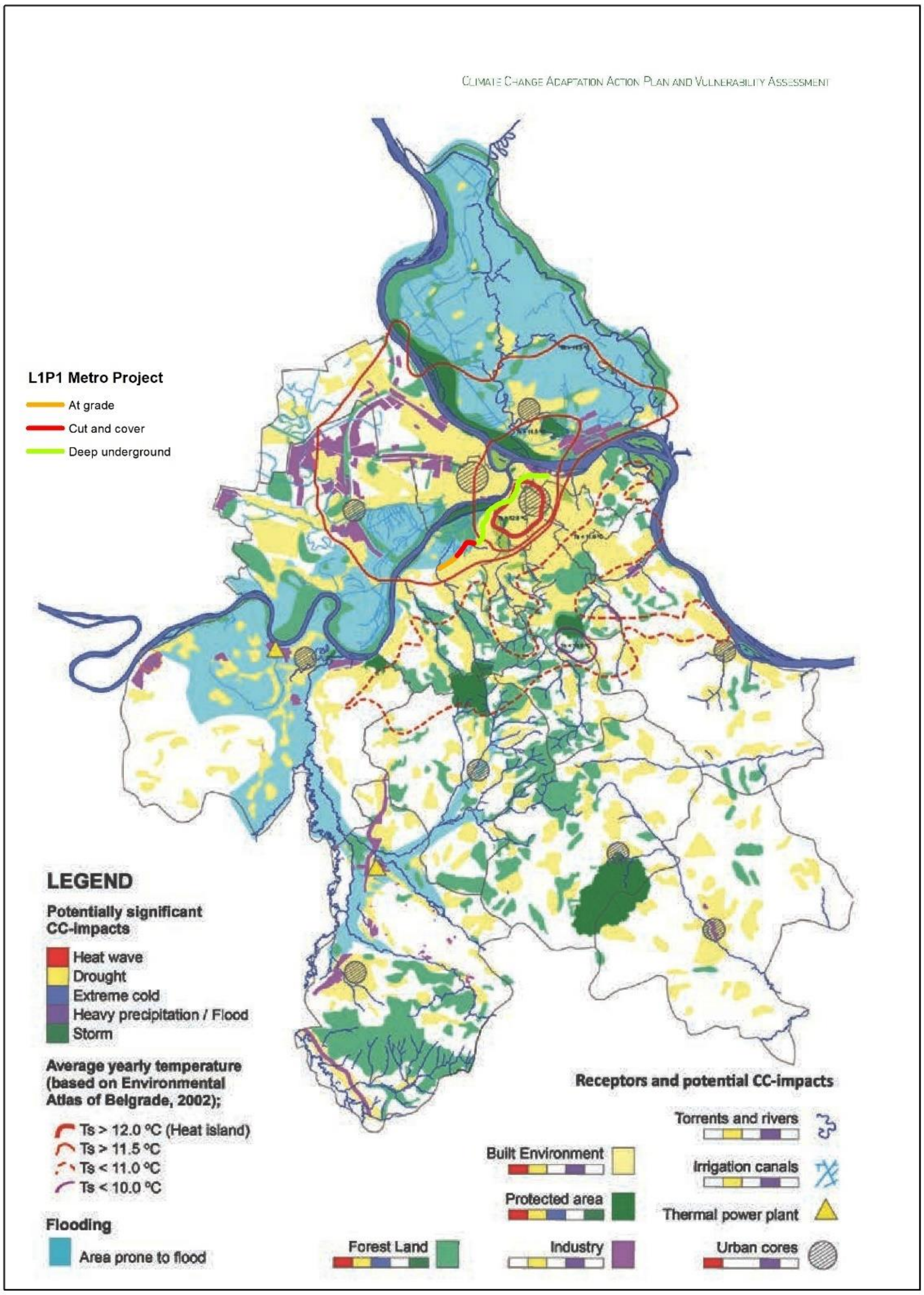


Figure 6: Spatial distribution of potential climate hazards in Belgrade and exposure of the L1P1 project

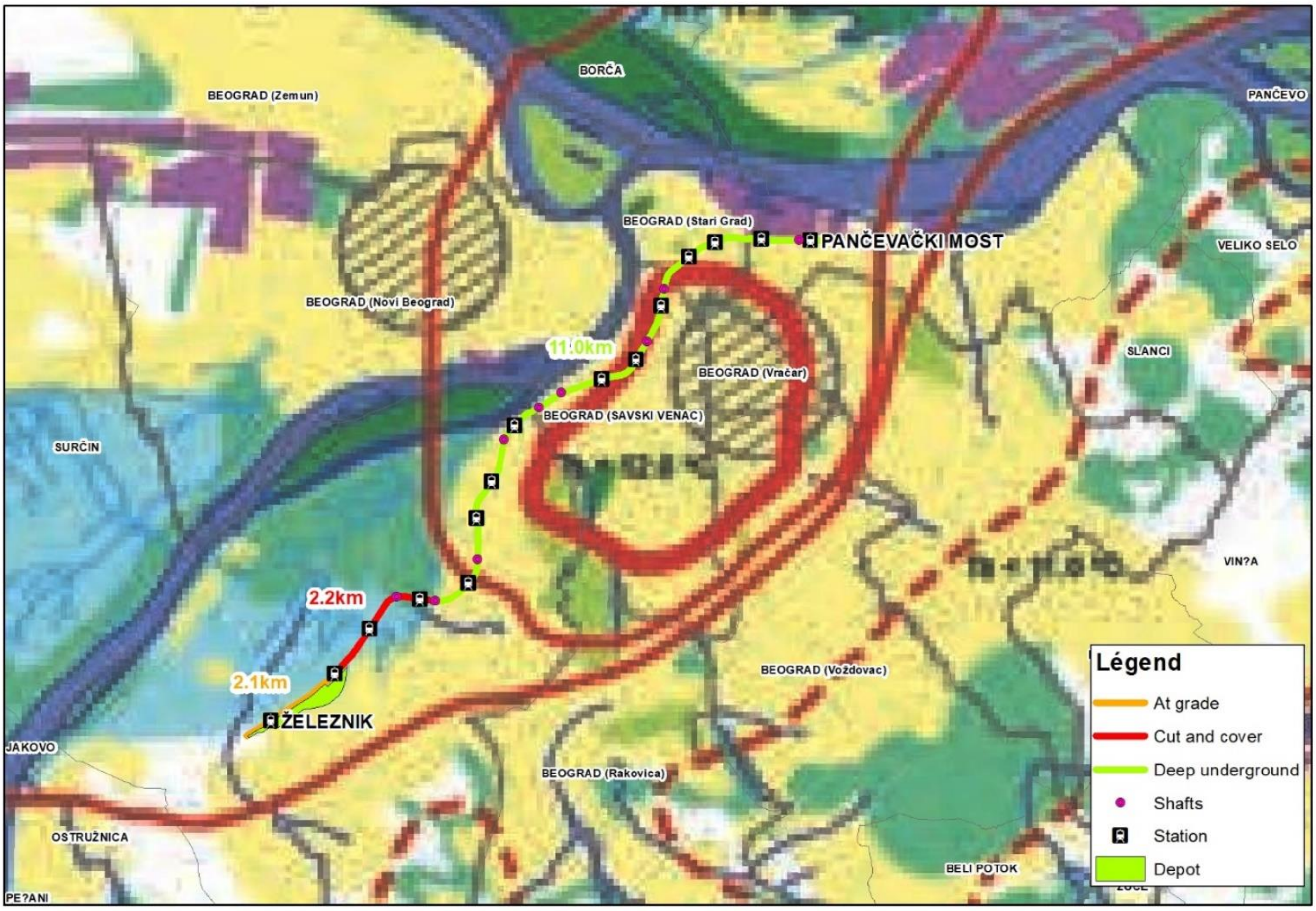


Figure 7: Zoom on the L1P1 metro project

Along the Line 1 Phase 1 Metro corridor, the following climate hazards are identified (from North to South):

- Danube River flooding from Pancevacki Most station to Dunav station (in the long run);
- Strong urban heat island area from Ada Ciganlija station to Savski Trg station;
- Sava River flooding for the cut and cover and at grade sections of the project.

Flood hazards in the current situation are specified in Chapter 5.5.1. of the ESIA.

5.4 Analysis of the Physical Vulnerabilities of the Metro Line Project

5.4.1 Methodological Approach

Vulnerability is a function of sensitivity to climate hazards, and adaptive capacity. The objective is therefore to identify, for each component of the project, what its physical sensitivities are. Then, the adaptive capacity is assessed.

An analysis of the physical sensitivity of each component of the project to the identified hazards is carried out. The potential impacts of each hazard are specified. This analysis is performed through bibliographical analysis and Egis experts' feedback. Each component is assessed and classified according to its degree of sensitivity for each climate hazard, from Low (no significant impact) to High (high impacts). It should be noted that this rating is not site specific (as it is based on the intrinsic sensitivity of each component, it is relevant whatever the level of exposure).

