Case study: Climate proofing of a water and wastewater project

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Abbreviations

AEP	Annual Exceedance Probability
AR6	Sixth Assessment Report
CO_2e	Carbon Dioxide Equivalent
DWD	Drinking Water Directive
EIA	Environmental Impact Assessment
GHG	Greenhouse Gas
GWL	Global Warming Levels
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
p.e.	population equivalent
SLR	Sea Level Rise
SuDS	Sustainable Drainage Systems
TKM	Tonne per Kilometre (for transport emissions)
TTW	Tank To Wheel (for transport emissions)
UNFCCC	United Nations Framework Convention on Climate Change
UWWTD	Urban Wastewater Treatment Directive (91/271/EEC)
WWTP	Wastewater Treatment Plant

1. BACKGROUND

As defined by the [Commission Notice — Technical guidance on the climate proofing of infrastructure in the period 2021-2027 - Publications Office of the EU (europa.eu)] *"Climate proofing is a process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects. It enables European institutional and private investors to make informed decisions on projects that qualify as compatible with the Paris Agreement. The process is divided into two pillars (mitigation, adaptation) and two phases (screening, detailed analysis)."* Projects seeking investment should demonstrate they are climate proof.

The definition in the Commons Provisions Regulations Article 2(42) is *"climate proofing means a process to prevent infrastructure from being vulnerable to potential long-term climate impacts whilst ensuring that the 'energy efficiency first' principle is respected and that the level of greenhouse gas emissions arising from the project is consistent with the climate neutrality objective in 2050".*

In practical terms a climate proof project is both of the following:

Is consistent with the ability to achieve GHG emission and climate neutrality targets by demonstrating:	Manages all climate hazard risks to an acceptable level through:
•It will not generate significant GHG emissions, •Has considered GHG emissions from alternative means of achieving project objectives (which must be compliant with EU legislation and policy (e.g. UWWT Directive).	•Inbuilt resilience of the project to climate hazards, •Additional adaptation measures included within the project investment, or •A clear long term implementation plan for future adaptation measures informed by a monitoring programme (which may include measures to be implemented as part of the project investment to facilitate future adaptation).

This document is a demonstration of the climate proofing documentation **for an example water supply and wastewater project.**

This Climate proofing document should be made an integral part of the EIA for the project in line with the requirements of the Revised EIA Directive (2011/92/EU, as amended by Directive 2014/52/EU).

2. PROJECT DESCRIPTION

The project area is a section of a northen county in the foothills of the mountain range, with forest nearby located in a hilly area with plains. The population of the main town has recently grown and is predicted to continue to grow in response to economic development.

The project will ensure compliance with Government legislation and European Union Directives. The following project objectives were set:

- Improving WFD water body status
- Consideration of the Energy Efficiency First Principle to minimise where practical GHG emissions through improved wastewater treatment plant processes and sludge disposal.
- Increasing headroom for future increase in wastewater treatment and water supply demand.
- Compliance with the provisions of the Drinking Water Directive[1] (DWD) and the Urban Wastewater Treatment Directive[2] (UWWTD).

2.1 Water supply aspects

The water supply is currently obtained from groundwater tube wells. The groundwater sources are not uniformly distributed, and their yield is not reliable.

Presently, the operation of the the water supply is through a dead end system i.e there is one main line that runs through the town or city with sub-mains branching off from left and right. These sub-mains then divide into a number of branch lines that provide service connections. In addition, the small rural communities and areas of scattered population rely on self-supply drinking water systems with shallow individual wells. Some communities have collective drinking water supply infrastructure in place. The main detected problems are the water uptake through shallow, vulnerable and polluted profiles (up to 30 m) and the existence of variable flows with the presence of incompatible elements, both organic and inorganic (arsenic), for drinking water and without the adequate treatment for its use.

The proposed project includes:

- There will be no change to the existing groundwater source.
- An additional new more reliable groundwater abstraction well and associated distribution network.
- A complete upgrade to the existing water treatment plant to increase the capacity for wastewater treatment for both groundwater abstractions.
- To improve and extend the distribution network new pumping stations are proposed, replacing the one existing pumping station. This will supply water to all small rural communities within the project area.

[1] Link to Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast): EUR-Lex - 32020L2184 - EN - EUR-Lex (europa.eu)
[2] Link to Directive Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment: EUR-Lex - 01991L0271-20140101 - EN - EUR-Lex (europa.eu)

- Solar PV panels are to be installed on the roofs of all pumping stations and the roof of the treatment plant buildings.

2.2 Wastewater treatment aspects

The 15,000 population equivalent (p.e.) in the main town is serviced by an existing Wastewater Treatment Plant (WWTP A) which discharges to the main river that flows through the town. This WWTP undertakes primary treatment with disposal of treated water to rivers and reuse of sewage sludge as agricultural fertiliser without further treatment and does not have the capacity to service the predicted population increase and is not fully compliant with the UWWTD. The 75,000 p.e. in the villages and smaller settlements outside of the town boundary are not connected to the existing WWTP and are serviced by individual septic tanks with disposal of sludge to landfill.

The proposed project includes the following:

- Upgrade of the existing WWTP (WWTP A) to more efficient processes with lower carbon emissions and to deal with a larger population equivalent. The upgraded WWTP is in the same location as the existing plant and has an extended footprint to be secured through land purchase.
    - The upgraded WWTP will have capacity to service 60,000 p.e. with tertiary treatment (Nitrogen and Phosphorous removal) with enhanced anaerobic Digestion.
    - Sewage sludge will be reused as agricultural fertiliser without further treatment.
    - Treated water will be collected and subject to further treatment for water reuse for irrigation of agricultural crops. This will include:
        - Pumping station, storage tank and pipe network to transport treated wastewater for further treatment.
        - Additional filtration with bio filters and disinfection prior after water has reached the storage tanks.
        - Pumping station and pipe networks to transfer water to irrigation channels.
        - Use of existing open irrigation channels.
- Connection of 5 small agglomerations not currently serviced, by extending the existing foul sewer pipe network to the upgraded WWTP A.
- A new WWTP (WWTP B) and wastewater pipe networks will be constructed to service 5 small agglomerations.
    - The new WWPT will have capacity for a total of 50,000 p.e. with Secondary treatment with anaerobic digestion.
    - Sewage sludge will be reused as agricultural fertiliser without further treatment.
    - A 2 ha constructed wetland will be developed to further treat discharge from WWTP B prior to discharge to the river.
- There will remain 5,000 p.e. that cannot be feasibly connected to the new WWTPs and so these shall continue to be treated through individual septic tanks, but now with disposal of sewage sludge to the upgraded WWTP A.
- Separation of some existing sections of the combined sewer network pipes to reduce the load on pumping stations and WWTP demand. Surface water in these sections will be managed by separate surface water drainage network and SuDS features so that there is no longer connection into the foul sewer network.
- Upgrades to existing pumping stations.
- New pumping stations.
- Installation of solar PV panels on new and upgraded pumping stations and buildings within the upgraded WWTP.

2.3 Alternatives to the proposed project

For the purpose of climate mitigation proofing, baseline emissions are defined as the GHG emissions from a legally compliant and economically viable alternative to the proposed project. For each of the localities/agglomerations in the study area three options for water supply and wastewater treatment were analysed as part of the Feasibility Study Options Appraisal.

The following options were considered for water supply:

1. Continue the current system and approach.
2. [preferred project] As described above.
3. [alternative to be used for the baseline GHG emission calculation] New standalone water supply network for each locality. Abstraction from either groundwater or river water depending on local conditions. Each with its own water treatment plant and pumping station.

The following options were considered for wastewater treatment:

1. [alternative will not reduce GHG emissions to a sufficient level] Upgrade and new septic tank systems.
2. [proposed project] As described above.
3. [alternative to be used for the baseline GHG emission calculation] Proposed project without reuse of water and without constructed wetland. With discharge of treated water directly to river waterbodies.
4. [alternative not economically viable] Individual wastewater treatment plant for each agglomeration.

The criteria for selecting a preferred option included appraisal of GHG emissions, the effect of climate change on water resource availability and the effect of climate change on assimilative capacity of receiving waterbodies.

2.4 Climate proofing project boundary

The project boundary for climate mitigation includes all localities/agglomerations that will be serviced by the new water and wastewater treatment facilities. This is the same boundary as the alternative to the proposed project and so the baseline (be) and absolute (ab) GHG emissions have the same project boundary. The without project GHG emissions will include the localities/agglomerations that do not receive an improved service as a result of the proposed project. This is consistent with Section 7 of the EIB Project Carbon Footprint Methodologies (version 11.3, January 2023).

For climate resilience the project boundary includes the contributing catchment of the groundwater water body source, the receiving water body for discharge of treated wastewater, and spatial extent of irrigated land and land used for spreading of sewage sludge.

3. CLIMATE MITIGATION (NEUTRALITY)

For climate mitigation (neutrality) proofing there are two phases with the following objectives:

- The screening (Phase 1) identifies whether the operation of a proposed project may result in significant absolute or relative GHG emissions above 20,000 tonnesCO_2e per year, averaged over the lifetime of the project.

- The detailed assessment (Phase 2) confirms that projects with significant carbon emissions are consistent with credible GHG pathways of national plans, sectoral plans and the Paris Agreement.

The estimation of GHG emissions for all projects will also provide useful information on indicators for operational programmes.

The stages of the carbon footprint estimation are:

1. Identifying project components which result in GHG emissions during operation of the project.
2. Defining the project boundary.
3. Defining the assessment period (first full year of operation and project lifespan).
4. Calculate:
    a. Absolute (Ab) GHG emissions.
    b. Baseline (Be) or Without Project GHG emissions.
    c. Relative (Re) GHG emissions.
5. Verify the GHG emissions in relation to the screening thresholds.
6. Monetarise the shadow cost of carbon for inclusion in the economic appraisal.
7. Very consistency of the project with GHG pathways.

3.1 Relevant GHG and global warming factors

The EIB Project Carbon Footprint Methodologies (version 11.3, January 2023) has been used as the methodology for this estimation. For water and wastewater treatment projects the following GHGs are relevant and need to be considered in the GHG emission calculations

- CH_4 from degradation of organic material in wastewater under anaerobic conditions, and management of sewage sludge.
- CO_2 emissions from the consumption of electricity in the treatment process, and transport of sewage sludge.
- N_2O as an intermediate product from the degradation of nitrogen components in wastewater.

All of the above GHG can also be emitted or sequestered from forestry, reservoirs and land use change which can be part of an overall water and wastewater project.

The following global warming potential factors[3] are used to convert GHG emissions into CO_2e.

- CH_4 x 28
- CO_2 x 1
- N_2O x 265

The specific methodology for estimating GHG emissions from project components is described in section 3.3.

For the use of electricity from the national grid the Country-specific electricity emission factor in Table 3-1 is applied. The Medium Voltage (MV) factor of 360 gCO_2/kWh (highlighted in bold text) is used for supply to all of the utility infrastructure. This is not an electricity generation project and so it is appropriate to use this value.

Table 3-1. Country specific electricity emission factor for project[4]

Emission factors in gCO_2/kWh (The impact of non-CO_2 GHGs is negligible. For calculation purposes, the factors below can be considered as CO_2e.)					
Country	Combined margin Intermittent electricity generation	Combined margin firm electricity generation/ electricity consumption	Electricity consumption/ network losses HV grid +2%	Electricity consumption/ network losses MV grid +4%	Electricity consumption/ network losses LV grid +7%
Project country	447	346	353	**360**	370

3.2 Categories and types of GHG emissions

The categories and types of GHG emissions use the definitions in the EIB Project Carbon Footprint Methodologies (version 11.3, January 2023). Relevant definitions are applied in this climate proofing document are:

- **Scope 1: Direct GHG emissions.** Direct GHG emissions are physically emitted from sources that are operated by the project. For example, emissions produced by the combustion of fossil fuels, by industrial processes and by fugitive emissions, such as refrigerants or methane leakage.

- **Scope 2: Indirect GHG emissions.** Scope 2 accounts for indirect GHG emissions associated with energy (electricity, heating, cooling and steam) consumed but not produced by the project. These are included because the project has direct control over energy consumption, for example, by improving it through energy-efficiency measures or by switching to consuming electricity from renewable sources.

[3] From Table A1.9 of EIB Project Carbon Footprint Methodologies (version 11.3 January 2023)
[4] From Table A1.3 of EIB Project Carbon Footprint Methodologies (version 11.3 January 2023)

- **Scope 3: Other indirect GHG emissions.** Scope 3 emissions are all other indirect emissions that can be considered consequences of project activities (e.g., emissions from the production or extraction of raw materials or feedstock and vehicle emissions from the use of road infrastructure, including emissions from the electricity consumption of trains and electric vehicles).

- **Absolute emissions (Ab).** Absolute emissions concern a project's emissions during a typical year of operation (that is, not including its commissioning or unplanned shutdowns).

- **Baseline emissions (Be).** Measuring baseline emissions (Be) is a useful complement to absolute emissions. It provides a credible alternative scenario "without" the project, against which the "with" project scenario[5] can be compared, giving an indication of how — measured in GHG metrics — the proposed project performs. However, the "without" project scenario, or baseline, is clearly theoretical and hence incorporates an additional level of uncertainty beyond that involved in estimating absolute emissions.

  The project baseline scenario (or "without" project scenario) is defined as the expected alternative means to meet the output supplied by the proposed project.[6]

  The baseline scenario must therefore propose the likely alternative to the proposed project which (i) in technical terms can meet the required output; and (ii) is credible in terms of economic and regulatory requirements.[7]

- **Relative emissions (Re)**. Relevant emissions (Re) concern a project's emissions from a typical year of operation (that is, not including its commissioning or unplanned shutdowns). Relative emissions are defined simply as:

  Relative Emissions = "With" Project Emissions (Wp) — "Without" Project Emissions, or Baseline Emissions (Be)

  (Re = Wp — Be)

  The "with" project emissions must have the same boundary as the "without" project emissions in terms of scope but can differ from the boundary used for absolute emissions because the boundary is sometimes extended for relative emissions, such as in the case of networks.