The adaptive capacity is assessed through an analysis of the socioeconomic background of the country. Adaptation dimensions such as knowledge and awareness, technology, infrastructure, institutions, and economic resources are usually considered to assess the adaptive capacity.

5.4.2 Analysis of the Physical Sensitivity of the Project Components

Introduction

The aim of the present chapter is to answer the following questions:

- Which project components are susceptible to damage when exposed to climatic hazards?
- What kind of damage/impact can be expected?

The main bibliographical references used for this analysisi are mentionned below:

- Egis & Résallience (2022). Enhancing DRM for Hanoi Metro Line 5. Task 1 Report: Vulnerability Assessment.
- NetworkRail (2020). NW&C Region Weather Resilience and Climate Change Adaptation Plan – Version 2 – May 2020.
- SYSTRA (2017). High Speed and Intercity Natural Risks. International Union of Railways – UIC.
- Federal Transit Administration (2011). Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation. FTA, Office of Budget and Policy. FTA Report No. 0001

The physical sensitivities are analyzed below according to the category of project components, for the climatic hazards identified in Chapter 5.2.

Heat waves

Table 5: Main sensitive metro components to heat waves

Components	Type of impact	Impact mechanisms	Sensitivity rating
Track	Rail buckling	Rails expand as they warm up; they also absorb heat and in the bright Summer sun they can reach temperatures far in excess of air temperatures. Both Continuous Welded Rail (CWR) and jointed track can buckle as a result of the expansion. As a buckle normally occurs whilst a train is passing over the site there is a risk of derailment Rail buckling more often affect track with rock ballast than concrete slab track with a paved right-of-way, as the concrete slab provides stronger support.	Moderate with concrete slab track
Buildings	Heave, cracks, interior over-heating	High temperatures have little impact on building fabric although other assets such as platform surfacing can be affected by differential expansion. This can lead to heave and displacement of elements such as platform copers and tactile paving. There is a safety risk for station users with	Low

Components	Type of impact	Impact mechanisms	Sensitivity rating
		access limitations imposed and a potential short-term impact on station capacity. Much of the impact of hot weather on buildings is secondary and related to lineside structures intended for or adapted to housing electrification or signalling plant and equipment. These are usually passively ventilated, but the equipment is often susceptible to over-heating.	
Structures	Masonry bulging	As with buildings the impacts of heat on structures are limited, however the majority of the masonry assets lacks the movement joints required for modern materials. This can be problematic on particularly large structures such as retaining walls where, in rare cases, it can cause bulging and separation of areas of masonry.	Low
Signalling and Telecoms	Failure, reduced performance	High temperatures can impact signalling electronics in lineside buildings and relay rooms which are not adequately cooled or ventilated. Many signalling assets are also contained within metal location cases which are also prone to over-heating. This risk can be increased if additional Signalling and Telecommunications (S&T) equipment is added to location cabinets over time, putting extra strain on any existing cooling systems. Track mounted signalling equipment is also vulnerable to direct heat and both solid state interlockings and axle counters can fail as a consequence of hot weather, leading to performance issues. Hot weather also impacts signalling assets which are integral to other asset groups such as the track system. Switch diamonds are prone to impairment of function and Insulated Block joints are vulnerable to damage due to rail expansion.	High
Electrification and Plant	Failure, reduced performance	As with the signaling system, many electrification and plant assets are housed in Relocatable Electrical Buildings. Substations may also be housed in technical rooms, lineside buildings or may be containerised. At many of these locations natural or forced air ventilation using ambient temperatures may be inadequate to maintain temperature levels suitable for the continued function of the components, causing failures leading to performance impacts.	High
Rolling stock	Overheated cars	Temperature stresses on engines and air conditioning systems could affect vehicle availability rates, disrupting overall scheduled service and increasing maintenance requirements. Simply by the nature of the services they provide, metro trains must frequently open and close vehicle doors, allowing hot outside air into air-conditioned vehicles on high heat days. On very hot days, air conditioning systems frequently cannot maintain comfortable temperatures in the vehicle and can fail completely.	Moderate

Extreme cold

Table 6: Main sensitive metro components to extreme cold

Components	Type of impact	Impact mechanisms	Sensitivity rating
Track	Rail broken	The rail is made up of steel. Therefore, low temperatures may cause intensive longitudinal forces that contract the rail, till the break (if the period of low temperatures is too long or if the decrease of temperature is too important).	Moderate
Buildings	Snow loading, frost heave	Snow loading on building roofs. Icing of platforms and potential for frost heave displacement of surfacing including paving. This is a safety risk for passengers and a further risk is of train strike of platform copers.	Low
Signalling	Failure, reduced performance	Snow and ice build-up obscuring signals and impairing the movement of mechanical switches and signal equipment.	Moderate
Rolling stock	Switch and brake malfunction	In case of frost, the hydraulic system of brakes can freeze and then extend the time to stop the train. Switch can also malfunction.	High
	Snow packing	Snow can creates packs on rolling stock. In consequence, some movements of the metro train can be blocked, some components can be damaged, and the accessibility for maintenance can be reduced.	
	Loss of electrical contact	Snow or ice can accumulate on the 3rd rail collector system, causing a loss of electrical contact.	

Droughts

Table 7: Main sensitive metro components to droughts

Components	Type of impact	Impact mechanisms	Sensitivity rating
Track	Ground settlement	Moisture abstraction by the root systems of trees increases during hot weather and in susceptible geologies (e.g. clays) can lead to shrinkage and hence settlement of the ground, in particular embankments. Desiccation effects such as these lead to a deterioration in track quality.	Moderate
Rolling stock	Dust cover	Droughts increase the dust on vehicles and require increased washing to maintain a quality appearance, at the same time that water use restrictions may be put into place.	Low

Heavy precipitation and floods

Table 8: Main sensitive metro components to flood

Components	Type of impact	Impact mechanisms	Sensitivity rating
Earthworks	Risk of erosion	In case of flood event, internal or external erosion of the earthworks can happen leading to partial or complete destruction	High
Depot	Risk of physical damage	Water flows and materials can ingress to the offices and impact their entrance to the structure	High
Turnout, switches and crossings	Physical damages, shortcuts, drown of the motor	Due to flooding, elements are carried along (vegetation, stones, ballast, etc.) and can get stuck between the switches and involve a blockage of the turnout. In case of high flows and shocks, it can also lead to physical damages.	Moderate
Signalling systems	Physical damages, shortcuts	In case floods are submerging the rail platform, signalling supports and cabinets can be damaged or destroyed. There is also a risk of shortcuts in electrical active devices.	Moderate
Drainage	Risk of blockage of the drainage and logjam	Flows of materials can block the drainage system	Low
Architectural finishes in stations	Physical damages, partial destruction, destruction	Water and shocks of materials during floods can damage architectural finishes	Low
Station superstructures	Physical damages, partial destruction, destruction	Water pressure and shocks of materials on station superstructures can damage the structures or even lead to destruction in case of high flows	High
Power stations components and electric systems	Physical damages, shortcuts	In case of water ingress in the transformer room there is a risk of flooding and shortcut of the transformer. Water flows and shocks of material can damage power station components and lead to failure.	High
Vertical transportation systems	Physical damages, shortcuts	In case of flooding in the metro station, water could lead to shortcuts in electrical systems of vertical transport systems (lifts, escalators) requiring their replacement. Water flows and materials can also lead to physical damages	Moderate
Automatic fare collection systems and ticketing gates	Physical damages, shortcuts	Water flows and materials can hit the automatic fare collection systems and the ticketing gates and lead to physical damages.	Low

Components	Type of impact	Impact mechanisms	Sensitivity rating
		Water can also lead to shortcuts in the AFC and in ticketing systems	
Platform screen doors	Physical damages, shortcuts	Water flows and materials can hit the PSD and lead to physical damages. Water can also lead to shortcuts in the PSD	Low

Storms

Table 9: Main sensitive metro components to storms (strong winds and lightning)

Components	Type of impact	Impact mechanisms	Sensitivity rating
Hydraulic structures	Risk of logjam	Due to strong wind, vegetation can block drainage pipes and create local flooding	Low
Substation	Substation short-circuit	In case of thunderstorms, lightning load can occur on the substation components, which protect themselves from overvoltage by circuit-breaking. A lightning load can also occur on the external power supply network, which can cut the power supply providing to the substation.	Moderate
Rolling stock	Risk of derail	In case of strong wind, rolling stock can move because of the wind and derail	Low
Architectural finishes of stations	Risk of physical damages	Architectural finishes and decorative elements can be damaged or destroyed by strong wind	Low

5.4.3 Analysis of the Adaptive Capacity

A brief assessment of the adaptive capacity can be performed based on an analysis of the socioeconomic background. A simple assessment is usually carried out using the GDP, but some organizations have developed specific tools to get a finer analysis.

In Europe, an analysis of the adaptive capacity has been conducted by ESPON (an EU funded program that delivers expertise to public authorities responsible for designing territorial policies) within a study on Climate Change and Territorial Effects on Regions and Local Economies issued in 2011. This study is probably not up to date, but it provides an analysis of the adaptive capacity at regional level, while more recent studies only provide results at country level.

The focus of the study is on generic determinants of adaptive capacity that can be measured across the regions in Europe: awareness, ability and action, which are further comprised of determinants of adaptive capacity as defined by the IPCC and others. The adaptive capacity in regard to climate change takes into account the economic, socio-cultural, institutional and technological ability of a region to adapt to the impacts of a changing regional climate. This could mean preventing or moderating potential damages, but also taking advantage of new opportunities opened up by climatic changes. A total of 15 indicators were developed and then aggregated to reflect on the five adaptation dimensions of knowledge and awareness, technology, infrastructure, institutions and economic resources. The overall adaptive capacity was determined by weighting and then combining these dimensions on the basis of a Delphi survey. The following map is a synthesis of the analysis showing the European regions' adaptive capacity.

The map shows that, in general terms, the Nordic countries have higher capacity than most of the Southern European countries. Also, in comparison, Eastern European countries, on the whole, have lower capacity than Western or Northern European countries. Overall, the countries around the Mediterranean appear to have lower capacity than the countries around the Baltic Sea region. In addition, regions with concentrations of population, economic and research activities have higher adaptive capacities than more rural regions.

Unfortunately, there was no data available for the ranking of the Serbian regions at the time of the study.

In any case, the ranking of the European countries must be put in perspective. Indeed, a low adaptive capacity for a European country may be considered as a high adaptive capacity worldwide. The ND-GAIN[3] Country Index shows that Serbia is ranked 97th regarding the adaptive capacity out of a total of 176 countries (scores for 2021), and appears as the European country with the lowest adaptive capacity.

The ND-GAIN Country Index also provides another interesting parameter, complementary to the adaptive capacity: the readiness to successfully implement adaptation solutions. Readiness measures a country's ability to leverage investments and convert them to adaptation actions. ND-GAIN measures overall readiness by considering three components – economic readiness, governance readiness and social readiness. In this respect, this indicator is relatively similar to the adaptive capacity measured by ESPON. Serbia shows a medium readiness profile (ranked 82 in 2021 out of a total of 192 countries), with - in particular - a low innovation capacity.

[3] the Notre Dame Global Adaptation Initiative (ND-GAIN) aims to help private and public sectors prioritize climate adaptation, ultimately lowering risk and enhancing readiness. Website: https://gain.nd.edu/our-work/

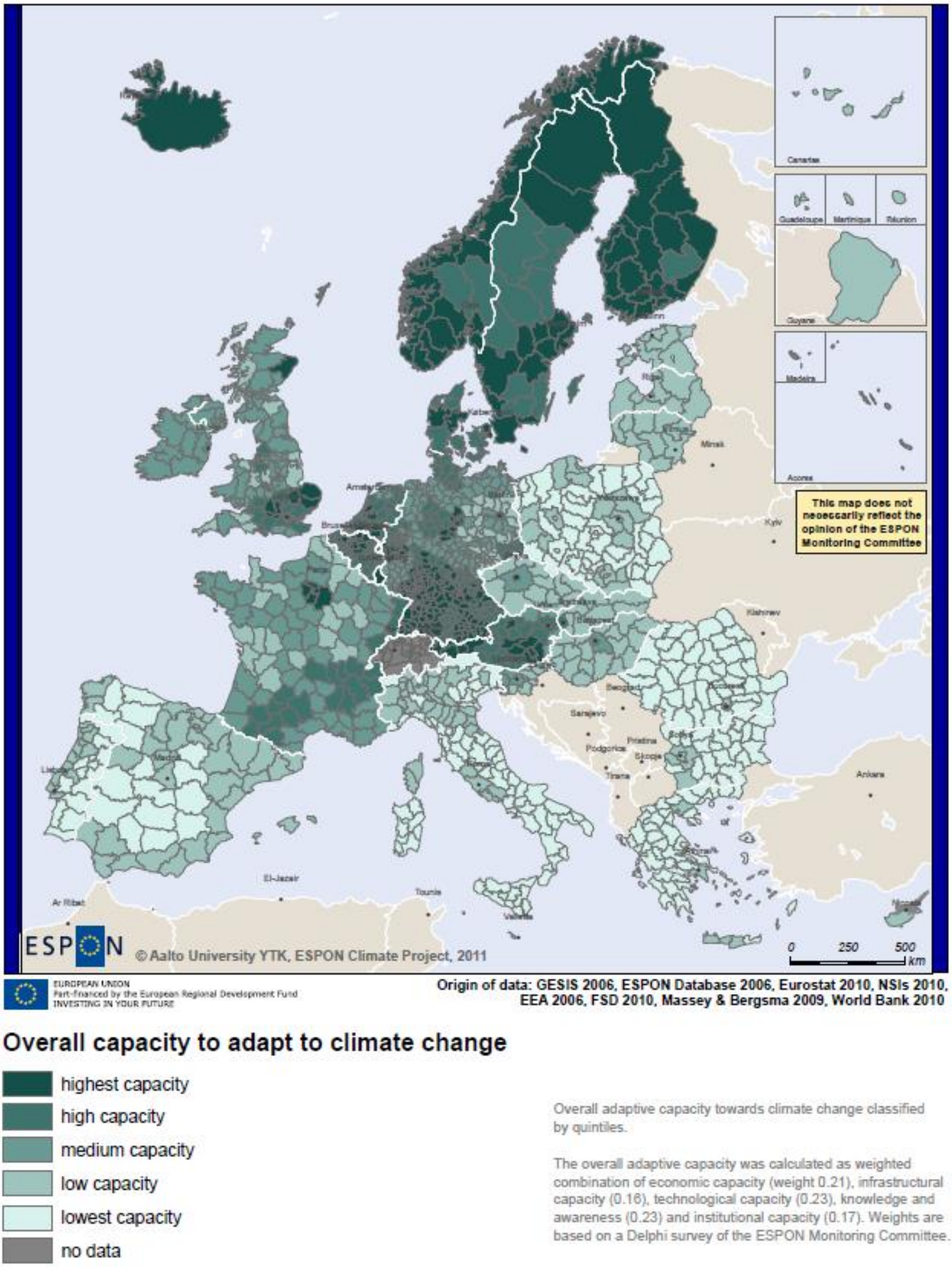


Figure 8 : Overall capacity to adapt to climate change in European regions (Source: ESPON, 2011)

5.5 Climate Risk Assessment in the Current Situation

5.5.1 Methodological approach

As explained in Chapter 5.1, the climate risk is the combination of three main criteria: climate hazards, exposure to the hazards, and vulnerability of the project components.

The climate risk assessment will be conducted using the following risk matrix:

Table 10: Climate risk matrix

		Exposure to the climate hazards		
		Low	Moderate	High
Vulnerability of the project components	Low	Low	Low	Moderate
	Moderate	Low	Moderate	High
	High	Moderate	High	High

For the purpose of the assessment, only the physical sensitivity of the project components will be considered. However, the results will be analysed taking the adaptive capacity into account.

The exercise will consist in completing the tables of the analysis of the physical sensitivity of the project components (see section 5.4.2) with a rating of the exposure of each component. This rating will take into account the line positionning, at grade or underground, as the exposure to climate hazards significantly differs in this respect.

5.5.2 Risk Assessment for the Project Components

Heat waves related risks

➔ Underground section of the metro line

Table 11: Main risks related to heat waves (underground + cut and cover)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Track	Rail buckling	Moderate with concrete slab track	Low (the tracks are not exposed to direct sun heat)	Low
Buildings	Heave, cracks, interior over-heating	Low	Low (the metro stations are not exposed to direct sun heat)	Low
Structures	Masonry bulging	Low	Low (not exposed to direct sun heat)	Low

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Signalling and Telecoms	Failure, reduced performance	High	Low (not exposed to direct sun heat)	Moderate
Electrification and Plant	Failure, reduced performance	High	Low (not exposed to direct sun heat)	Moderate
Rolling stock	Overheated cars	Moderate	Low (not exposed to direct sun heat)	Low

➔ At grade section of the metro line

Table 12: Main risks related to heat waves (at grade)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Track	Rail buckling	Moderate with concrete slab track	Moderate (the at grade part of the line is not exposed to urban heat island effect)	Moderate
Buildings	Heave, cracks, interior over-heating	Low	Moderate (the at grade part of the line is not exposed to UHI effect)	Low
Structures	Masonry bulging	Low	Moderate (the at grade part of the line is not exposed to UHI effect)	Low
Signalling and Telecoms	Failure, reduced performance	High	Moderate (the at grade part of the line is not exposed to UHI effect)	High
Electrification and Plant	Failure, reduced performance	High	Moderate (the at grade part of the line is not exposed to UHI effect)	High
Rolling stock	Overheated cars	Moderate	Moderate (the at grade part of the line is not exposed to UHI effect)	Moderate

Conclusion: regarding heat waves, there are only low or moderate risks in underground and cut and cover sections for the current situation. Risks become high for the at grade section and depot, mainly due to possible over-heating of electric systems.