[5] The EIB Project Carbon Footprint Methodologies (version 11.3 January 2023) considers the "with" project scenario in this case to be the expected emissions from the project.
[6] In general, the baseline scenario is based on a combination of best-available technology and least-cost principles. In some circumstances, one could also assess alternative scenarios in which prices or regulatory requirements are used to determine options or constrain demand to existing supply. This is relevant where current pricing is clearly inefficient or when regulatory requirements impose specific conditions on all installations.
[7] A baseline that is consistent with the best economic alternative is not necessarily identical to it. The best economic alternative is defined as the most competitive and viable alternative investment to which the project is compared, whereas the baseline for the carbon footprint is the most likely outcome in the absence of the project (e.g. meeting demand through a combination of existing and new infrastructure). The baseline is expected to include the best economic alternative as a component of the emissions calculation.

This water and wastewater project is reliant on a network for water supply and wastewater collection. The indirect scope 2 GHG emission sources from the network components relate to the electricity consumption for pumping stations. There are also relevant scope 3 GHG emissions from the transport of sewage sludge. As the whole network is being considered for upgrade the project boundary for the “with” and “without” project is identical.

The alternative to the project for the carbon footprint methodology must be a means of achieving legal compliance. The current situation does not comply with legal minimum standards and so cannot be considered as the Baseline emissions.

3.3 Project components and GHG emission methodology and estimates

3.3.1 Project components

The first task is to identify the project components which during operation of the proposed project can generate direct and indirect GHG emissions, as well as relevant sources of GHG emissions in the baseline (existing operation).

GHG emission sources for in the **without project scenario (baseline emissions)** include:

- Existing WWTP A servicing 15,000 p.e.
    - Direct emissions from the primary treatment and anaerobic digestion processes.
    - Indirect emissions from electricity consumed by the WWTP.
    - Indirect emissions from the reuse of sewage sludge as agricultural fertiliser without further treatment.
- Individual septic tanks servicing 75,000 p.e.
    - Direct emissions from the septic tanks.
    - Indirect emissions from the disposal of sewage sludge to landfill without further treatment.
    - Indirect emissions from the transport of sewage sludge.
- Indirect emissions from electricity consumed by the existing:
    - groundwater supply pumping station,
    - pumping stations to distribute drinking water, and
    - pumping station on the foul sewer collection network.

GHG emission sources for the **Absolute (Ab) and with project scenario** include:

- Upgraded WWTP A servicing 60,000 p.e.
    - Direct emissions from Tertiary Treatment (Nitrogen and Phosphorous removal) with enhanced anaerobic digestion processes.
    - Indirect emissions from electricity consumed by the WWTP
    - Indirect emissions from the reuse of sewage sludge as agricultural fertiliser without further treatment.
- Filtration of water for irrigation of wastewater for 60,000 p.e.
    - Direct emissions from bio filtration process.
    - Indirect emissions from electricity consumed by the filtration process.
    - Disposal of filtered material via composting.
    - Indirect emissions from electricity consumed by pumps.
- New WWTP B servicing 50,000 p.e.
    - Direct emissions from secondary treatment with anaerobic digestion processes.
    - Indirect emissions from electricity consumed by the WWTP.

    - Indirect emissions from the reuse of sewage sludge as agricultural fertiliser without further treatment.
    - Indirect emissions from the 2 hectare constructed wetland.
- Individual septic tanks servicing 5,000 p.e.
    - Direct emissions from the septic tanks.
    - Indirect emissions from the disposal of sewage sludge to the upgraded WWTP A.
    - Indirect emissions from the transport of sewage sludge.
- Indirect emissions from electricity consumed by the:
    - upgraded groundwater supply pumping station,
    - additional groundwater supply pumping station,
    - upgraded pumping stations to distribute drinking water, and
    - upgraded and new pumping stations on the foul sewer collection network.
- Installation of solar PV panels on new and upgraded pumping stations and buildings within the upgraded WWTP.

There will be no change to septic tanks which service 5,000 p.e. in the proposed project. However these will benefit from improved sludge disposal via the upgraded WWTP A and so the direct and indirect emissions from these remaining septic tanks are included in the Absolute (Ab) GHG emissions from the project.

The operating authority have an Environmental Management Plan and are committed to reducing GHG emissions from their operational activities. These are not included here. GHG emissions associated with construction materials, activity and machinery is not to be included in the climate proofing.

The following project components will not generate any GHG emissions:

- Changes to discharge of treated water into receiving river waterbodies.
- Upgrade of existing foul sewer pipes.
- Retention of existing combined sewer outflows.
- Retention of sections of existing foul sewer pipes.
- Upgrade of existing water supply pipe network.
- Retention of sections of existing water supply pipe network.

GHG emission sources for the Baseline (Be) scenario must be for an alternative means of achieving legal compliance and include (the difference to the proposed project being the omission of the reuse of treated wastewater for agricultural supply and the electricity required for individual drinking water treatment plants and associated pumps):

- Upgraded WWTP A servicing 60,000 p.e.
    - Direct emissions from tertiary treatment (Nitrogen and Phosphorous removal) with enhanced anaerobic digestion processes.
    - Indirect emissions from electricity consumed by the WWTP.
    - Indirect emissions from the reuse of sewage sludge as agricultural fertiliser without further treatment.
- New WWTP B servicing 50,000 p.e.
    - Direct emissions from secondary treatment with anaerobic digestion processes.
    - Indirect emissions from electricity consumed by the WWTP.
    - Indirect emissions from the reuse of sewage sludge as agricultural fertiliser without further treatment.
    - Indirect emissions from the 2 ha constructed wetland.
- Individual septic tanks servicing 5,000 p.e.
    - Direct emissions from the septic tanks.
    - Indirect emissions from the disposal of sewage sludge to the upgraded WWTP A.

    - Indirect emissions from the transport of sewage sludge.
- Indirect emissions from electricity consumed by the:
    - upgraded groundwater supply pumping station,
    - 5 new surface water drinking water micro filtration treatment plants each with new pumping station.
    - 3 new reverse osmosis groundwater supply drinking water treatment plants with new pumping stations,
    - upgraded pumping stations to distribute drinking water, and
    - upgraded and new pumping stations on the foul sewer collection network.
- Installation of solar PV panels on new and upgraded pumping stations and buildings within the upgraded WWTP.

3.3.2 GHG emission methodology

3.3.2.1 Wastewater treatment processes

The GHG emissions for wastewater treatment processes are calculated using the following approach as described in the EIB Project Carbon Footprint Methodologies (version 11.3, January 2023).

$$CF= (CFWW + ID + CFSD) \times PE$$

Where:

- CF is the carbon footprint of the project expressed in t $CO2e$/year.
- CFWW is the $CO2e$ emitted per PE and per year in the wastewater treatment process (including
- CH_4 and N_2O).
- ID is the $CO2e$ indirect emissions produced by the consumed electricity per PE. The electricity was evaluated for every process, and for the emissions the grid factor used was the EU average of 245 gCO_2/kWh.
- CFSD is the $CO2e$ indirect emissions produced by the sewage sludge disposal and depends on the final destination of the sludge (landfill, land use, composting etc.).
- PE is population equivalent.

The country specific emission factor (as shown in Table 3-1) is 360 and so the Indirect Emissions (ID) values are multiplied by 1.469.

$$360 / 245 = 1.469$$

The relevant values from Annex 6 of shall be used to estimating the direct and indirect GHG emissions from wastewater treatment processes and sludge disposal. These relevant values are shown in Table 3-2.

Table 3-2. GHG emission values (tonnes per CO_2e/PE per year) for WWTP processes relevant to the proposed project[8]

Wastewater treatment process	Carbon footprint wastewater treatment (CFWW)	Indirect emissions (ID) EU average	Indirect emissions (ID) country specific	Sludge disposal	Carbon footprint sludge disposal (CFSD)	Total
Septic tanks	0.091	0.0000	0.0000	Landfill	0.194	**0.285**
				Wastewater treatment plant	0.055	**0.146**
primary treatment and anaerobic digestion	0.039	0.0024	0.0353	Land use without further treatment	0.020	**0.094**
secondary treatment with anaerobic digestion	0.014	0.0073	0.0107	Land use without further treatment	0.035	**0.060**
Tertiary Treatment (Nitrogen and Phosphorous removal) with enhanced anaerobic digestion	0.01	0.0075	0.0110	Land use without further treatment	0.027	**0.048**
Bio filters	0.017	0.0092	0.0135	Composting	0.056	**0.087**

The GHG emission estimates from the wastewater treatment components is presented in Table 3-3. The proposed project (Absolute GHG emissions) almost half the GHG emissions from the current wastewater treatment approach. The proposed project does result in higher GHG emissions from the treatment process than the alternative (Baseline GHG emissions), however this is due to the additional filtration required prior to reuse of the treated water for irrigation. The additional benefits of water reuse for irrigation are discussed and justified in the Feasibility Study.

[8] From Annex 6 of the EIB Project Carbon Footprint Methodologies (Version 11.3, January 2023)

3.3.2.2 Electricity consumption for pumping stations and drinking water treatment plants

Annual electricity consumption data is available for the last five years of operation of the existing pumping stations. The average annual energy consumption over this five-year period is used to determine the current GHG emissions.

The upgraded pumping stations will all be more efficient and require less electricity consumption per volume of water transported. Based on analysis in the Feasibility Study an average electricity consumption of 0.14 kWh/m^3 of water supplied or pumped is used in the GHG emission calculations for the upgraded pumps.

The electricity consumed by the WWTP processes are already captured in the WWTP indirect emission values.

For the Baseline (Be) emissions from the legally compliant alternative the water treatment process requires electricity consumption for treatment of water abstracted for human consumption. The Feasibility Study has estimated the electricity consumption of 0.2 kWh/m^3 for filtration process plants and 0.6 kWh/m^3 for reverse osmosis process plants.

The electricity grid factor is 360 gCO_2/kWh which is 0.00036 t.CO_2/kWh.

The GHG emission estimates from electricity consumption excluding wastewater treatment processes is presented in Table 3-4. The proposed project is estimated to significantly reduce electricity consumption compared to the current situation and also consumes less electricity that the alternative (baseline). The alternative has greater opportunity for installation of Solar PV panels as there are more utility building roofs for the installation of Solar PV panels, however this does not offset the increased electricity demand for treatment of drinking water in the alternative.

3.3.2.3 Constructed wetland

The estimation of the constructed wetland sequestration has used the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the 2013 Wetlands Supplement. The emissions are based on the specific design, concentration and flow of inputs and outputs to the constructed wetland system and not based on the surface area. The values are then converted from Methane (CH_4), and Nitrous Oxide (N_2O), Carbon Dioxide (CO_2) to CO_2equivalent (CO_2e) values.

The estimation is for 1.6 tonnes CO_2e/year to be sequestered from the wetland once it is established after 5 years.

3.3.2.4 Transport of sewage sludge

Sewage sludge transport methods will remain the same in the proposed project as for the baseline situation and the GHG emission estimates assume an average HGV with 77 TTW gCO_2e/tkm. All transport of sewage sludge is by road. This is 77 grams of CO_2e per kilometre travelled of the full load.

As documented in the Feasibility Study, the current average annual volume of sewage sludge removed from the existing septic tanks is 217,350 m^3/year. There is currently a total of 124,560 km annual average distance travelled for the collection and disposal of sewage sludge. Therefore, the current without project emissions are 9.59 tonnes CO_2e/year.

With the project the total distance travelled reduces significantly to a predicted 56,500 km per year. The Absolute (Ab) GHG emissions from the transport of sewage sludge will be 4.35 tonnes CO_2e/year. Taking a precautionary approach this assumes there is no upgrade to the HGV fleet.

The annual transport distance for sewage sludge transport is the same in the alternative to the project, used to derive the Baseline (Be) GHG emissions as the Absolute (Ab) emissions.

Table 3-3. GHG emission estimates for wastewater treatment processes

Wastewater treatment process	Sludge disposal	GHG emission for treatment process $t.CO_2e/PE/yr$	Without project p.e.	Without project GHG emissions $t.CO_2e/yr$	Baseline (alternative) p.e	Baseline (Be) emissions $t.CO_2e/yr$	With project p.e.	With project or Absolute (Ab) GHG emissions $t.CO_2e/yr$
Septic tanks	Landfill	0.285	75,000	21,375	0	0	0	0
	Wastewater treatment plant	0.146	0	0	5,000	730	5,000	730
primary treatment and anaerobic digestion	Land use without further treatment	0.094	15,000	1,410	0	0	0	0
secondary treatment with anaerobic digestion	Land use without further treatment	0.060	0	0	50,000	3,000	50,000	3,000
Tertiary Treatment (Nitrogen and Phosphorous removal) with enhanced anaerobic digestion	Land use without further treatment	0.048	0	0	60,000	2,880	60,000	2,880
Bio filters	Composting	0.087	0	0	0	0	60,000	5,220
Total				**22,785**		**6,610**		**11,830**

Table 3-4. GHG emission estimates from electricity consumption (excluding electricity consumption by wastewater treatment processes)

Component		Electricity consumption rate and unit	Without project	Without project GHG emissions $t.CO_2e/yr$	Baseline (alternative) kWh/yr	Baseline (Be) emissions $t.CO_2e/yr$	With project kWh/yr	With project or Absolute (Ab) GHG emissions $t.CO_2e/yr$
Groundwater pumping station	Existing	Average electricity use for 2017-2022	650,000 kWh/yr	234	n/a	0	n/a	0
	Upgraded	0.14 kWh/m^3	n/a	0	140,000 kWh/yr 1 million m^3	50.4	476,000 kWh/yr 3.4 million m^3	171.4
Water supply distribution network pumps	Existing	Average electricity use for 2017-2022	715,000 kWh/yr	257.4	n/a	0	n/a	0
	Upgraded	0.14 kWh/m^3	n/a	0	455,000 kWh/yr 3.25 million m^3	163.8	455,000 kWh/yr 3.25 million m^3	163.8
Wastewater collection network pumps	Existing	Average electricity use for 2017-2022	776,000 kWh/yr	279.36	n/a	0	n/a	0
	Upgraded	0.14 kWh/m^3	n/a	0	358,400 kWh/yr 2.56 million m^3	129.0	358,400 kWh/yr 2.56 million m^3	129.0
Water supply treatment plants (combined total)	Microfiltration	0.2 kWh/m^3	0 m^3	0	400,000 kWh/yr 2 million m^3	144.0	0 m^3	0
	Reverse Osmosis	0.6 kWh/m^3	0 m^3	0	750,000 kWh/yr 1.25 million m^3	270.0	0 m^3	0
Solar PV installation	Negative value for generation of electricity		0 kWh	0	-475,000 kWh/yr	-171.0	-350,000 kWh/yr	-126.0
Total				**770.76**		**586.2**		**338.2**

3.4 Climate mitigation screening conclusion

A summary of the total project GHG emissions by emission source is provided in Table 3-5.