Cold waves related risks

➔ Underground section of the metro line

Table 13: Main risks related to cold waves (underground + cut and cover)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Track	Rail broken	Moderate	Low (not exposed to the outside cold air)	Low
Buildings	Snow loading, frost heave	Low	Low (not exposed to the outside cold air and snow)	Low
Signalling	Failure, reduced performance	Moderate	Low (not exposed to the outside cold air and snow)	Low
Rolling stock	Switch and brake malfunction Snow packing Loss of electrical contact	High	Low (not exposed to the outside cold air and snow)	Moderate according to the risk matrix, but low knowing that there cannot be frost/ice or snow

➔ At grade section of the metro line

Table 14: Main risks related to cold waves (at grade)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Track	Rail broken	Moderate	Moderate (days below -10°C are scarce)	Moderate
Buildings	Snow loading, frost heave	Low	Moderate number of icy or snowy days	Low
Signalling	Failure, reduced performance	Moderate	Moderate	Moderate
Rolling stock	Switch and brake malfunction Snow packing Loss of electrical contact	High	Moderate	High

Conclusion: regarding cold waves, there are only low risks in underground and cut and cover sections for the current situation. Risks become high for the at grade section and depot, mainly due to possible disruption of the rolling stock operation caused by frost, ice, or snow.

Droughts related risks

➔ At grade section of the metro line

Table 15: Main risks related to droughts (at grade)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Track	Ground settlement	Moderate	High (clay soils prevail at Makis depot, see section 5.4.3 of the ESIA)	High
Rolling stock	Dust cover	Low	Moderate	Low

Conclusion: droughts related risks only concern the at grade section and depot. The presence of clay soils at Makis depot can trigger shrinkage effect during droughts, which can lead to settlement of the ground and damage infrastructures and buildings.

Heavy precipitation and floods related risks

➔ Underground section of the metro line

Table 16: Main risks related to floods (underground + cut and cover)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Earthworks	Risk of erosion	High	Low for the tunnel section, moderate for the cut and cover section (during the construction works)	High for the cut and cover section (during the construction works)
Signalling systems	Physical damages, shortcuts	Moderate	Moderate exposure through metro station entrances	Moderate
Architectural finishes in stations	Physical damages, partial destruction, destruction	Low	Low	Low
Station superstructures	Physical damages, partial destruction, destruction	High	Low	Moderate

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Power stations components and electric systems	Physical damages, shortcuts	High	High exposure through the metro shafts and the technical grids located on the sidewalks	High
Vertical transportation systems	Physical damages, shortcuts	Moderate	Moderate exposure through the metro station entrances	Moderate
Automatic fare collection systems and ticketing gates	Physical damages, shortcuts	Low	Low	Low
Platform screen doors	Physical damages, shortcuts	Low	Low	Low

➔ At grade section of the metro line

Table 17: Main risks related to floods (at grade)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Earthworks	Risk of erosion	High	Moderate exposure to Savah River floods	High
Depot	Risk of physical damage	High	Moderate exposure to Savah River floods	High
Turnout, switches and crossings	Physical damages, shortcuts, drown of the motor	Moderate	Moderate exposure to Savah River floods	Moderate
Signalling systems	Physical damages, shortcuts	Moderate	Moderate exposure to Savah River floods	Moderate
Drainage	Risk of blockage of the drainage and logjam	Low	Moderate exposure to Savah River floods	Low
Architectural finishes in stations	Physical damages, partial destruction, destruction	Low	Moderate exposure to Savah River floods	Low

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Station superstructures	Physical damages, partial destruction, destruction	High	Moderate exposure to Savah River floods	High
Power stations components and electric systems	Physical damages, shortcuts	High	Moderate exposure to Savah River floods	High
Automatic fare collection systems and ticketing gates	Physical damages, shortcuts	Low	Moderate exposure to Savah River floods	Low

Conclusion: regarding heavy precipitation and floods, for underground sections, the main risks concern damage to operating systems (signalling, power supply, elevators, automatic gates…), as water flow velocity inside the tunnel is not likely to cause damage to structures and infrastructures. Moreover, underground sections are more exposed to flooding by intense precipitation than river floods. On the opposite, the at grade section and depot are exposed to risks of flooding by the Sava River, with both potential operational and structural impacts. A detailed analysis of flood risks is provided in Chapter 5.5.1. of the ESIA.

Storms related risks

➔ At grade section of the metro line

Table 18: Main risks related to storms (strong winds and lightning)

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating
Hydraulic structures	Risk of logjam	Low	Low	Low
Substation	Substation short-circuit	Moderate	Moderate	Moderate
Rolling stock	Risk of derail	Low	Moderate	Low
Architectural finishes of stations	Risk of physical damages	Low	Moderate	Low

Conclusion: storms related risks only concern the at grade section and depot. Strong winds are not likely to generate significant damage. Lightnings can cause temporary blackouts.

General conclusion

The main climate related risks are floods, either by exceptional rainfalls (for the underground section of the project) or by river floods (for the at grade section of the project). Potential damage can be either structural or operational. The other climate related risks (heat or cold waves, storms) mainly affect the operational systems (power supply, signalling, rolling stock…), except droughts, which can lead to settlement of the ground and damage infrastructures and buildings.

5.6 Climate Risk Assessment in the Future Situation

5.6.1 Methodological Approach

The climate risk assessment in the future situation is carried out in two successive steps:

- First, a reminder of the results of the last IPCC report on the projected risks in Europe for urban areas.
- Then, a focus on the projected risks related to climate change for the L1P1 Project.

The analysis of the climate change projections is performed for climate variables relevant for the climate hazards identified in Chapter 5.2 (see the table below).

Table 19: List of climate variables considered for the climate change analysis

Climate hazards	Climate variables
Chronic climate change	Mean annual temperature in °C
	Mean annual precipitation in mm
Cold wave	Number of frost days
Heat wave	Number of days with maximum temperature above 35°C
Drought	Longest dry spell (annual mean)
Heavy rain	Maximum of 1-day accumulated precipitation in mm
	Maximum of 5-days accumulated precipitation in mm
Flood	Water runoff in mm/month
	Water discharge: 10-year return period of annual max in m3/s
	Water discharge: 50-year return period of annual max in m3/s

It is recalled that the user of climate projections or climate scenarios should not trust in the results of only one climate projection or scenario for impact analyses, as there is no such thing as “best Global Climate Model (GCM)”, “best Regional Climate Model (RCM)” or “best climate scenario”. Therefore, it is advisable to make use of a group of projections (ensemble) and a set of climate scenarios.

The study explores the two GHG emission scenarios the most relevant for the assessment of the project vulnerability. These scenarios are currently the most used in the world:

- RCP8.5 / SSP5-8.5, the most pessimistic scenario that allows application of the prevention principle in the context of high uncertainty;
- RCP4.5 / SSP2-4.5, corresponding to the stabilization of the GHG concentration in the atmosphere.

The time horizons to be considered are the reference period (usually 1981-2010), early century (2011-2040), mid-century (2041-2070), and end of the century (2071-2100). The long-term projections are used to assess the sustainability of the project components on the long run (adequacy between the project lifespan and the selected time horizons for the assessment). As transport infrastructures are usually designed for a 100-year lifespan, it is therefore required to consider distant future, i.e. the furthest time horizon for which climate change projections are available.

The climate change models are those of Euro-CORDEX. Choosing the Euro-CORDEX ensemble enables assessing the uncertainty related to the modeling (variation of the results across the ensemble members gives an estimate of uncertainty). The various climate models of Euro-CORDEX (from 10 to 19 depending on the climate variables or scenarios) allow to obtain mean and median values together with the confidence interval. The choice of two different climate change scenarios also allows to assess the uncertainty regarding GHG emission projections.

Depending on the climate variables availability, two portals on climate change projections were used: Climate Information (https://dap.climateinformation.org/dap/) and the Copernicus Interactive Climate Atlas (https://atlas.climate.copernicus.eu/atlas). The first portal presents the advantage of quantifying the uncertainty by giving the 25% and 75% quartiles, while the second one shows a higher resolution (12 km).

For each climate variable considered, each scenario and each time horizon, the following parameters are analyzed based on the available climate projection data:

- Intensity: it translates the quantification (severity) of an event in absolute value;
- Spatial occurrence: this is mainly conditioned by the level of resolution of the climate change projections. In the present case, the study area corresponds to 1 or 2 pixels of the climate change models, so there is no noticeable spatial variations of the cliamte variables;
- Level of change: climatic evolution expressed in % of variation compared to the reference period;
- Uncertainty: it is estimated by means of the confidence intervals provided by the quantile method used with the Euro-CORDEX ensemble (25% and 75% quartiles). For the climate variables extracted from the Copernicus Atlas, only a qualitative estimate is provided when the uncertainty is high.

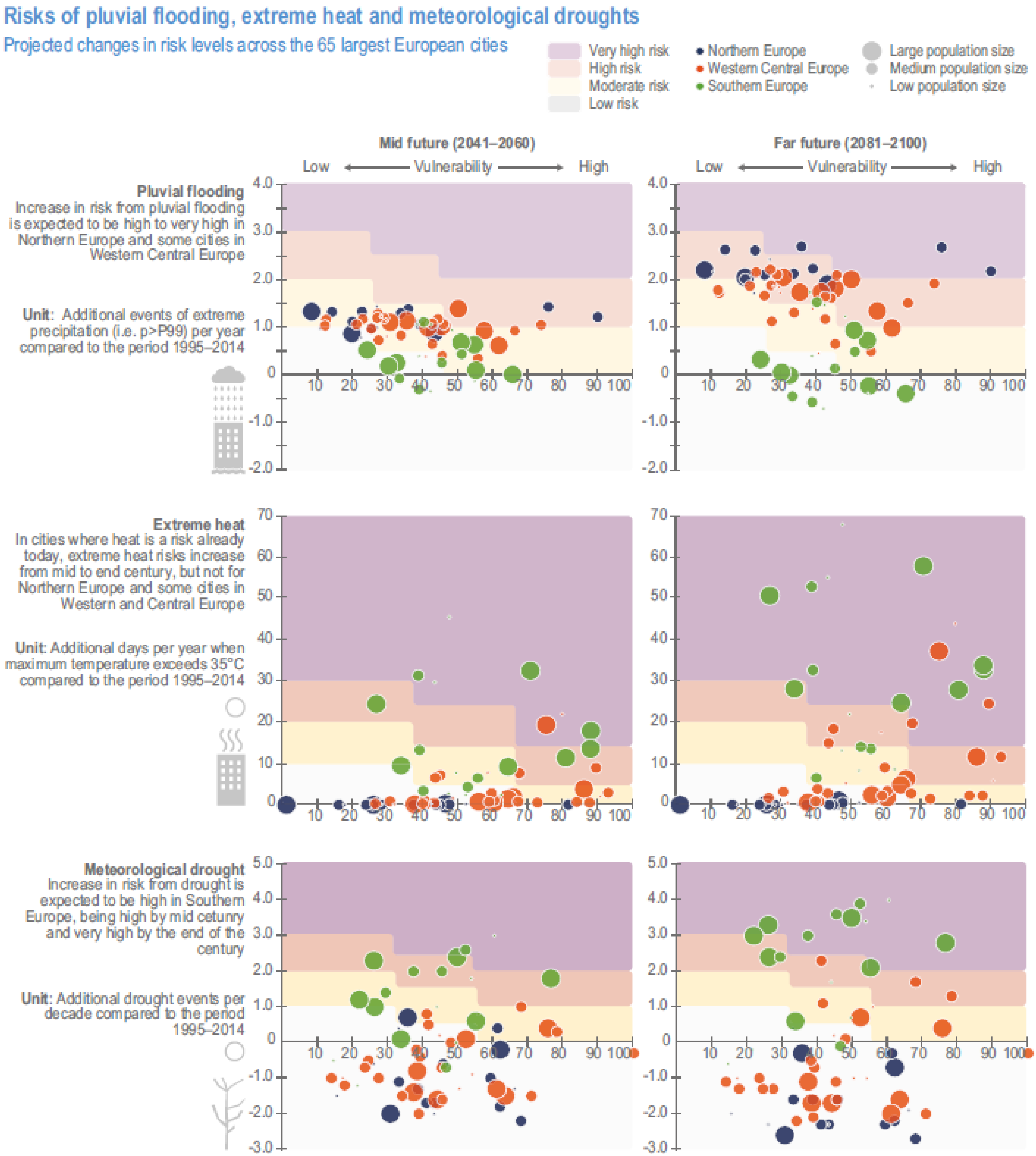
The results of the climate change projections are compared with those presented in "Climate change adaptation action plan and vulnerability assessment, City of Belgrade Secretariat for Environmental Protection, 2015".

5.6.2 Projected Risks related to Climate Change in Europe

To put things in perspective, it is interesting to recall the outputs of the last IPCC report (AR6, 2022). In this report devoted to "Impacts, Adaptation and Vulnerability", Chapter 13 provides an insight into observed impacts and projected risks in Europe. The following information is extracted from the section dedicated to the "Built Environment, Settlements and Communities".

Main trends

Under current vulnerabilities, future climate hazards will augment climate risks for several cities, particularly beyond +3°C of global warming level (see Figure below). In many Northern European (NEU) cities, a high increase in pluvial flooding risk by the end of the century is possible, while in Western Central Europe (WCE) cities may face a high increase in pluvial flooding risks, moderate to very high increase in extreme heat risk, and to some extent moderate to high increase in drought risk. Many Southern European (SEU) cities could face a high to very high increase in risks from extreme heat and meteorological drought.



Exposure is expressed in terms of current population. Values of climatic impact drivers are derived from the Euro-CORDEX regional climate model ensemble.

Figure 9 : Projected changes in pluvial flooding, extreme heat and meteorological drought risks for the 65 largest cities in EU-28 plus Norway and Switzerland for 2.5°C and 4.4°C GWL compared with the baseline (1995–2014) (Tapia et al., 2017).

Risks from river and pluvial flooding

In many cities, the sewer system is older than 40 years, potentially reducing their capacity to deal with more intense pluvial flooding. Apart from climate change, urbanisation is an important driver for increases in flooding risks as it results in growth of impervious surfaces. Flash floods are particularly challenging, causing the overburdening of drainage systems, urban transport disruptions, and health and pollution impacts due to untreated sewage discharges.

More than 25% of the population in nearly 13% of EU cities live within potential river floodplains. In many of these places, a significant increase in the 10-year high river flow is possible beyond +2°C GWL under a high-impact scenario (i.e., 90th percentile of projections).

Risks from heatwaves, cold waves and drought

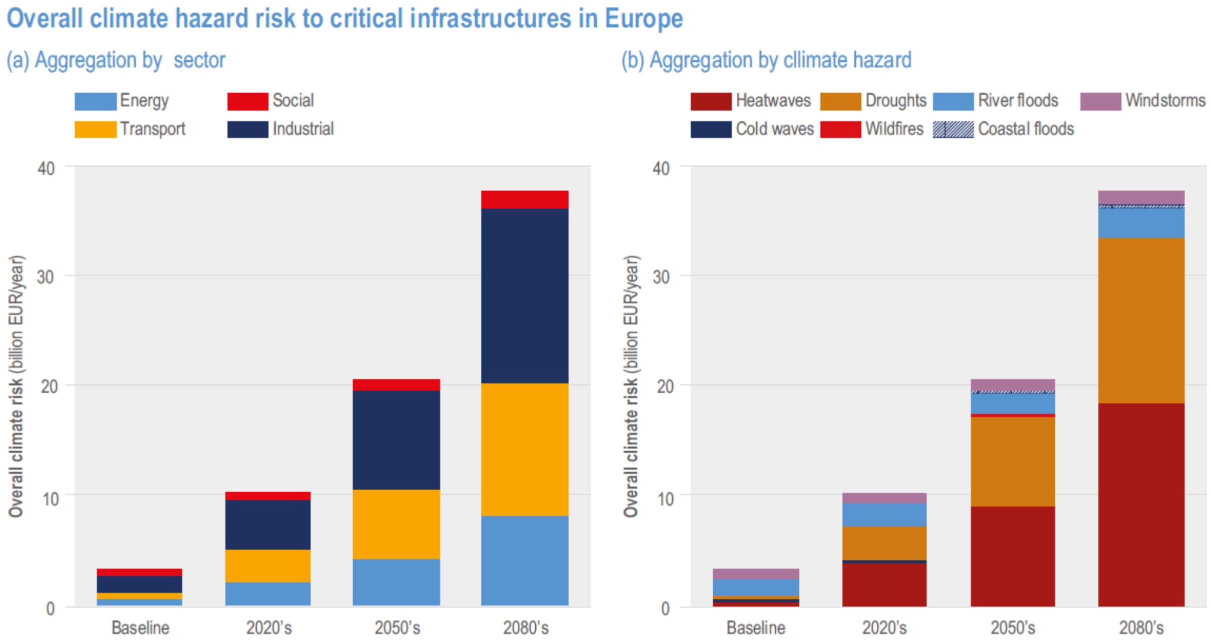
Heatwaves are likely to become a major threat, not only for SEU but also for WCE and Eastern Europe (EEU) cities. At 2°C GWL and SSP3, half of the European population will be under very high risk of heat stress in summer. The UHI effect will further increase urban temperatures. In many cities, hospitals and social housing tend to be located within the intense UHI, thus increasing exposure to vulnerable groups. There is high confidence that overheating during summer in buildings with insufficient ventilation and/or solar protection will increase strongly, with thermal comfort hours potentially decreasing by 74% in SEU at 3°C GWL. Highly insulated buildings, following present building standards, will be vulnerable to overheating, particularly under high GWL levels, unless adequate adaptation measures are applied. Cities in NEU and WCE are more vulnerable due to limited solar shading and fewer air conditioning installations. Cooling energy demand in SEU buildings has been projected to increase by 81–104% by 2035 and 91–244% after 2065 compared with 1961–1990 depending on GWL. Increases of 31–73% by 2050 and 165–323% by 2100 compared with 1996–2005 were estimated for buildings in NEU with risks modified by adaptation.