Table 3-5. GHG emission estimates for a typical year of operation of the project.

GHG emission source	Without project GHG emissions T CO_2e/yr	Alternative to project or Baseline (Be) GHG emissions T CO_2e/yr	With project or Absolute (Be) GHG emissions T CO_2e/yr
Direct and indirect GHG emissions from wastewater treatment processes	22,785	6,610	11,830
Electricity consumption for pumping from water supply network, abstraction, wastewater collection network, and Solar PV panels	770.6	586.2	338.2
Constructed wetland	-1.6	0	-1.6
Transport of sewage sludge	9.6	4.35	4.35
Total	**23,564**	**7,201**	**12,171**

The Absolute (Ab) GHG emissions for a typical year of operation is 12,171 tonnes CO_2e/year. This is below the screening threshold for the requirement for a detailed climate proofing assessment.

The Relative (Re) GHG emissions are +4,970 tonnes CO_2e/year when compared to the alternative to the project which is a means of achieving regulatory compliance. When compared to the current without project situation (which does not achieve regulatory compliance the relative (Re) GHG emissions are -11,393 tonnes CO_2e/year. The proposed project will reduce GHG emissions compared to the current situation. There is an alternative means of achieving regulatory compliance, however the economic appraisal of project options presented in the Feasibility Study concluded that the proposed project has greater environmental benefits and is more cost effective than this alternative. The relative (Re) GHG emissions is below the screening threshold for the requirement for a detailed climate proofing assessment.

The reduction in GHG emissions compared to the current situation is consistent with the aims of the Paris Agreement.

3.5 Monetarised GHG emissions

The conversion of GHG emissions to monetary values in the form of the shadow cost of carbon is presented in Table 3-6. The shadow costs prices are taken from the EIB Group Climate Bank Roadmap 2021-2025 (November 2020). The first year of operation is the year 2030 and the project shall be fully operational from this time. The shadow costs have been estimated up to the year 2060 to cover the full 30 year appraisal period of the economic appraisal and the costs are included in the economic appraisal of the project.

The conclusion of the screening has found that a detailed assessment is not necessary for the climate proofing documentation. However, the monetarised value of GHG emissions in the form of the Shadow Cost of Carbon is presented below as an example. This cost should be included within the economic appraisal for the project as appropriate. Care is needed in the correct definition of the baseline or counterfactual scenario. In our example our proposed project is expected to generate more GHG emissions than the baseline scenario (an alternative project to achieve regulatory compliance), and less emissions than the current without project conditions (the current water and wastewater treatment process and regime). Table 3-7 presents a comparison of the shadow costs of carbon for these different scenarios.

Table 3-6. Shadow cost of carbon for the proposed project (undiscounted).

Year	Shadow cost of carbon €	Net Absolute (Ab) GHG emissions tCO_{2e} / yr	Annual cost of GHG emissions €
2021	97	12171	€ 1,180,587
2022	114	12171	€ 1,387,494
2023	131	12171	€ 1,594,401
2024	148	12171	€ 1,801,308
2025	165	12171	€ 2,008,215
2026	182	12171	€ 2,215,122
2027	199	12171	€ 2,422,029
2028	216	12171	€ 2,628,936
2029	233	12171	€ 2,835,843
2030	250	12171	€ 3,042,750
2031	278	12171	€ 3,383,538
2032	306	12171	€ 3,724,326
2033	334	12171	€ 4,065,114
2034	362	12171	€ 4,405,902
2035	390	12171	€ 4,746,690
2036	417	12171	€ 5,075,307
2037	444	12171	€ 5,403,924
2038	471	12171	€ 5,732,541
2039	498	12171	€ 6,061,158
2040	525	12171	€ 6,389,775
2041	552	12171	€ 6,718,392
2042	579	12171	€ 7,047,009

Year	Shadow cost of carbon €	Net Absolute (Ab) GHG emissions tCO_{2e} / yr	Annual cost of GHG emissions €
2043	606	12171	€ 7,375,626
2044	633	12171	€ 7,704,243
2045	660	12171	€ 8,032,860
2046	688	12171	€ 8,373,648
2047	716	12171	€ 8,714,436
2048	744	12171	€ 9,055,224
2049	772	12171	€ 9,396,012
2050	800	12171	€ 9,736,800
		Total	**€ 152,259,210**

Table 3-7. Comparison of the shadow cost of carbon for the proposed project, the baseline and without project scenarios (undiscounted)

Scenario	Net Absolute (Ab) GHG emissions tCO_{2e} / yr	Shadow cost of GHG emissions over the full appraisal period €
Proposed project	12171	€ 152,259,210
Baseline	7201	€ 90,084,510
Current conditions	23564	€ 294,785,640

4. CLIMATE RESILIENCE (ADAPTATION)

The purpose of the climate proofing tests for resilience to climate change is to ensure that investment is only spent on infrastructure that is resilient or adaptive to future change. This climate proofing follows the requirements of the EC Climate Proofing Technical Guidance.

Climate proofing for climate resilience involves identifying (1) which climate hazards the project is vulnerable to, (2) assessing the level of risk and (3) integrating adaptation measures to reduce that risk to an acceptable level. The process starts at the outset of the feasibility and options appraisal stage and should be integrated into all subsequent stages of project development. The results are used to inform decision making as the project develops. Figure 4-1 shows the progression through four main stages of work.

- A clear description of the proposed project.

- **Sensitivity (Module 1)**. Which climate hazards influence a typical project of the type proposed, considring typical components of this type of project?
- **Exposure (Module 2)**. To what degree is the project location currently exposed to climatic hazards, and by how much will this change in the future due to climate change?
- **Vulnerability (Module 3)**. Is the project potentially vulnerable to climate change, and require a detailed risk assessment?

- **Likelihood (Module 4)**. What is the probability for a climate hazard to occur, specific to the project?
- **Consequence or Impact (Module 4)**. How significant is the impact of the occurrence of the hazard on different aspects or components of the project?
- **Risk (Module 4)**. Is the project as a whole, or are individual project components, resilient to climate change impacts or there are risks that need to be addressed through adaptation measures?

- **Adaptation Options (Module 5)**. What options are available to make the project resilient to climate change?
- **Options Appraisal (Module 6).** Which adaptation options are most appropriate for the project based on the project's specificities?
- **Adaptation Planning (Module 7).** Embed climate adaptation measures within the project description, EIA process, Feasibility Study and Economic Appraisal. Include detailes of monitoring and responsibility for future adaptation.

Figure 4-1. Overview of the purpose of each stage in the climate resilience process and grouping of work into four main stages and 7 modules from the non-paper guidelines.

4.1 Project components (preparatory phase)

To undertake the sensitivity analysis all relevant project components have been identified. Each component is then subject to the sensitivity analysis to understand which climate hazards are relevant. This provides structure and focus the assessment to ensure the proposed project is resilient to possible climate risks.

Inputs	Assets	Processes	Outputs
• Ground water aquifers.	• Water treatement plant (complete upgrade to WWT). • Pumping stations. • Existing and new distribution network pipes.	• Water treatment process.	• Potable water.

Figure 4-2. Water supply project components

Inputs	Assets	Processes	Outputs
• Raw effluent	• Existing, refurbished and new foul sewer network pipes. • Upgrade to Wastewater Treatment Plant A (WWTP A). • New Wastewater Treatment Plant B (WWTP B). • Pumping stations. • Resuse storage tank. • Filtration and disinfection plant. • Existing irrigation network. • Constructed Wetland.	• Wastewater treatement processes, filtration and disinfection. • Constructed wetland treatment.	• Treated wastewater discharged to river after constructed wetland. • Reuse of treated water for irrigation. • Sewage sludge (from septic tanks and WWTP) • Land for spreading of sewage sludge

Figure 4-3. Wastewater treatment project components

Interdependencies
• Power supply to all components. • Access roads to key facilities for maintenance and operations.

Figure 4-4. Interdependencies for water and wastewater treatment aspects of the project

4.2 Screening

4.2.1 Sensitivity

The sensitivity to all climate hazards of all the project components has been scored. The scoring is based on a typical instance of that project component within the Member State. The scoring is based on the methodology in Figure 4-5. Table 4-1 below presents the Sensitivity assessment for the water supply components of the proposed project, Tables 4-2 and 4-3 below present the sensitivity of wastewater project components and presents the sensitivity of the interdependencies.

High sensitivity (score 3)

- the climate hazard may have a significant impact on assets and processes, inputs, outputs and transport links
- as a result of climate hazard occurring WWTP or water supply network shutdown for more than 2 days

Medium sensitivity (score 2)

- the climate hazard may have a slight impact on assets and processes, inputs, outputs and transport links
- as a result of climate hazard occurring WWTP or water supply network shutdown for 1-2 days, pollution incident which affects non-residential properties and has medium impact for water quality

Low sensitivity (score 1)

- the climate hazard has no (or insignificant) impact
- as a result of climate hazard occurring WWTP or water supply network shutdown for up to 24 hours, minor pollution incident affecting collection system and minor impacts for water quality

No sensitivity (score 0)

- no possible impact of the climate hazard on any of the project components
- no impact on the ability to manage the infrastructure - business as usual

Figure 4-5. Sensitivity criteria and scores (from the 2014-21 programming period JASPERS CCVRA guidance) with thresholds for a waste project

Table 4-1. Sensitivity assessment for the water supply project components

Hazard Category	**Climate Hazards**	**Inputs**	**Assets and Processes**			**Outputs**	**Global score**
		Ground Water Aquifer (Water Source)	**Water Distribution Network (pipes)**	**Pumping stations**	**Water treatment plant and treatment processes**	**Quantity and quality of water supplied**	
Heat and cold	Annual / seasonal / monthly average (air) temperature	1 Possible degradation of raw water quality through increased turbidity.	0 No impact	0 No impact	2 Impact on efficiency of treatment processes	1 Possible impact on quality of treated water.	**2**
	Extreme temperature occurrences (including heat waves)	0 no impact on groundwater sources (see drought for secondary effects of heat waves on water resources)	0 no impact	1 Difficult operating conditions which may affect pumping station efficiency and equipment	2 Possible increase in the concentration of pollutants on the influence with effect on the treatment process,	1 Additional demand for water during heatwaves.	**2**
	Cold spells	1 Difficult conditions for managing / exploiting water resources due to frost, however groundwater sources are less sensitive than surface water sources.	1 Difficult operating conditions due to frost	1 Difficult operating conditions due to frost	2 Decreased purification efficiency	1 Potential for water to freeze	**2**
	Freeze-thaw damage	0 Groundwater resources are isolated from the effect of freeze thaw cycles.	1 Minor damage to concrete structures (underground infrastructure less vulnerable to temperature variations)	2 Damage to concrete structures and electricity supply (above ground infrastructure more vulnerable to temperature variations)	2 Damage to concrete structures and electricity supply (above ground infrastructure more vulnerable to temperature variations)	2 Potential contamination from any pipe damage	**2**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs	Global score
		Ground Water Aquifer (Water Source)	**Water Distribution Network (pipes)**	**Pumping stations**	**Water treatment plant and treatment processes**	**Quantity and quality of water supplied**	
Wind	Average wind speed	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	**0**
	Maximum wind speed / Storms (tracks and intensity)	0 No impact	0 No impact	1 Possible damage to structures	3 Significant impact – can destroy the structure (Exceedance of design conditions could result in structural damage or collapse.)	0 No impact	**3**
Other air and atmospheric	Air quality	0 No impact	0 No impact	0 No impact	1 Possible impact on some treatment processes	1 Possible impact on drinking water quality.	**1**
Wet and dry	Annual / seasonal / monthly average rainfall	2 Seasonal variation in rainfall could alter groundwater aquifer recharge	0 Water supply network is sperate to stormwater drainage network so no possible interaction	0 Water supply network is sperate to stormwater drainage network so no possible interaction	1 Possible impact on water treatment process efficiency.	1 Possible change in water demand and supply.	**2**
	Extreme rainfall (frequency and magnitude)	3 Potential for rainfall to alter groundwater aquifer conditions	2 Potential ingress of untreated rainfall into water distribution network.	2 Potential for ingress into supply network with impact on pumping station efficiency.	3 Potential to decreases the efficiency of the treatment process (influential dilution) or by-pass of treatment.	2 Potential for flood water to contaminate treated water.	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs	Global score
		Ground Water Aquifer (Water Source)	**Water Distribution Network (pipes)**	**Pumping stations**	**Water treatment plant and treatment processes**	**Quantity and quality of water supplied**	
	River and groundwater flooding	3 Groundwater flooding and links between surface, coastal and fluvial flooding with groundwater could contaminate or alter groundwater aquifer conditions.	2 Potential ingress of untreated floodwater into water distribution network.	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Potential for long duration contamination of treated water	**3**
	Aridity	0 Aridity has no direct impact on groundwater resources.	0 No impact	0 No impact	0 No impact	2 Increased water demand for irrigation reducing drinking water availability	**2**
	Drought / Water availability	3 Significant impact on water resources	0 No impact on the distribution network.	0 No impact on pumping stations	0 No impact on the treatment plant itself or treatment process.	3 Insufficient water to meet demand	**3**
	Wild Fire	0 No impact	0 No impact	3 Infrastructure damage, danger of explosion	3 Infrastructure damage, danger of explosion	2 Potential increased demand for water for firefighting	**3**
Snow and ice	Avalanche	0 No impact	0 No impact	3 Avalanche could significantly damage pumping stations	3 Avalanche could significantly damage water treatment plants	0 No impact	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs	Global score
		Ground Water Aquifer (Water Source)	Water Distribution Network (pipes)	Pumping stations	Water treatment plant and treatment processes	Quantity and quality of water supplied	
					and impact on treatment processes		
	Melting permafrost	3 Potential for change to groundwater recharge and quality	3 Potential for changes to ground stability	3 Potential for changes to ground stability	3 Potential for changes to ground stability	0 No impact	**3**
	Ice flows in rivers	3 Potential change to groundwater recharge and quality which may last for a season.	0 No impact	0 No impact	0 No impact	0 No impact	**3**
Coastal	Sea level rise	0 No impact	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Possible saline incursion into drinking water supply.	**3**
	Flood (coastal)	3 Groundwater flooding and links between surface, coastal and fluvial flooding with groundwater could contaminate or alter groundwater aquifer conditions.	2 Potential ingress of untreated floodwater into water distribution network.	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Potential for contamination of treated water	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs	Global score
		Ground Water Aquifer (Water Source)	Water Distribution Network (pipes)	Pumping stations	Water treatment plant and treatment processes	Quantity and quality of water supplied	
	Coastal erosion	3 Potential for change to groundwater recharge and quality	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	2 Potential for contamination of treated water	**3**
Oceanic	Sea water temperature	0 no impact	0 no impact	0 no impact	0 no impact	0 no impact	**0**
	Ocean acidity	1 Possible but unlikely effect on groundwater quality	1 Possible effect in water quality which may affect piping of network	0 No impact	1 Possible effect in water quality which may affect treatment plant parts	0 no impact	**1**
	Ocean oxygen level	1 Possible but unlikely effect on groundwater quality	1 Possible effect in water quality which may affect piping of network	0 No impact	1 Possible effect in water quality which may affect treatment plant processes	0 No impact	**1**
	Ocean salinity	1 Possible but unlikely effect on groundwater quality	1 Possible effect in water quality which may affect piping of network	0 No impact	1 Possible effect in water quality which may affect treatment plant parts	0 no impact	**1**
Other water	Fresh water temperature	2 Changing the quality of groundwater sources,	0 no impact	1 Possible effect on pumping station flow and efficiency.	2 Possible increase of the pollutant concentration on the	1 Possible slight impact on quality of supplied water	**2**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs	Global score
		Ground Water Aquifer (Water Source)	Water Distribution Network (pipes)	Pumping stations	Water treatment plant and treatment processes	Quantity and quality of water supplied	
		complicating the treatment process			influence with effect on the treatment process		
	Fresh water quality	3 Potential for change to groundwater quality	1 Possible effect in water quality which may affect piping of network	0 No impact	3 Increase level of water treatment required	3 Lack of water fit for supply	**3**
Land, soil and geotechnical	Soil erosion	0 no impact on groundwater sources	0 no impact	0 no impact	0 no impact	1 Possible slight impact on quality of supplied water	**1**
	Saline intrusion	3 Saline intrusion into groundwater aquifers would significantly alter quality and availability of fresh water	1 Possible effect in water quality which may affect piping of network	1 Possible corrosive impact on pumping station equipment	3 Treatment process may not be able to deal with saline water	3 Lack of water fit for supply	**3**
	Ground Instability / landslides	3 Potential change to groundwater recharge hydrology	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Potential incursion of untreated water into supply	**3**
	Dust storms	0 no impact on groundwater sources	0 no impact	1 Difficult operating conditions, minor sand deposits on pumping station equipment	1 Difficult operating conditions, minor sand deposits on the technological line	1 Possible impact on water quality from dust settling	**1**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs	Global score
		Ground Water Aquifer (Water Source)	**Water Distribution Network (pipes)**	**Pumping stations**	**Water treatment plant and treatment processes**	**Quantity and quality of water supplied**	
	Earthquake	3 Potential change to groundwater recharge hydrology	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Potential incursion of untreated water into supply	**3**