Cold waves beyond 3°C GWL will not represent an effective threat for European cities at the end of the century, and only a marginal hazard under 2°C GWL.

At 2°C GWL and beyond, cities in SEU and large parts of WCE would exceed the historical maximum 12-month Drought Severity index of the past 50 years and 30% will have at least 30% probability of exceeding this maximum every month. This could adversely affect the operation of municipal water services. For example, under 2°C GWL, the reservoir storage volume is predicted to decrease for all of England and Wales catchments, resulting in a probability of years with water-use restrictions doubling by 2050 and quadrupling by 2100 compared with 1975–2004.

The combination of high temperatures, drought, and extreme winds, potentially coupled with insufficient preparedness and adaptation, may amplify the damage of wildfires in peri-urban environments. High fuel load combined with proximity of the built environment to wildland highly increases fire risks.

Extreme heat and drought cause shrinking and swelling of clays, threatening the stability of small houses in peri-urban environments, with damage costs of 0.9–1 billion EUR during the 2003 heatwave. In WCE and SEU, mean annual damage costs could increase by 50% for 2°C GWL, and by a factor of 2 for 3°C GWL.



Baseline: 1981–2010; 2020s: 2011–2040; 2050s: 2041–2070; 2080s: 2071–2100.

Figure 10 : Climate risks to critical infrastructures, aggregated at European (EU+) level under the SRES A1B scenario (Forzieri et al., 2018).

5.6.3 Climate Change Projections for the study area of the L1P1 Metro Project

Table 20 presents the results of climate change modelling for the study area. These results are analysed below.

Overview

On the study area, an increase in mean temperature and change in precipitation distribution and intensity are expected on the future for both scenarios compared to the 1981-2010 reference period. This change will also be experienced through the onset of extreme heat waves, severe drought episodes and an increase in precipitation amounts during extreme events.

In the future, we can very likely expect further temperature and precipitation record breaks, both in regions around the world and in Serbia.

Temperatures

Temperatures are expected to continue rising until the end of this century to values that are on average 2 to 4°C higher than the temperatures from mid-last century. Such changes cause an even further destabilisation of the climate system. This projection relates on a small uncertainty range. It is correlated with less cold spells (-14% to -64%) and much more heat waves (+52% to +334%), although the uncertainty of these kind of extreme events is rather high.

Frost days

Depending on the horizon and scenarios, there will be 1 to 5 weeks less of frosty days annually. During the mid-21st century climatic period, according to the RCP8.5, there will be more than one month less frosty days and according to the RCP4.5 there will be about half a month less of them. By the end of the 21st century, frost days could become a rarer event in Belgrade.

Heat waves

Heat waves will become more frequent during future climate periods. While such climatic events remain rare for the 1980-2010 reference period, hots days will increase in the next decades. According to the RCP8.5 scenario, their average occurrence in Belgrade area will triple by the end of the 21st century.

Precipitations

By the end of the century, the mean annual precipitation shows a 14% increase with RCP 8.5, but a -5% decrease with RCP 4.5. The difference between both scenarios shows the strong uncertainty over the projections.

The data suggest a further intensification of the precipitations. More frequent heavy precipitation events and higher precipitation amounts during intense precipitation events should occur (+16 to +19% of the maximum daily precipitation). This should lead to increased water runoff (up to 7.5% by the end of the century).

Droughts

At the same time, summer droughts could significantly worsen, with the longest dry spells possibly increasing by 14% with RCP 8.5 by the end of the century. However, this trend is highly uncertain, as the longest dry spells show a -5% decrease with RCP 4.5.

Floods

Only the Danube River flow changes are estimated. The 10-year return period flood could increase by 15% by the end of the century, and the 50-year return period flood by 19%.

These findings are in line with those presented in "Climate change adaptation action plan and vulnerability assessment, City of Belgrade Secretariat for Environmental Protection, 2015"

Table 20: Climate change projections for the the study area of the L1P1 Metro Project

Hazards	Climatic data	Horizon	Intensity RCP 4,5	Intensity RCP 8,5	Spatial occurrence	Climatic evolution compared to 1981-2010 RCP 4,5	Climatic evolution compared to 1981-2010 RCP 8,5	Uncertainty range RCP 4,5	Uncertainty range RCP 8,5
General parameters	Mean annual temperature	**Reference period : 1981-2010**	**12,35°C**		*Uniform for Belgrade territory (reference coordinates: 44,82 ; 20,49)*	*COMPARED TO 12,35°C*			
		Near term (2011-2040)	13,21°C (+0,86°C)	13,25°C (+0,90°C)		6,96%	7,29%	[5,16% ; 7,94%]	[5,22% ; 8,17%]
		Medium term (2041-2070)	13,93°C (+1,59°C)	14,33°C (+1,98°C)		12,87%	16,03%	[10,60% ;13,35%]	[15,31% ; 19,81%]
		Long term (2071-2100)	14,20°C (+1,86°C)	16,27°C (+3,93°C)		15,06%	31,82%	[13,65 %; 17,93%]	[28,05% ; 34,19%]
	Mean annual precipitation	**Reference period : 1981-2010**	**726,35 mm/y**		*Uniform for Belgrade territory (coordinates: 44,82 ; 20,49)*	*COMPARED TO 726,35 MM/YEARS*			
		Near term (2011-2040)	739,5 (+13,15) mm/y	752,79 (+26,44) mm/y		1,81%	3,64%	[-2,73% ; 6,11%]	[1,38% ; 4,55%]
		Medium term (2041-2070)	751,63 mm/y (+25,28 mm/y)	743,78 (+17,43) mm/y		3,48%	2,40%	[-0,03% ; 8,48%]	[-0,66% ; 7,48%]
		Long term (2071-2100)	689,09 (-37,26) mm/y	826,95 (+100,60) mm/y		-5,13%	13,85%	(-12,81%; 23,22%]	[-8,70% ; 54,24%]
Cold spell	Frost days	**Reference period : 1981-2010**	**53,10 days**		*Uniform for Belgrade territory (reference coordinates: 44,82 ; 20,49)*	*COMPARED TO 53,10 DAYS*			
		Near term (2011-2040)	45,4 (-7,7) days	44,8 (-8,30) days		-14,50%	-15,63%	[-23,95%; -11,80%]	[-24,27%; -8,98%]
		Medium term (2041-2070)	38,67 (-14,43) days	33,15 (-19,95) days		-27,18%	-37,57%	[-43,46%; -22,53%]	[-44,96%; -31,78%]
		Long term (2071-2100)	33,4 (-19,70) days	19,08 (-34,02) days		-37,10%	-64,07%	[-43,80%; -27,33%]	[-72,20%; -53,22%]
Heat wave	Days with maximum temperature above 35°C	**Reference period : 1981-2010**	**10,56 days**		*Project location y = 44,81; x = 20,49*	*COMPARED TO 10,56 DAYS*			
		Near term (2011-2040)	16,03 days (+5,47) days	18,03 days (+7,47) days		51,80%	70,74%	no data	no data
		Medium term (2041-2070)	20,96 days (+10,4) days	24,85 days (+14,29) days		98,48%	135,32%	no data	no data