Table 4-2. Sensitivity assessment for the wastewater project components

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	**Sewerage networks (new and existing) including pumping stations**	**Wastewater treatment plants and treatment processes (inc. filtration and disinfection)**	**Constructed wetland**	**Receiving river water body**	**Land used for spreading of sewage sludge**	**Reuse of treated water for irrigation and irrigation channels**	
Heat and cold	Annual / seasonal / monthly average (air) temperature	1 Possible increase in concentration of pollutants in effluent	0 No impact	2 Impact on processes involved	1 Impact on natural processes may alter effectiveness of tertiary treatment	0 No impact	1 Possible effect of land quality change on baseline which may result in air quality from sludge spreading exceeding tolerable thresholds	1 Possible effect on soil and growing conditions and demand for irrigation water	**2**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	Sewerage networks (new and existing) including pumping stations	Wastewater treatment plants and treatment processes (inc. filtration and disinfection)	Constructed wetland	Receiving river water body	Land used for spreading of sewage sludge	Reuse of treated water for irrigation and irrigation channels	
	Extreme temperature occurrences (including heat waves)	2 Possible decrease in wastewater flow which could increase concentration of pollutants	2 Possible of difficult conditions from potential for clogged pipes and accumulation of gases resulting from fermentation	2 Possible increase in the concentration of pollutants on the influence with effect on the treatment process	2 Decreases the efficiency of the treatment process	2 Possible change to hydrological regime and temperature of water body	1 Possible effect of soil temperature and conditions which could alter the available window for sludge spreading	0 Possible increase in seasonal demand for irrigation (not likely to have a negative impact on the project itself)	**2**
	Cold spells	0 No impact	0 No impact	2 Decreased purification efficiency due to the decrease of the influence temperature below the allowable limit	1 Impact on functioning of wetland	2 Possible change to hydrological regime and temperature of water body.	1 Possible effect of soil temperature and conditions which could alter the available window for sludge spreading.	2 Possible reduction in irrigation demand affecting storage capacity	**2**
	Freeze-thaw damage	1 Potential increase in	1 Minor damage to concrete structures (underground	2 Damage to concrete structures and electricity supply (above ground	0 No impact	0 No impact	1 Possible effect of soil temperature and conditions which	0 No impact	**2**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	Sewerage networks (new and existing) including pumping stations	Wastewater treatment plants and treatment processes (inc. filtration and disinfection)	Constructed wetland	Receiving river water body	Land used for spreading of sewage sludge	Reuse of treated water for irrigation and irrigation channels	
		discharged flow from snow melt	infrastructure less vulnerable to temperature variations)	infrastructure more vulnerable to temperature variations)			could alter the available window for sludge spreading.		
Wind	Average wind speed	0 No impact	0 No impact	1 Possible secondary effect on air quality and odour through changes in wind speed and direction.	0 No impact	0 No impact	1 Possible secondary effect on air quality and odour through changes in wind speed and direction.	0 No impact	**1**
	Maximum wind speed / Storms (tracks and intensity)	0 No impact	0 No impact	1 Possible damage to structures	0 No impact	0 No impact	0 No impact	0 No impact	**1**
Other air and atmospheric	Air quality	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	2 Possible effect of air quality change on baseline which may result in air quality from	0 No impact	**2**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	**Sewerage networks (new and existing) including pumping stations**	**Wastewater treatment plants and treatment processes (inc. filtration and disinfection)**	**Constructed wetland**	**Receiving river water body**	**Land used for spreading of sewage sludge**	**Reuse of treated water for irrigation and irrigation channels**	
							sludge spreading exceeding tolerable thresholds.		
Wet and dry	Annual / seasonal / monthly average rainfall	1 Possible change in the concentration of pollutants and total volume of discharge	1 Possible change in the total volume of discharge in relation to pipe network capacity and frequency of combined sewer flows.	1 Possible change to volume of discharge and concentration of pollutants for treatment	2 Possible secondary effect on hydrological regime and treatment process.	2 Possible secondary effect on flow regime and assimilative capacity for sufficient dilution.	2 Possible effect of soil moisture and the number of wet days which could alter the available window for sludge spreading.	2 Change in demand for irrigation water and available storage capacity.	**2**
	Extreme rainfall (frequency and magnitude)	3 Increase in flow which could exceed inlet capacity to sewer networks	3 Exceeding network capacity, urban flooding, uncontrolled discharges, bypass of treatment, and combined sewer discharge	3 Difficult / impossible conditions for water resources management	3 Severe impact on performance	3 Erosion or scour of riverbanks at discharge outlets could alter local dilution of discharge.	2 Possible effect of soil moisture and the number of wet days which could alter the available window for sludge spreading.	2 Reduced demand for irrigation water and available storage capacity.	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	**Sewerage networks (new and existing) including pumping stations**	**Wastewater treatment plants and treatment processes (inc. filtration and disinfection)**	**Constructed wetland**	**Receiving river water body**	**Land used for spreading of sewage sludge**	**Reuse of treated water for irrigation and irrigation channels**	
	River flooding	3 Increase in flow which could exceed inlet capacity to sewer networks	3 Exceeding network capacity, urban flooding, uncontrolled discharges, bypass of treatment, and combined sewer discharge	3 Decreases the efficiency of the treatment process (influential dilution), by-pass, uncontrolled discharges	2 Potential exceedance of water inputs into the wetland system that reduces tertiary treatment capacity.	3 Erosion or scour of riverbanks at discharge outlets could alter local dilution of discharge.	3 Flooded land may be unavailable for spreading of sewage sludge.	2 Reduced demand for irrigation water and available storage capacity.	**3**
	Aridity	2 Possible decrease in wastewater flow which could increase concentration of pollutants	0 No impact	0 No impact	2 Possible effect on hydrological regime which could alter the effectiveness of the treatment process.	1 Dry riverbanks may be more susceptible to erosion and increase turbidity of receiving water body	2 Possible effect of soil moisture and the number of wet days which could alter the available window for sludge spreading.	0 Increased demand for irrigation water (not likely to have a negative impact on the project itself)	**2**
	Drought / Water availability	2 Possible decrease in wastewater flow which could	0 No impact on the network itself	0 No impact on the treatment plant itself or treatment process	2 Possible effect on hydrological regime which could alter the	3 Insufficient flow for dilution	2 Possible effect of soil moisture and the number of wet days	0 Increased demand for irrigation water (not likely to	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	Sewerage networks (new and existing) including pumping stations	Wastewater treatment plants and treatment processes (inc. filtration and disinfection)	Constructed wetland	Receiving river water body	Land used for spreading of sewage sludge	Reuse of treated water for irrigation and irrigation channels	
		increase concentration of pollutants			effectiveness of the treatment process.	of discharged water.	which could alter the available window for sludge spreading.	have a negative impact on the project itself)	
	Wild Fire	0 No impact	0 No impact	3 Infrastructure damage, danger of explosion	0 No impact	0 No impact	2 Possible effect on soil conditions and suitability for sludge spreading.	0 Increased demand for water (not likely to have a negative impact on the project itself)	**3**
Snow and ice	Avalanche	2 Potential significant input to hydrological regime and concentration of pollutants	3 Avalanche could significantly damage pumping stations	3 Avalanche could significantly damage water treatment plants and impact on treatment processes	2 Potential damage to wetland	1 Possible effect of avalanche on river flow	0 No impact	0 No impact	**3**
	Melting permafrost	3 Potential change to hydrological regime and	3 Potential for changes to ground stability	3 Potential for changes to ground stability	0 No impact. Constructed wetlands would	3 Potential change to hydrological	0 No impact as permafrost soil is unsuitable for	0 No impact as permafrost soil	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	Sewerage networks (new and existing) including pumping stations	Wastewater treatment plants and treatment processes (inc. filtration and disinfection)	Constructed wetland	Receiving river water body	Land used for spreading of sewage sludge	Reuse of treated water for irrigation and irrigation channels	
		concentration of pollutants			unlikely be constructed in permafrost soils.	regime and assimilative capacity of receiving water body	spreading of sewage sludge.	is unsuitable for irrigation.	
	Ice flows in rivers	2 Potential change to hydrological regime and concentration of pollutants	0 No impact	0 No impact	2 Potential damage from ice flows or rapid thaw to wetlands.	3 Potential change to hydrological regime and assimilative capacity of receiving water body	0 No impact	0 No impact	**3**
Coastal	Sea level rise	3 Potential incursion of sea water during high tides.	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact – increase of water levels	3 Could significantly alter land available for sewage sludge spreading	3 Could significantly alter land available for irrigation and demand for irrigation	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	**Sewerage networks (new and existing) including pumping stations**	**Wastewater treatment plants and treatment processes (inc. filtration and disinfection)**	**Constructed wetland**	**Receiving river water body**	**Land used for spreading of sewage sludge**	**Reuse of treated water for irrigation and irrigation channels**	
	Coastal flooding	3 Increase in flow which could exceed inlet capacity to sewer networks	3 Exceeding network capacity, uncontrolled discharges, bypass of treatment, and combined sewer discharge	3 Decreases the efficiency of the treatment process (influential dilution), by-pass, uncontrolled discharges	2 Potential exceedance of water inputs into the wetland system that reduces tertiary treatment capacity.	3 Erosion or scour of riverbanks at discharge outlets could alter local dilution of discharge.	3 Flooded land may be unavailable for spreading of sewage sludge.	2 Change in demand for irrigation water and available storage capacity.	**3**
	Coastal erosion	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Significant change in water body	3 Loss of land suitable for sludge spreading.	2 Change in demand for irrigation water and available storage capacity.	**3**
Oceanic	Sea water temperature	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	**0**
	Ocean acidity	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	**0**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	Sewerage networks (new and existing) including pumping stations	Wastewater treatment plants and treatment processes (inc. filtration and disinfection)	Constructed wetland	Receiving river water body	Land used for spreading of sewage sludge	Reuse of treated water for irrigation and irrigation channels	
	Ocean oxygen level	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	**0**
	Ocean salinity	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	0 No impact	**0**
Other water	Fresh water temperature	2 Increase in pollution concentration	2 Difficult operating conditions due to low flow rates, accumulation of gases resulting from fermentation	2 Possible increase of the pollutant concentration on the influence with effect on the treatment process	2 Changing the quality of water sources, complicating the treatment process	2 Possible variation in temperature of water body which could reduce assimilative capacity.	1 Possible effect on soil conditions and suitability for sludge spreading.	2 Water quality does not meet minimum standards for irrigation reuse	**2**
	Fresh water quality	2 Increase in pollution concentration	2 Difficult operating conditions due to low flow rates, accumulation of gases resulting from fermentation	2 Possible increase of the pollutant concentration on the influence with effect on the treatment process	2 Changing the quality of water sources, complicating the treatment process	3 Impact on assimilative capacity of receiving water body	1 Possible effect on soil conditions and suitability for sludge spreading.	3 Water quality does not meet minimum standards for irrigation reuse	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	**Sewerage networks (new and existing) including pumping stations**	**Wastewater treatment plants and treatment processes (inc. filtration and disinfection)**	**Constructed wetland**	**Receiving river water body**	**Land used for spreading of sewage sludge**	**Reuse of treated water for irrigation and irrigation channels**	
Land, soil and geotechnical	Soil erosion	0 No impact	0 No impact	0 No impact	1 Could result in effect on the wetland structure	2 Possible change is morphology and sediment regime of water body which could reduce assimilative capacity.	2 Possible effect on soil conditions and suitability for sludge spreading.	2 Change in demand for irrigation water.	**2**
	Saline intrusion	2 Increase in salinity of effluent that requires treatment	1 Possible network erosion	1 Possible impairment of the treatment process.	2 Decrease in quality of water sources, Difficult / impossible conditions for managing the treatment process	2 Decrease in quality of water, and reduction in assimilative capacity of receiving water body.	2 Possible effect on soil conditions and suitability for sludge spreading.	2 Change in demand for irrigation water.	**2**
	Ground Instability / landslides	2 Potential change in pollutant concentration	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Natural functions within the wetland can adapt to ground	3 Significant impact – could cause morphological	3 Could significantly alter land available for sewage	2 Change in demand for	**3**

Hazard Category	Climate Hazards	Inputs	Assets and Processes			Outputs			Global score
		Raw effluent	Sewerage networks (new and existing) including pumping stations	Wastewater treatment plants and treatment processes (inc. filtration and disinfection)	Constructed wetland	Receiving river water body	Land used for spreading of sewage sludge	Reuse of treated water for irrigation and irrigation channels	
					instability, but landslide could fill the wetland.	change to the water body	sludge spreading	irrigation water.	
	Dust storms	1 Possible slight change in concentration of dust particles within effluent	0 No impact	1 Difficult operating conditions, minor sand deposits on the technological line	0 No impact	1 Could reduce water quality	0 No impact	2 Change in demand for irrigation water.	**2**
	Earthquake	2 Could alter effluent flow volume	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	3 Natural functions within the wetland can adapt to ground instability, but landslide could fill the wetland.	3 Significant impact – could cause morphological change to the water body	3 Could significantly alter land available for sewage sludge spreading	2 Change in demand for irrigation water.	**3**

Table 4-3. Sensitivity assessment for the interdependencies for water and wastewater aspects of the project

Hazard category	**Climate Hazards**	**Interdependencies for water and wastewater aspects**		**Global score**
		Power supply	**Access roads**	
Heat and cold	Annual / seasonal / monthly average (air) temperature	2 Medium impact if metal used for wiring is sensitive	0 No impact	**2**
	Extreme temperature occurrences (including heat waves)	0 no impact	0 no impact	**0**
	Cold spells	2 Potential to increase demand for electricity.	1 Possible difficult operating conditions due to icy road conditions	**2**
	Freeze-thaw damage	0 no impact	0 no impact	**0**
Wind	Average wind speed	0 Average wind speeds will not have any impact on transmission network.	0 No impact from average wind speeds.	**0**
	Maximum wind speed / Storms (tracks and intensity)	2 Possible impact from high winds on overground power distribution networks to structures	2 Some access routes may be temporarily cut off during and after storms.	**2**
Other air and atmospheric	Air quality	0 No impact	0 No impact	**0**
Wet and dry	Annual / seasonal / monthly average rainfall	0 No impact	1 Slight impact on road drainage may occur	**1**
	Extreme rainfall (frequency and magnitude)	2 Medium impact (possible power outage from flooding to transmission network)	2 Medium impact (possible flooding of access roads)	**2**
	River flooding	2 Medium impact (possible power outage from flooding to transmission network)	2 Medium impact (possible flooding of access roads)	**2**

Hazard category	Climate Hazards	Interdependencies for water and wastewater aspects		Global score
		Power supply	Access roads	
	Aridity	0 No impact	0 No impact	**0**
	Drought	0 no impact	0 no impact	**0**
	Wild Fire	3 Infrastructure damage	2 Access routes may be cut off for the duration of a wildfire.	**3**
Snow and ice	Avalanche	3 Avalanche could significantly damage power supply networks	3 Avalanche could cut off access or damage access roads	**3**
	Melting permafrost	0 no impact	0 no impact	**0**
	Ice flows in rivers	0 no impact	0 no impact	**0**
Coastal	Sea level rise	3 Significant impact on the integrity of the infrastructure	3 Significant impact on the integrity of the infrastructure	**3**
	Coastal flooding	2 Medium impact (possible power outage from flooding to transmission network)	2 Medium impact (possible flooding of access roads)	**2**
	Coastal erosion	3 Significant impact on the integrity of the infrastructure	2 Potential erosion of access roads in coastal environments.	**3**
Oceanic	Sea water temperature	0 no impact	0 no impact	**0**
	Ocean acidity	0 No impact	0 No impact	**0**
	Ocean oxygen level	0 No impact	0 No impact	**0**

Hazard category	Climate Hazards	Interdependencies for water and wastewater aspects		Global score
		Power supply	Access roads	
	Ocean salinity	0 No impact	0 No impact	**0**
Other water	Fresh water temperature	0 no impact	0 no impact	**0**
	Fresh water quality	0 no impact	0 no impact	**0**
Land, soil and geotechnical	Soil erosion	0 no impact	0 no impact	**0**
	Saline intrusion	0 no impact	0 no impact	**0**
	Soil salinity	0 no impact	0 no impact	**0**
	Ground Instability / landslides	3 Significant impact on the integrity of the infrastructure	3 Significant impact on road networks.	**3**
	Dust storms	0 no impact	1 Impact on visibility	**1**
	Earthquake	3 Significant impact on the integrity of the infrastructure	3 Significant impact on road networks.	**3**

4.2.2 Exposure

It is reminded that the climate proofing document should be:

- **complete;**
- **evidence-based;**
- **well-referenced;**
- **well justified.**

Therefore, it is necessary to present in this chapter all the necessary details regarding the current and the future climate data for all climate hazards. This should include information about the historical and current situation and projections for the future for the entire lifespan of the project. It should be based on reliable national and EU sources.

The preference for information on climate impacts should be in order below so that local and high-resolution impact data, where available, is used in preference to broad scale assessments:

1. ***Project specific analysis of climate hazards which influence the project design (e.g., hydrological and hydraulic models used to develop and design flood risk management infrastructure, water resource models for water supply projects, receiving water body diffuse pollution models).***
2. ***Existing national risk maps and inventories such as River Basin Management Plans, Floods Directive flood hazard and risk maps, coastal erosion risk maps, landslide and flash flood risk zones and maps.***
3. ***Official national climate change (adaptation) strategies, scenarios, datasets, meteorological data, assessments and reports and communications to the UNFCCC.***
4. ***EU climate indicators and assessments, at Regional or Member State level (e.g., data published on C3C Copernicus Climate Data Explorer, or EEA reports based on CMIP5 and EURO-CODEX data).***
5. ***IPCC AR6 climate impacts.***

The exposure must be informed by official or nationally/regionally adopted climate data. Climate projections and assessment of impacts should be based on best practice and available guidance, taking into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change (IPCC) reports. The use of academic research should not be used if it is not part of an adopted national or regional dataset.

4.2.2.1 *Description of climatic conditions, project change and timescales and projections used to inform exposure.*

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report — IPCC (AR6) completed in 2022 includes a dedicated chapter on the climate change impacts, risks and vulnerability to Europe[9].

The AR6 reports use the term Global Warming Levels (GWL) which refers to global climate-change emissions relative to pre-industrial levels, expressed as global surface air temperature.

A core set of five illustrative scenarios based on the Shared Socio-economic Pathways (SSPs) are used consistently across the latest ICCP AR6 Reports: SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. These scenarios cover a broader range of greenhouse gas and air pollutant futures than assessed in earlier IPCC reports, and they include high-CO_2 emissions pathways without climate change mitigation as well as new low-CO_2 emissions pathways.

Figure 4-6 shows when the different GWLs are projected to occur under the different SSPs. The IPCC AR6 Technical Summary (Box TS2.2) states common set of reference years and time periods for describing climate impacts. These are the near-term (2021-2040), mid-term (2041-2060) and long-term (2081-2100). It is clear that all SSPs result in a similar GWL in the near term, with divergence starting in the mid-term and significant variation in the long-term. This exposure section of the climate proofing document focuses on the exposure of the project location to the resulting climate hazards.

The first year of operation for the project is expected to be in the middle of the near-term (2021-2040) time period and so conditions under a 1.5 °C warmer world will be used as the data of the current exposure. If the SSP 1-1.9 or SSP 1-2.6 are followed then this will also reflect the future long-term exposure of the project location.

The lifetime of the project infrastructure is 100 years and so the long-term (2081-2100) time period will be used for the future exposure. It is not possible to confirm which SSP or GWL will occur in the long-term and so the exposure of the project location will be assessed where comparable data for determining exposure to the hazard data for the SSP 2-4.5 (similar to a 3 °C GWL) and SSP 3-7.0 (similar to a 4 °C GWL). This will allow for the climate proofing risk assessment consider any limits to the adaptive capacity of the proposed project.

[9] Bednar-Friedl, B., R. Biesbroek, D.N. Schmidt, P. Alexander, K.Y. Børsheim, J. Carnicer, E. Georgopoulou, M. Haasnoot, G. Le Cozannet, P. Lionello, O. Lipka, C. Möllmann, V. Muccione, T. Mustonen, D. Piepenburg, and L. Whitmarsh, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1817–1927, doi:10.1017/9781009325844.015.

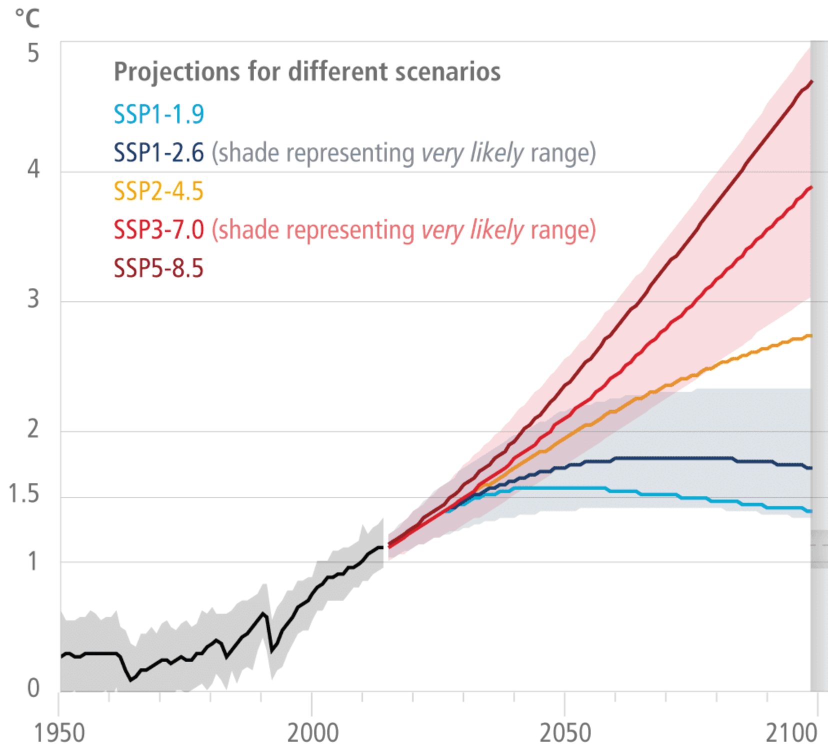

Figure 4-6. Global surface temperature change in °C relative to 1850-1900 for five Shared Socio-economic Pathways (Figure TS.4(a) from Technical Summary to the 6th Assessment Report[10]).

The AR6 concludes that the current trend and situation for Europe is:

"Our current 1.1°C warmer world is already affecting natural and human systems in Europe (very high confidence1). Since AR5, there has been a substantial increase in detected or attributed impacts of climate change in Europe, including extreme events (high confidence). Impacts of compound hazards of warming and precipitation have become more frequent (medium confidence). Climate change has resulted in losses of, and damages to, people, ecosystems, food systems, infrastructure, energy and water availability, public health and the economy (very high confidence)".

The AR6 finds that:

"Warming in Europe will continue to rise faster than the global mean, widening risk disparities across Europe in the 21st century (high confidence). Largely negative impacts are projected for southern regions (e.g., increased cooling needs and water demand, losses in agricultural production and water

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[10] Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 37–118, doi:10.1017/9781009325844.002.

scarcity) and some short-term benefits are anticipated in the north (e.g., increased crop yields and forest growth)".

Four key risks have been identified for Europe. The summaries below are taken from chapter 13 of AR6 and set the scene for the exposure assessment at the regional scale.

- **Key Risk 1: Heat. mortality and morbidity of people and ecosystems disruptions due to heat.**

  "The number of deaths and people at risk of heat stress will increase two- to threefold at 3°C compared with 1.5°C GWL (high confidence). Risk consequences will become severe more rapidly in Southern and Western Central Europe and urban areas (high confidence). Thermal comfort hours during summer will decrease significantly (high confidence), by as much as 74% in Southern Europe at 3°C GWL. Above 3°C GWL, there are limits to the adaptation potential of people and existing health systems, particularly in Southern Europe, Eastern Europe and areas where health systems are under pressure (high confidence).

  Warming will decrease suitable habitat space for current terrestrial and marine ecosystems and irreversibly change their composition, increasing in severity above 2°C GWL (very high confidence). Fire-prone areas are projected to expand across Europe, threatening biodiversity and carbon sinks (medium confidence). Adaptation actions (e.g., habitat restoration and protection, fire and forest management, and agroecology) can increase the resilience of ecosystems and their services. Trade-offs between adaptation and mitigation options (e.g., coastal infrastructure and NbS) will result in risks for the integrity and function of ecosystems (medium confidence)."