Hazards	Climatic data	Horizon	Intensity RCP 4,5	Intensity RCP 8,5	Spatial occurrence	Climatic evolution compared to 1981-2010 RCP 4,5	Climatic evolution compared to 1981-2010 RCP 8,5	Uncertainty range RCP 4,5	Uncertainty range RCP 8,5
		Long term (2071-2100)	24,65 days (+14,09) days	45,86 days (+35,3) days		133,43%	334,28%	no data	no data
Drought	longest dry spell (annual mean)	**Reference period : 1981-2010**	**45 days**		*Uniform for Belgrade territory (reference coordinates: 44,82 ; 20,49)*	*COMPARED TO 45 DAYS*			
		Near term (2011-2040)	43,68 (-1,32) days	46,38 (+1,38) days		-2,94%	3,06%	[-17,77% ; 2,62%]	[-13,11%;22,62%]
		Medium term (2041-2070)	47,31 (+2,31) days	44,63 (-0,37) days		5,13%	-0,83%	[-11,11% ; 20,70%]	[-11,21% ; 22,59%]
		Long term (2071-2100)	42,69 (-2,31) days	51,23 (+6,23) days		-5,13%	13,85%	[-12,81% ; 23,22%]	[-8,70% ; 54,24%]
Precipitations and floods	Water runoff	**Reference period : 1981-2010**	**16,80 mm/month**		*Uniform for Belgrade territory (reference coordinates: 44,82 ; 20,49)*	*COMPARED TO 16,80 MM/MONTHS*			
		Near term (2011-2040)	17,77 (+0,97) mm/month	18,06 (+1,26) mm/month		5,76%	7,50%	[-2,73% ; 12,98%]	[3,25%; 11,07%]
		Medium term (2041-2070)	17,65 (+0,85) mm/month	17,81 (+1,01) mm/month		5,08%	6,02%	[-5,64% ; 9,10%]	[3,60 %; 10,25%]
		Long term (2071-2100)	18,07 (+1,27) mm/month	17,64 (+0,84) mm/month		7,57%	5,00%	[2,67 %; 13,78%]	[0,84% ; 9,14%]
	Water discharge: 10-year return period of annual max	**Reference period : 1981-2010**	**14 864,04 m^3/s**		*Uniform for Belgrade territory (reference coordinates: 44,82 ; 20,49)*	*COMPARED TO 14 864,04 M^3/S*			
		Near term (2011-2040)	15934,25 (+1070,21) m^3/s	15937,22 (+1073,18) m^3/s		7,20%	7,22%	[1,21% ; 12,47%]	[3,17 ; 14,41]
		Medium term (2041-2070)	15577,51 (+-356,74) m^3/s	16488,68 (+551,46) m^3/s		4,80%	10,93%	[1,34 %; 10,72%]	[5,60 ; 21,21]
		Long term (2071-2100)	16606,11 (+1028,59) m^3/s	17112,97 (+624,29) m^3/s		11,72%	15,13%	[3,14 %; 16,24%]	[10,15 ; 26,34]
	Water discharge: 50-year return	**Reference period : 1981-2010**	**18574,37 m^3/s**		*Uniform for Belgrade*	*COMPARED TO 18 574,37 M^3/S*			

Hazards	Climatic data	Horizon	Intensity		Spatial occurrence	Climatic evolution compared to 1981-2010		Uncertainty range	
			RCP 4,5	RCP 8,5		RCP 4,5	RCP 8,5	RCP 4,5	RCP 8,5
	period of annual max	Near term (2011-2040)	19932,16 (+1357,79) m^3/s	20069,61 (+1495,24) m^3/s	*territory (reference coordinates: 44,82 ; 20,49)*	7,31%	8,05%	[1,91% ; 13,53%]	[3,18% ; 15,78%]
		Medium term (2041-2070)	19529,09 (+954,72) m^3/s	21020,61 (+2446,24) m^3/s		5,14%	13,17%	[0 08% ; 9,90%]	[5,46% ; 22,01%]
		Long term (2071-2100)	20597,12 (+2022,75) m^3/s	22177,8 (+3603,43) m^3/s		10,89%	19,40%	[3,21% ; 15,38%]	[11,94% ; 29,64%]
	Maximum of 1-day accumulated precipitation	**Reference period : 1981-2010**	**34,49 mm/day**		*Project location y = 44,81; x = 20,49*	*COMPARED TO 34,49 MM/DAY*			
		Near term (2011-2040)	36,91 (+2,42) mm/day	36,37 (+1,88) mm/day		7,02%	5,45%	high	high
		Medium term (2041-2070)	38,03 (+3,54) mm/day	37,7 (+3,21) mm/day		10,26%	9,3%	high	high
		Long term (2071-2100)	40,08 (+5,59) mm/day	41,02 (+6,53) mm/day		16,21%	18,93%	no data	no data
	Maximum of 5-days accumulated precipitation	**Reference period : 1981-2010**	**55,95 mm/day**		*Project location y = 44,81; x = 20,49*	*COMPARED TO 55,95 MM/DAY*			
		Near term (2011-2040)	64,78 (+4,83) mm/day	63,32 (+3,37) mm/day		8,06%	5,62%	high	high
		Medium term (2041-2070)	64,49 (+4,54) mm/day	64,65 (+4,7) mm/day		7,57%	7,84%	high	high
		Long term (2071-2100)	69,01 (+9,06) mm/day	68,72 (+8,77) mm/day		15,11%	14,63%	high	no data

5.6.4 Risk Assessment for the Project Components in the Future Situation

Introduction

The purpose of the present section is to reassess the risks presented in section 5.5.2 taking climate change into account.

Only the moderate to high risks identified in the current situation are considered at this stage of the study, as risk management studies usually focus on significant risks. In other words, it is assumed that low climate risks in the current situation cannot become high by the end of the century. Of course, current low climate risks can (and will) become higher in the future but should remain moderate at the most (at least by the end of the century).

Climate change trends are represented by symbols showing the order of magnitude of climate change by the end of the century: = if the change is not significant (i.e. less than 5% compared to the reference value, taking uncertainties into account), + if the change does not exceed 15%, and ++ if the change exceeds 15% for the 2071-2100 horizon.

Heat waves related risks

➔ Underground section of the metro line

Table 21: Main risks related to heat waves (underground + cut and cover) in the future

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Signalling and Telecoms	Failure, reduced performance	High	Low (not exposed to direct sun heat)	Moderate	++	High
Electrification and Plant	Failure, reduced performance	High	Low (not exposed to direct sun heat)	Moderate	++	High

➔ At grade section of the metro line

Table 22: Main risks related to heat waves (at grade) in the future

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Track	Rail buckling	Moderate with concrete slab track	Moderate (the at grade part of the line is not exposed	Moderate	++	High

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
			to urban heat island effect)			
Signalling and Telecoms	Failure, reduced performance	High	Moderate (the at grade part of the line is not exposed to UHI effect)	High	++	Higher
Electrification and Plant	Failure, reduced performance	High	Moderate (the at grade part of the line is not exposed to UHI effect)	High	++	Higher
Rolling stock	Overheated cars	Moderate	Moderate (the at grade part of the line is not exposed to UHI effect)	Moderate	++	High

Comments: risks of over-heating will become high for electric systems (including ventilation and air conditioning) even in underground and cut and cover sections. Rail buckling could occur in the at grade section and depot.

Cold waves related risks

➔ At grade section of the metro line

Table 23: Main risks related to cold waves (at grade) in the future

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Track	Rail broken	Moderate	Moderate (days below -10°C are scarce)	Moderate	--	Low
Signalling	Failure, reduced performance	Moderate	Moderate	Moderate	--	Low
Rolling stock	Switch and brake malfunction Snow packing Loss of electrical contact	High	Moderate	High	--	Moderate

Comments: the drop in frost days will reduce the risks related to ice and snow. However, due to the natural climate variability, the likelihood of cold winters by the end of the century is not negligible, and could still impact the rolling stock operation.

Droughts related risks

➔ At grade section of the metro line

Table 24: Main risks related to droughts (at grade) in the future

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Track	Ground settlement	Moderate	High (clay soils prevail at Makis depot, see section 5.4.3 of the ESIA)	High	=	High

Comments: droughts related risks only concern the at grade section and depot. The presence of clay soils at Makis depot can trigger shrinkage effect during droughts, which can lead to settlement of the ground and damage infrastructures and buildings. Uncertainties about drought trends do not make possible to state that the risk will increase in the future.

Heavy precipitation and floods related risks

➔ Underground section of the metro line

Table 25: Main risks related to floods (underground + cut and cover) in the future

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Earthworks	Risk of erosion	High	Low for the tunnel section, moderate for the cut and cover section (during the construction works)	High for the cut and cover section (during the construction works)	++	Higher
Signalling systems	Physical damages, shortcuts	Moderate	Moderate exposure through metro station entrances	Moderate	++	High

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Station superstructures	Physical damages, partial destruction, destruction	High	Low	Moderate	++	High
Power stations components and electric systems	Physical damages, shortcuts	High	High exposure through the metro shafts and the technical grids located on the sidewalks	High	++	Higher
Vertical transportation systems	Physical damages, shortcuts	Moderate	Moderate exposure through the metro station entrances	Moderate	++	High

➔ At grade section of the metro line

Table 26: Main risks related to floods (at grade) in the future

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Earthworks	Risk of erosion	High	Moderate exposure to Savah River floods	High	++	Higher
Depot	Risk of physical damage	High	Moderate exposure to Savah River floods	High	++	Higher
Turnout, switches and crossings	Physical damages, shortcuts, drown of the motor	Moderate	Moderate exposure to Savah River floods	Moderate	++	High
Signalling systems	Physical damages, shortcuts	Moderate	Moderate exposure to	Moderate	++	High

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
			Savah River floods			
Station superstructures	Physical damages, partial destruction, destruction	High	Moderate exposure to Savah River floods	High	++	Higher
Power stations components and electric systems	Physical damages, shortcuts	High	Moderate exposure to Savah River floods	High	++	Higher

Comments: the risks of heavy precipitation and related floods identified in the current situation will increase in the future. In particular, as shown on Figures 6 and 7, the Danube River flood risk will increase in the northern part of the metro line (from Pancevacki Most station to Dunav station).