- **Key Risk 2: Agriculture. loss in agricultural production due to combined heat and droughts.**

  "Due to a combination of heat and drought, substantive agricultural production losses are projected for most European areas over the 21st century, which will not be offset by gains in Northern Europe (high confidence). Yield losses for maize will reach 50% in response to 3°C GWL, especially in Southern Europe. Yields of some crops (e.g., wheat) may increase in Northern Europe if warming does not exceed 2°C (medium confidence). While irrigation is an effective adaptation option for agriculture, the ability to adapt using irrigation will be increasingly limited by water availability, especially in response to GWL above 3°C (high confidence)."

- **Key Risk 3: Water scarcity. Water scarcity across sectors.**

  "Risk of water scarcity will become high at 1.5°C and very high at 3°C GWL in Southern Europe (high confidence), and increase from moderate to high in Western Central Europe (medium confidence). In Southern Europe, more than a third of the population will be exposed to water scarcity at 2°C GWL; under 3°C GWL, this risk will double, and significant economic losses in water- and energy-dependent sectors may arise (medium confidence). For Western Central and Southern Europe, and for many cities, the risk of water scarcity will be strongly increasing under 3°C GWL. Adaptation becomes increasingly difficult at 3°C GWL and above, due to geophysical and technological limits; hard limits are likely2 first reached in parts of Southern Europe."

- **Key Risk 4: Flooding. Impacts of floods on people, economies and infrastructure.**

  "Due to warming, changes in precipitation and sea level rise (SLR), risks to people and infrastructures from coastal, riverine and pluvial flooding will increase in Europe (high confidence). Risks of inundation and extreme flooding will increase with the accelerating pace

of SLR along Europe's coasts (high confidence). Above 3°C GWL, damage costs and people affected by precipitation and river flooding may double. Coastal flood damage is projected to increase at least tenfold by the end of the 21st century, and even more or earlier with current adaptation and mitigation (high confidence). Sea level rise represents an existential threat for coastal communities and their cultural heritage, particularly beyond 2100."

The exposure assessment is proportionate to the type of climate hazards which have the greatest effect on water and wastewater projects. The exposure scores for water related climate hazards are therefore analysed in more detail than wind related hazards.

The proposed project is located within the Western and Central Europe (WCE) region of the AR6 as seen in Figure 4-7. The project is not in a coastal area and so the marine sub-regions are not applicable to this climate proofing document. Figure 4-8 shows the projected direction of change in climate impacts for each of these European Regions.

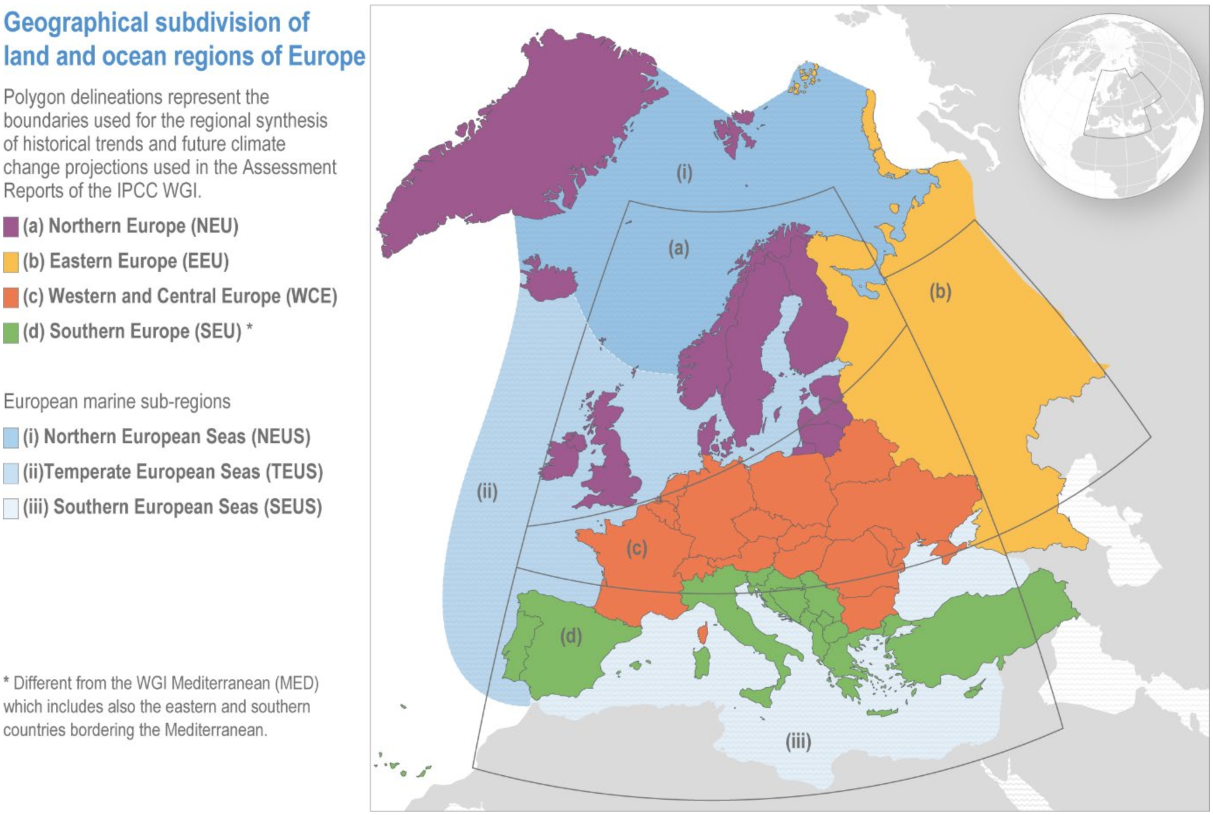


Figure 4-7. Regions of Europe used in AR6 (figure 13.1 from chapter 13 Europe of AR6 report)

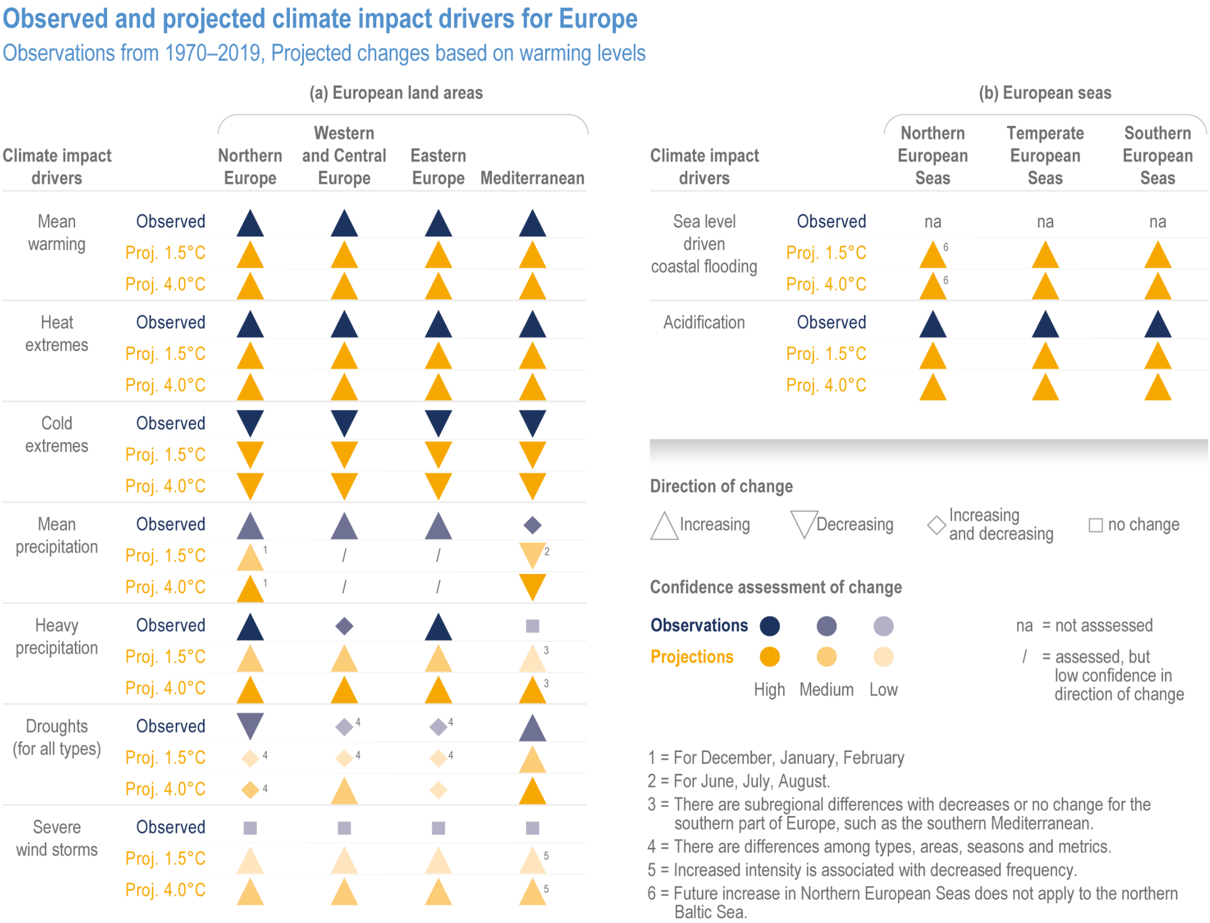


Figure 4-8. Observed and projected direction of change in climate-impact drivers at 1.5°C and 4°C GWL for European sub-regions and European seas. (Figure 13.3 of AR6 Chapter 13 based on assessment from Gutiérrez et al., 2021; Ranasinghe et al., 2021; Seneviratne et al., 2021).

In 2017, The European Environmental Protection Agency (EEA) published a report "Climate change, impacts and vulnerability in the countries in Europe"[11], which contains information on past and projected climate change and related impacts in Europe assessed on the basis of the number of indicators, an assessment of the vulnerability of society, human health and ecosystems in Europe, and defines those regions that are at the highest risk of climate change.

In the Continental Region of Europe and the EEA report summarises the key climate change impacts which are presented in Figure 4-9, which for this region are:

- Increase in heat extremes,
- Decrease in summer precipitation,
- Increasing risk of river floods,
- Increasing risk of forest fires,
- Decrease in economic value of forests, and

[11] EEA, 2017, Climate change, impacts and vulnerability in Europe 2016 — an indicator-based report, EEA Report No 1/2017, European Environment Agency.

- Increase in energy demand for cooling.

Many of these observed trends for the hazards are expected to continue in the near future and a part of them to amplify on medium and long terms, as global warming is progressing towards the end of this century. The key climate change impacts are consistent with those described in the IPCC AR6, however the more recent AR6 report provides more recent science. The EEA[12] and ClimateADAPT[13] continue to publish impact assessments of specific climate change indicators.

Where there is no nationally specific climate impact assessment for a climate hazard, a decision is made on whether the IPCC AR6, ClimateADAPT or EEA indicators are most relevant to the project location for that climate hazard.

[12] Indicators — European Environment Agency (europa.eu)
[13] Indicators in Climate-ADAPT — English (europa.eu)

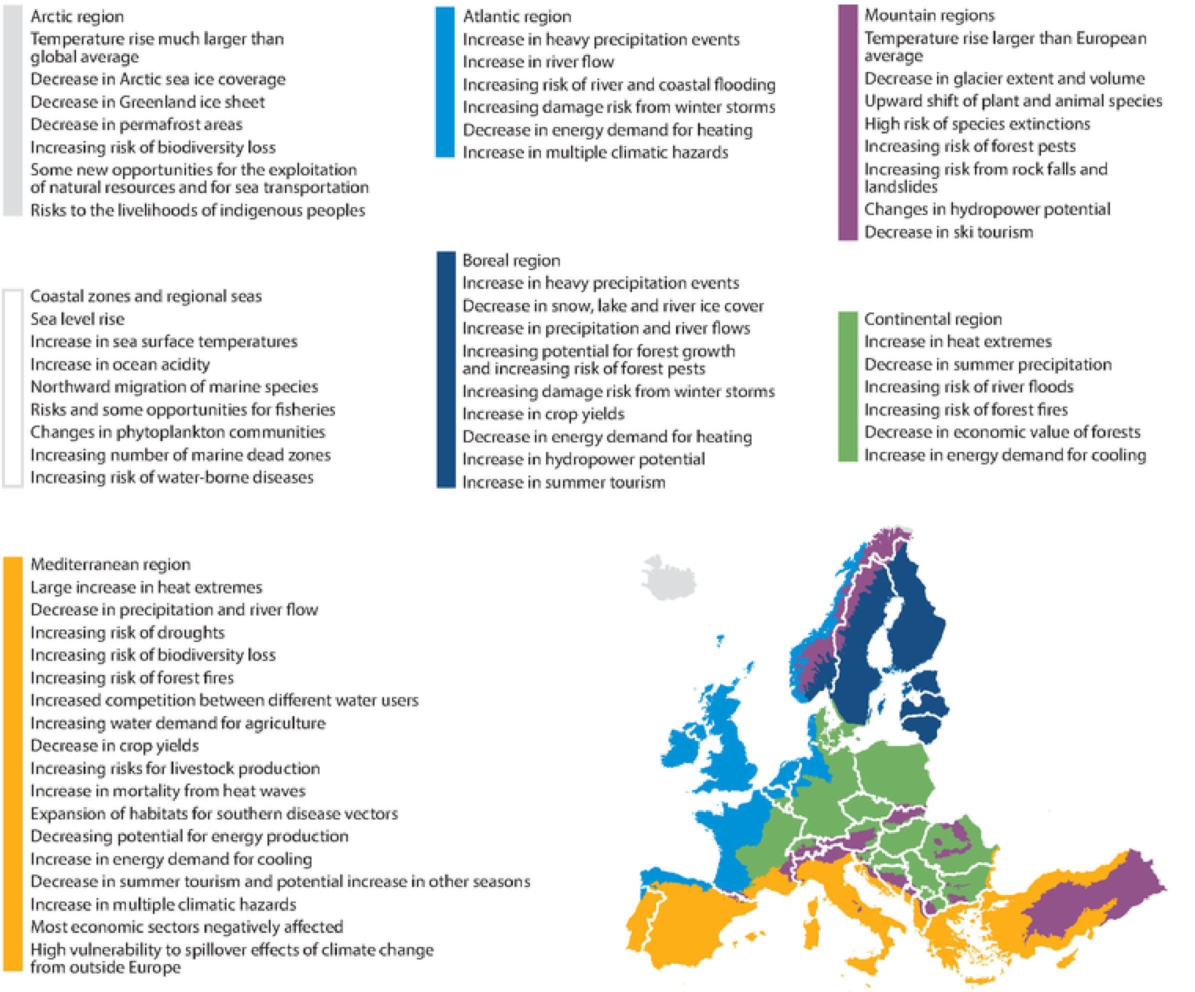


Figure 4-9. Observed and projected climate change and impacts for the main biogeographical regions in Europe (Map ES.1 from Climate Change, impacts and vulnerability in Europe in 2016[14]).

[14] [Climate change, impacts and vulnerability in Europe 2016 — European Environment Agency (europa.eu)]

According to the latest national communication on climate change and adaptation strategy, the territory of the county belongs to the sector with continental climate. The climatic regime is characterized in the continental part by hot summers with weak rainfalls and not too cold winters, but in which sometimes strong blizzards appear, but also with frequent heating intervals that interrupt the continuity in time of the snow layer. The maritime area of the county is characterized by summers whose heat is attenuated by the sea breeze. Winters are characterized by temperatures not too low but marked by strong, cold winds, from the direction of the sea.

The next sections describe the relevant datasets, indicators that describe the effect of climate change and the scoring method to assign an exposure score. Figure 4-10 outlines a generic scoring method that is used as a starting point to inform the method for scoring of each hazard.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• Hazard has occurred (current exposure) or expected to occur (future exposure) a number of times in five years.	• Hazard has occurred (current exposure) or expected to occur (future exposure) twice in 10 years.	• Hazard has occurred occurred (current exposure) or expected to occur (future exposure) once in 25 years.	• There is no possibility that the hazard can occur in the project location (e.g. an inland project cannot be exposed to coastal erosion).

Figure 4-10. Generic exposure criteria and score methodology.

4.2.2.2 Heat and cold

- **Annual / seasonal / monthly average (air) temperature**

The latest national meteorology authority annual report states the average annual temperature was about 10.2 °C in the years before 1991 and about 11.7 °C in the last years before 2021. So, in less than 31 years, it has increased by about 1.5 °C. This trend only applies to selected 13 weather stations.

The EEA Global and European temperatures indicator[15] is the best available reference for assessing exposure to average temperature. Figure 4-11 shows that annual average temperature has increased by 0.2 to 0.3 °C per decade in the period 1960 to 2021. By 2100 annual average temperature at the project location is predicted to increase by 2-3 °C (SSP 1-2.6) or 4-5 °C (SSP 5-8.5), relative to the 1981-2010 average.

[15] Global and European temperatures (europa.eu)

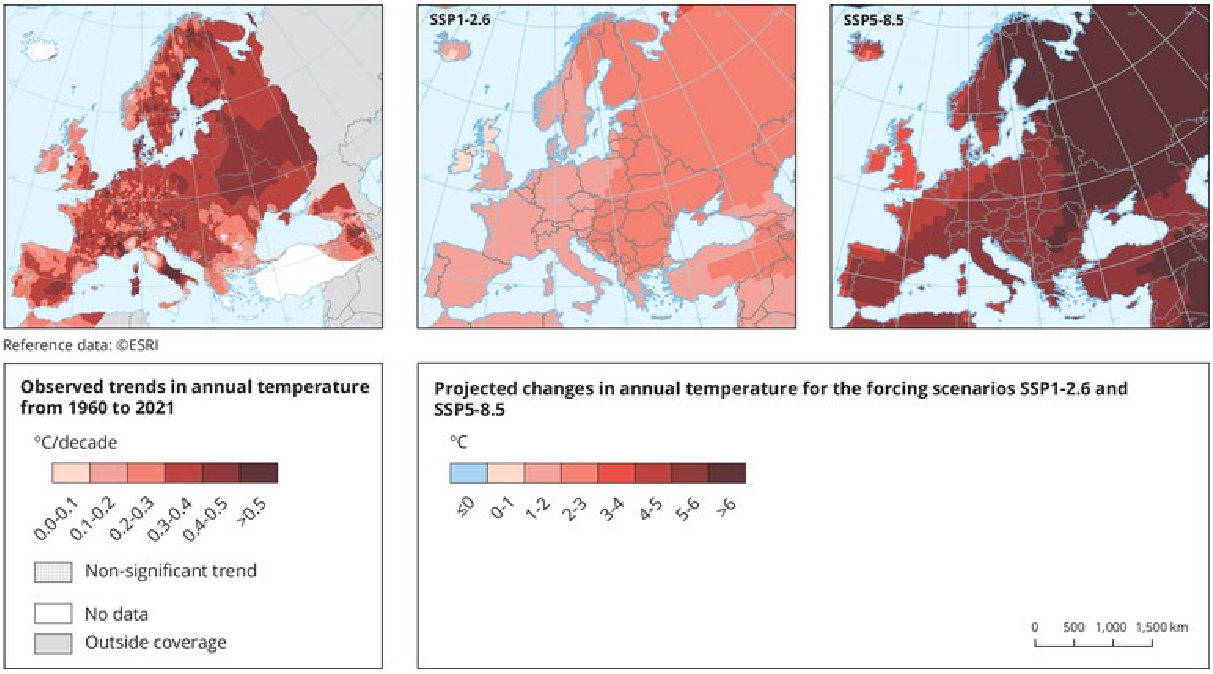


Figure 4-11. Observed annual mean temperature trend from 1960 to 2021 (left panel) and projected 21st century temperature change under different SSP scenarios (right panel) in Europe (from EEA indicators – 15 June 2022)

The effect of this climate hazard on water and wastewater projects is mostly related to the efficiency of treatment processes. The scoring method is presented in Figure 4-12 and reflects the likely frequency of changes in efficiency in relation to the technical norms and standards that are required for all water and wastewater project components.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• Annual average air temperature increase of >4°C compared 1981-2010 average.	• Annual average air temperature increase of 2-4°C compared 1981-2010 average.	• Annual average air temperature increase of <2°C compared 1981-2010 average.	• No change in annual average air temperature compared 1981-2010 average.

Figure 4-12. Exposure scoring method for annual / seasonal / average air temperature.

- **Extreme temperature occurrences (including heat waves)**

The latest national meteorology authority annual report states that the hottest temperature on record from 1954 to September 2022 is 42.6 °C on 17th July 2007. The hottest summer from July to September, based on all 14 weather stations in the country below 1,450 meters altitude, was recorded in 2012 with an average temperature of 22.5 °C. This average temperature will normally be measured every four to six hours, thus also including the nights. Normally, this value is 19.7 °C. There is a clear trend with the annual maximum temperature increasing since 1901 as shown in Figure 4-13.

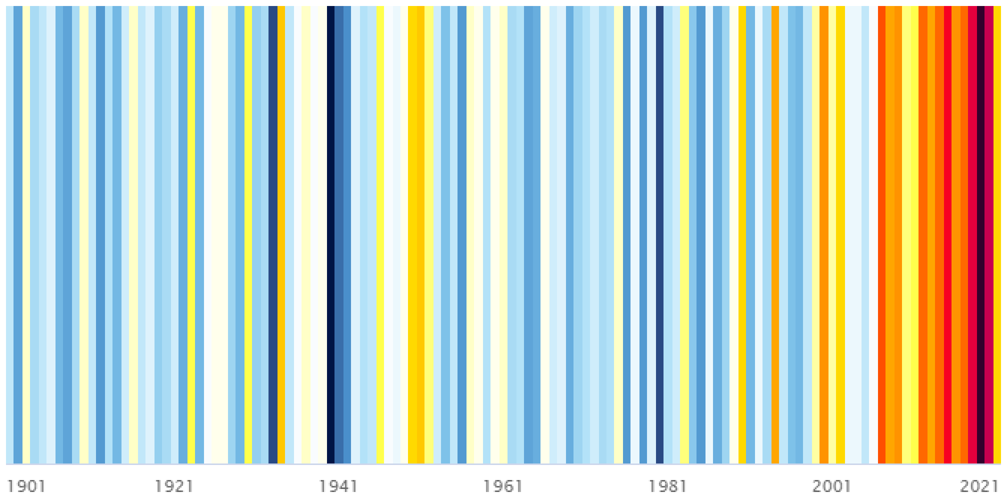


Figure 4-13: Observed annual Max-Temperature, 1901-2021[16]

The effect of this climate hazard on water and wastewater projects is mostly related to the ability of humans to operate, maintain and manage systems. The secondary effect of water availability and drought which are often a consequence of extreme temperatures, are covered by other climate hazards. The indicator to be used in the exposure assessment is the Number of health-related heatwave days from the EURO-CORDEX data for two CMIP5 scenarios[17]. The scenarios are based on the RCP rather than SSP projections. The annual number of heatwave days is based on the heatwave definition used by the health community. A health-related heatwave is considered to be a period of at least 2 consecutive days on which the maximum apparent temperature (Tappmax) exceeds the 90th percentile of Tappmax and the minimum temperature (Tmin) exceeds the 90th percentile of Tmin. Health heatwaves are calculated for each month of the summer period between June and August. The apparent temperature is a measure of relative discomfort due to combined heat and high humidity.

[16] NHESS - Hotspots for warm and dry summers in Romania (copernicus.org)
[17] Health Heatwave (High Temperature and Humidity), 1971-2099 — English (europa.eu)

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• >20 days human health heat waves per year.	• 5 to 20 days human health heat waves per year.	• <5 days human health heat waves per year.	• Zero days human health heat waves per year.

Figure 4-14. Exposure scoring for extreme temperature.

- **Cold spells**

The latest national meteorology authority annual report states that the coldest day on record from 1954 to September 2022 was January 2017 when the temperature dropped to -29.0 °C. The coldest winter (January to March) was in 1954 with an average temperature of -4.6 °C. In the county the project is located within, it is usual to have about 5.7 degrees more at 1.1 °C for this three-month period. Figure 4-15 presents the trend in the recorded minimum temperate each year from 1901 to 2021. Figure 4-16 shows how the average winter season (December, January and February) temperature has increased from 1961 to 2013 based on national datasets.

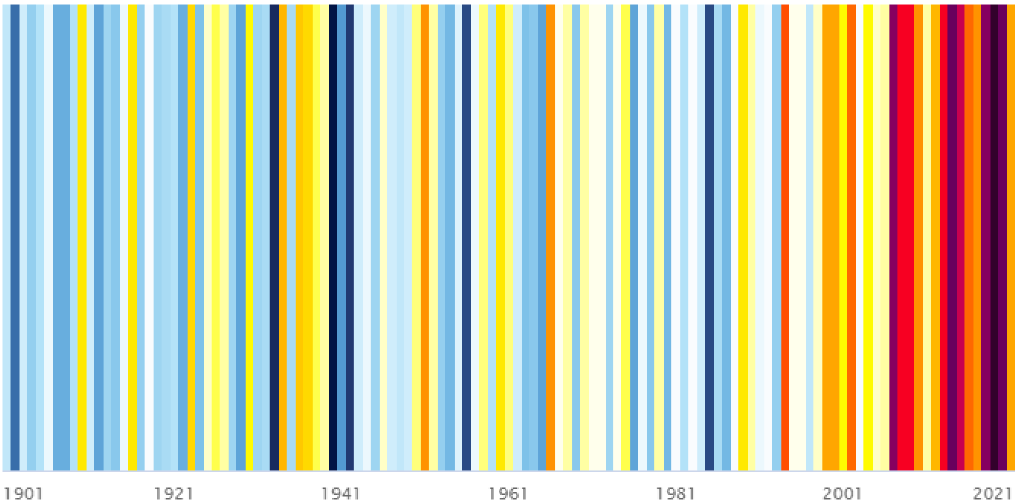


Figure 4-15: Observed annual min-temperature, 1901-2021[18]

[18] NHESS - Hotspots for warm and dry summers in Romania (copernicus.org)

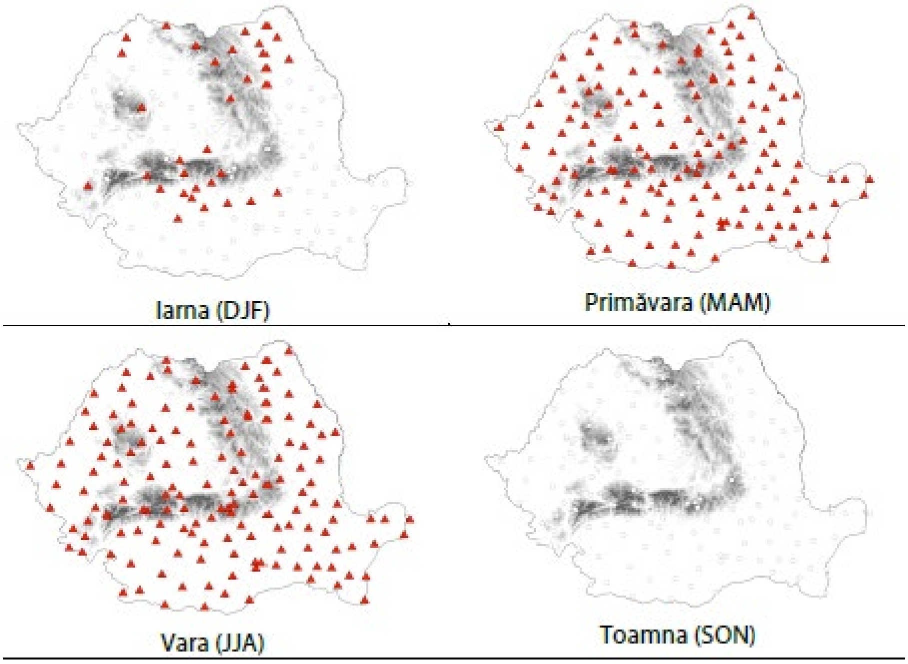


Figure 4-16. Trend in average seasonal temperature (source. National Climate Change Communication)

The effect of this climate hazard on water and wastewater projects is mostly related to the ability of humans to operate, maintain and manage systems, and freezing of water and pipes. A cold spell is officially defined as six or more consecutive days in which the minimum temperate is less than the 10th percentile of the average daily temperature. The exposure score is based on the duration and frequency of cold spells.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• More than 4 cold spells per year, or the duration of cold spells exceeding 6 days duration.	• 2 to 4 cold spells per year, of 1 cold spell with a duration of longer than 6 days.	• 1 cold spell per year, of no more than 6 days duration.	• No cold spells.