Storms related risks

➔ At grade section of the metro line

Table 27: Main risks related to storms (strong winds and lightning) in the future

Components	Type of impact	Sensitivity rating	Exposure rating	Risk rating in the current situation	Climate change trend (2071-2100)	Risk rating with climate changes
Substation	Substation short-circuit	Moderate	Moderate	Moderate	+	Moderate

Comments: thunderstorm cells should develop more often in the future, though it is difficult to quantify the change. The lightnings related risks should remain moderate.

Conclusion

In the future, the main climate related risks are still floods, either by exceptional rainfalls (for the underground section of the project) or by river floods (for the northern part of the underground section and the at grade section of the project). Most of the climate risks will increase, especially those related to heat waves. There are strong uncertainties about drought and storm trends. Frost wave related risks will significantly decrease.

5.7 Climate Change Risk Mitigation

5.7.1 Methodological Approach

Following the physical risk assessment taking climate change into consideration, the purpose is to identify the measures allowing to reduce the risks to an acceptable level, i.e. from high to moderate or low.

5.7.2 Climate Risks Mitigation Plan

Nota bene: all the proposed mitigation measures are already incorporated in the project design and will therefore not generate additional costs.

Heat waves related risks

➔ Underground section of the metro line

Table 28: Mitigation measures for risks related to heat waves (underground + cut and cover)

Components	Type of impact	Mitigation Measures
Signalling and Telecoms	Failure, reduced performance	Installing more ventilation and/or air conditioning for the electrical equipment. Building a relay room that keeps electrical equipment cool using energy efficient natural and mechanical ventilation systems. Installation of a replacement electrical relay system
Electrification and Plant	Failure, reduced performance	

➔ At grade section of the metro line

Table 29: Mitigation measures for risks related to heat waves (at grade)

Components	Type of impact	Mitigation measures
Track	Rail buckling	Tracks are designed for temperatures from -20°C to 60°C. Short rails fitted with expansion joints instead continuously welded rail. Monitoring and replacement of deformed rails if necessary.
Signalling and Telecoms	Failure, reduced performance	Installing more ventilation and/or air conditioning for the electrical equipment. Building a relay room that keeps electrical equipment cool using energy efficient natural and mechanical ventilation systems. Installation of a replacement electrical relay system
Electrification and Plant	Failure, reduced performance	
Rolling stock	Overheated cars	New trees will be planted, providing shade, the Administrative and OCC Building will be equipped with a green roof and the implemented green areas will limit the urban heat island effects

Comments: The design of the ventilation/HVAC system (energy, fan, noise attenuation) provides sufficient reserves to meet the design criteria by 2100 (for system as for users), with an hypothesis of a temperature raise of +5.6°C relatively to the 1970-2000 period (see chart below).

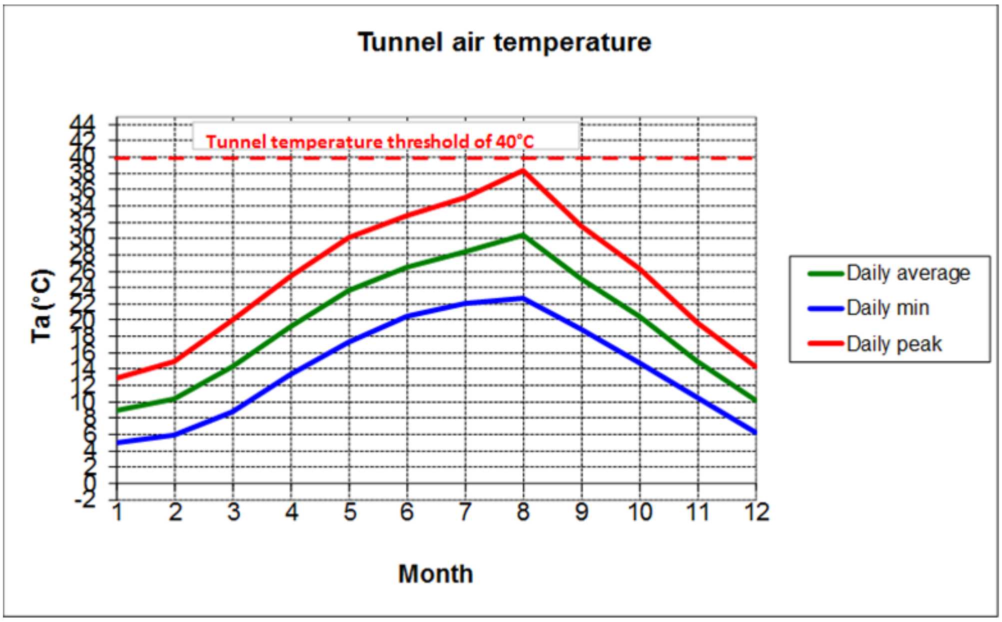


Figure 11 : Tunnel air temperature at the horizon 2100, with a raise of outside surface temperature due to climate change

Droughts related risks

➔ At grade section of the metro line

Table 30: Mitigation measures for risks related to droughts (at grade)

Components	Type of impact	Mitigation measures
Track	Ground settlement on clay soils (Makis depot)	Not planting trees in close vicinity to infrastructures and buildings, as moisture abstraction by the root systems of trees increases during hot weather and can lead to shrinkage and hence settlement of the ground. Detailed geotechnical study to be performed for a better knowledge of the risks.

Heavy precipitation and floods related risks

➔ Underground section of the metro line

Table 31: Mitigation measures for risks related to floods (underground + cut and cover)

Components	Type of impact	Mitigation measures
Earthworks	Risk of erosion during the construction of the C&C section	Special attention given to the drainage of the construction site (protection for a 100-year return period rain or flood)

Components	Type of impact	Mitigation measures
Station superstructures	Physical damages, partial destruction, destruction	Detailed hydraulic study to be performed to assess the climate change effect on the Danube River floods. From shaft 02 (Makiš hill) to Trg Republike station: 76,30 masl is considered as the 100 year flood level. From Skadarlija station to Shaft 10: 76,80 masl is considered as the 100 year flood level. At Ada Ciganlija, Sajam, and Savski stations, for some technical grids located on the sidewalks, the levels are defined based on the existing ground level in order to not create an obstacle for the passengers. Increasing them could create potential issues for population safety and for future land use. Thus, these grids could be under the 100 year flood level. In case of flooding events above the grid level, technical rooms could be flooded. The technical rooms that would be affected are only related to the station operation. Thus, in case of flooding, the global functioning of the metro operation would not be affected.
Signalling systems	Physical damages, shortcuts	
Power stations components and electric systems	Physical damages, shortcuts	
Vertical transportation systems	Physical damages, shortcuts	

Comments: the stations and shafts elevation levels (masl) determined against flood risk, are provided in Chapter 7.6 of the ESIA.

➔ At grade section of the metro line

Table 32: Mitigation measures for risks related to floods (at grade)

Components	Type of impact	Mitigation measures
Earthworks	Risk of erosion	Detailed hydraulic study to be performed to assess the climate change effect on the Sava River floods. Construction sites are located out of areas exposed to flooding risk, or plan for adequate protections of non-mobile equipment and material, and withdrawal of mobile machinery in case of flooding alert (evacuation plan). Mobile protections that will raise the current dikes level in case of exceptional flooding (under the responsibility of the local authorities) The metro line and adjacent urban development areas are built on backfilled zones, in order not to be exposed to the 100-year return period flood of the Sava River.
Depot	Risk of physical damage	
Station superstructures	Physical damage, partial destruction, destruction	
Turnout, switches and crossings	Physical damages, shortcuts, drown of the motor	
Signalling systems	Physical damages, shortcuts	Setting the electrical equipment above the highest known water levels and/or making the technical rooms watertight.
Power stations components and electric systems	Physical damages, shortcuts	

5.7.3 Potential Financial Risks

The purpose is to assess the materiality of climate risks. It is recalled that, according to the EP IV guidance on CCRA, a climate-related risk is material for the Project, and requires to be considered within the CCRA, if there are associated significant financial risks. In the present case, the climate-related risks are not material for the L1P1 Metro Project, in so far as most of the costs of the mitigation measures are already incorporated in the overall cost of the project. Therefore, there is no associated significant financial risk. It does not mean that there is no financial risks, but the residual risks after mitigation are considered acceptable according to the state of the art for this kind of project. That being said, it should be borne in mind that Serbia has a relatively low adaptive capacity (see section 5.4.3), which – intrinsically – increases the level of risks.

In the next steps of the project design, further studies are planned to verify if safety margins are necessary to keep all the project components climate-proof, based on cost-benefit analyses. The existing feedback on resilience and adaptation plans for transport infrastructure shows that it is much less expensive to incorporate the adaptation costs at the project design stage, than retrofitting the infrastructure after its construction. In addition, benefits of adaptation always outweigh initial costs. As a rough order of magnitude estimate, a FEMA-commissioned study found that on average, regardless of hazard (such as flood, earthquake, etc.), for every dollar spent on protecting an asset, the owner saves four dollars in avoided losses[4].

[4] National Institute of Building Sciences, Multihazard Mitigation Council, Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities, 2005.