Figure 4-17. Exposure scoring for cold spells.

- **Freeze-thaw damage**

Freeze-thaw damage is different to cold spells in that the repeated freezing and thawing of pipes and other components is related to a daily cycle rather than a prolonged cold period.

Records from the national meteorological authority show that there are currently on average in the 1981-2010 period 60 frost days in the project location.

The ClimateADAPT number of frost days is used as the indicator for assigning an exposure score. The change in the number of frost days is presented in Figure 4-18. The number of frost days index is calculated from an ensemble of five global climate model (GCM) simulations for two CMIP5 scenario projections: RCP2.6 (with low greenhouse gas emissions) and RCP8.5 (with high greenhouse gas emissions). Projected changes are calculated relative to a (1981-2010) ERA5 reference period. A positive value indicates more frost days than the reference period while a negative value indicates fewer frost days than the reference period.

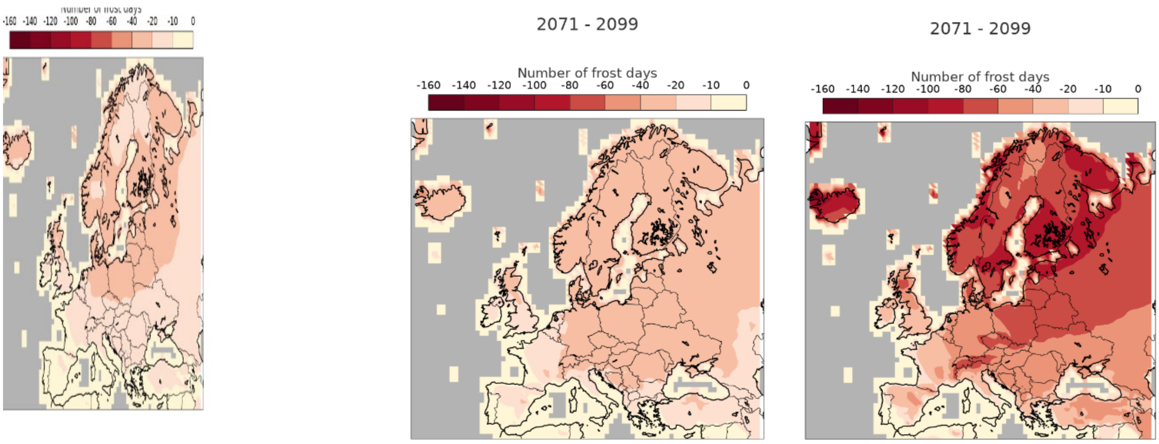


Figure 4-18. Change in the number of frost days[19] (left: RCP 2.6 for 2011-2040, Middle: RCP 2.6 for 2071-2099, Right: RCP 8.5 for 2071-2099)

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• More than 90 frost days per year.	• Between 30 and 90 frost days per year.	• Less than 30 frost days per year.	• No frost days.

Figure 4-19. Exposure scoring for freeze thaw damage.

4.2.2.3 Wind

- **Average wind speed**

National Meteorological Authority records and data shows that over the period 1961-2013 there has been a decrease in average wind speed across the country. Figure 4-20 shows that this trend has been observed at all weather stations and applies to the project location. Wind conditions are not considered as a notable climate or weather-related risk in the project location. The best available prediction for future change in average wind is the EEA indicators as presented in Figure 4-21.

The project location is not currently exposed to any average wind related hazard and the future projected increase is negligible.

[19] [Frost Days, 2011-2099 — English (europa.eu)](https://www.eea.europa.eu)

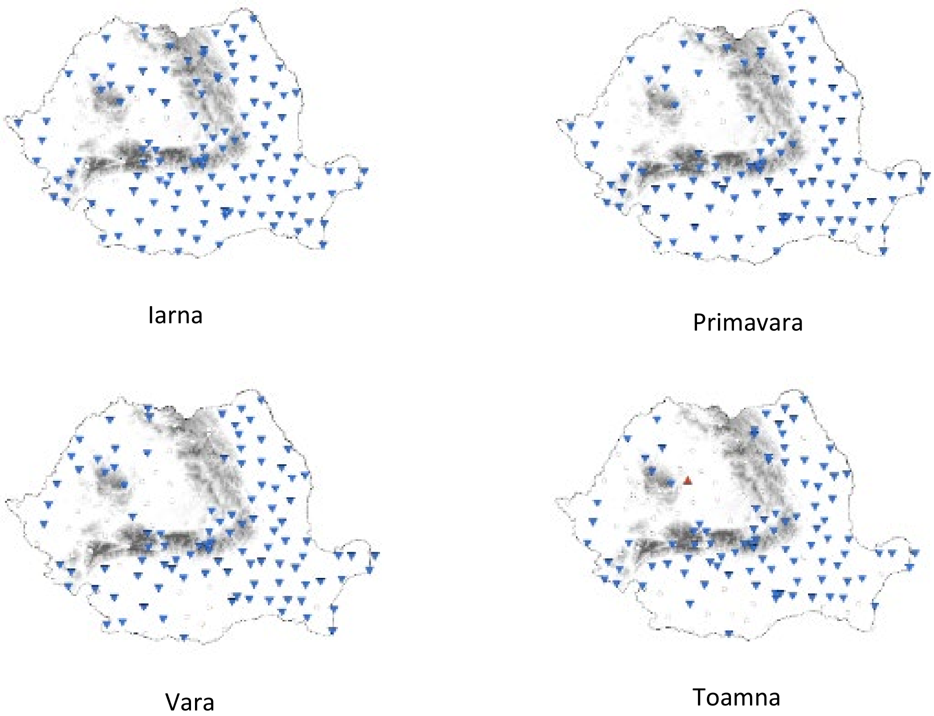


Figure 4-20: Seasonal trends of wind speed at 104 meteorological stations for the interval 1961-2013 [Significant trends (at the 90%confidence level) are represented by red triangle for increasing temperatures and blue triangles for decreasing ones].

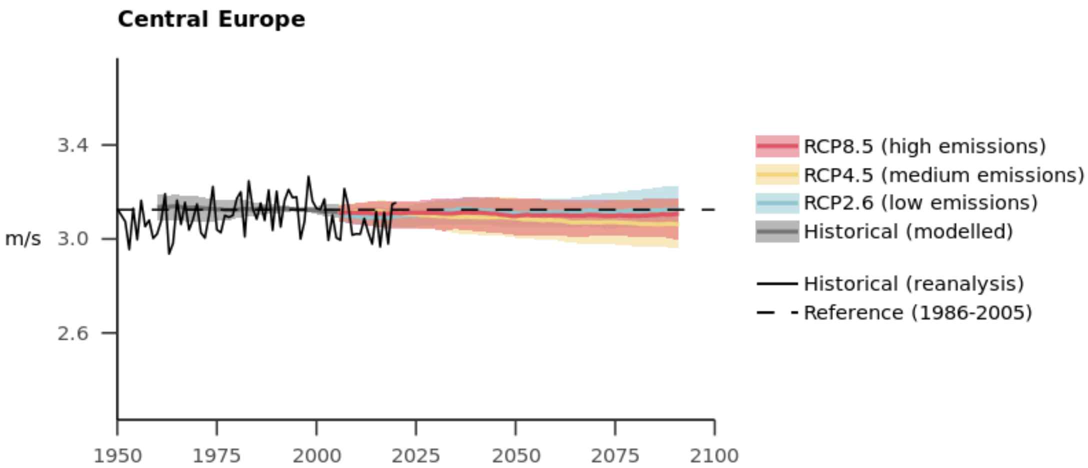


Figure 4-21. Projected change in average wind speed for Central Europe[20].

[20] [Annual mean wind speed for the European land area and sub-regions — European Environment Agency (europa.eu)]

* **Maximum wind speed / Storms (tracks and intensity)**

Windstorms associated with Mediterranean low-pressure systems (Medicanes) have been experienced with at 2 severe storms in the period 2090-2020 affecting the project location. Tornadoes have also been experienced in the region as shown in Figure 4-22.

The IPCC AR6 [21] concludes with medium confidence that the frequency of storms, including Medicanes, is projected to decrease in Mediterranean regions, and their intensities are projected to increase, by the middle of the century. Projections of smaller-scale hazard phenomena such as tornadoes, wind gusts, hailstorms and lightning are currently not directly available partly due to the inability of climate models to simulate such phenomena.

The latest EEA climate indicator for extreme wind speed (now archived and not kept up to date) projected no change to extreme wind speed in the project location as shown in Figure 4-23.

The generic scoring method in Figure 4-10 will be applied.

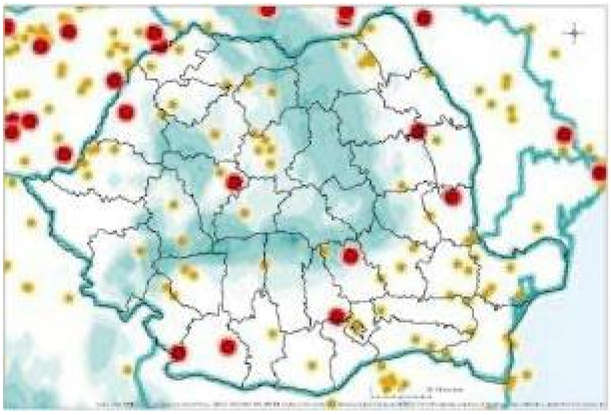


Figure 4-22: Locations of all tornado reports contained in the European Severe Weather Database. Orange points are weak (F0, F1) and unrated tornadoes; red points are strong (F2, F3) tornadoes; and black points violent (F4, F5) tornadoes.

[21] Chapter 12: Climate Change Information for Regional Impact and for Risk Assessment (ipcc.ch)

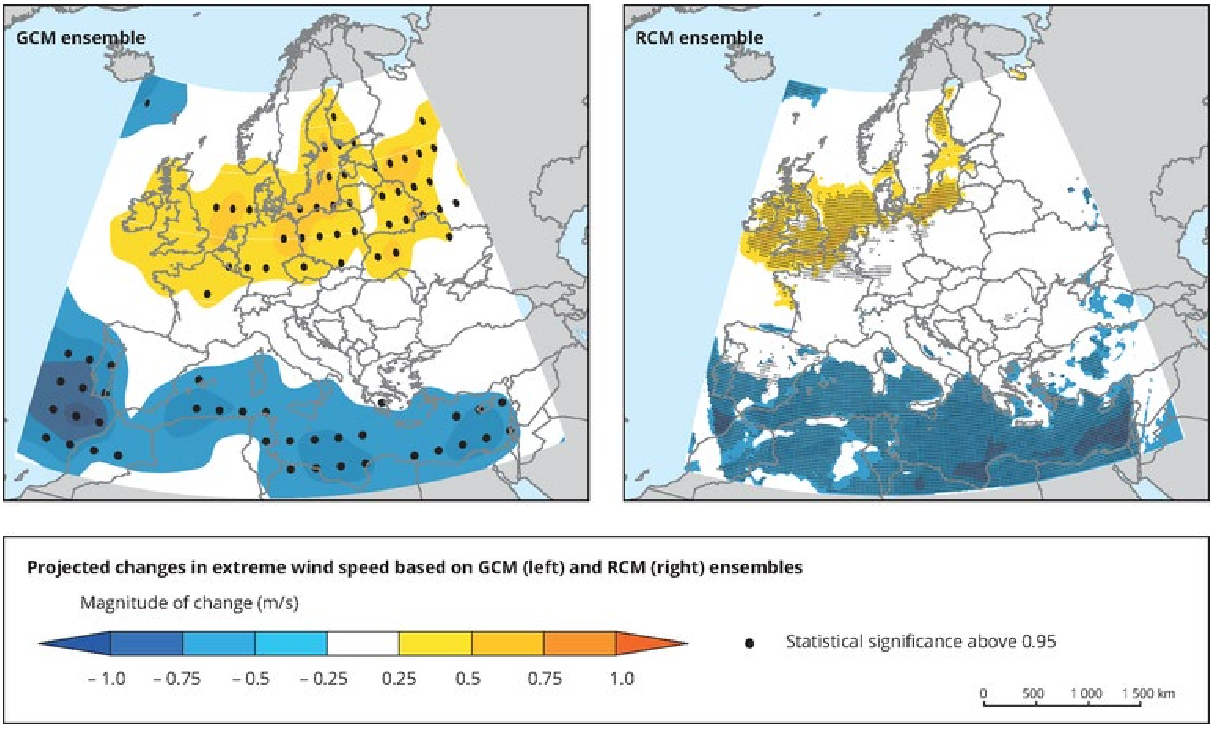


Figure 4-23. Projected changes in extreme wind speed based on GCM and RCM ensembles[22]

4.2.2.4 Other atmospheric

Air quality

Air quality is currently a significant risk to human population in urban areas and the IPCC AR6 (chapter 13 section 13.7.1.2) concludes with medium confidence that air pollution effects will increase with climate change. Increased particulate matter could reduce the efficiency of water and wastewater treatment processes and affect the ability of humans to operate and service infrastructure.

Air quality has significant spatial variability. Within the project location there are three air quality monitoring stations that are part of the National Air Quality Monitoring Network. Current records since the monitoring stations were installed in 2013 are that there has only been one exceedance of the target value for SO_2, CO and NO_2, which did not exceed the maximum legal limit. PM_{10} monitoring has found that during winter there are periods where the target daily limit of 50 µg/m^3 has been exceeded more than 30 times. This remains below the legal limit.

The exposure score method for air quality is listed in Figure 4-24 and is based on the number of times the legal limits may be exceeded. Given the short duration of the monitoring network and high degree of uncertainty in how other climate drivers will affect climate change a precautionary approach is taken

[22] Projected changes in extreme wind speed based on GCM and RCM ensembles — European Environment Agency (europa.eu) [note EEA indicator no longer updated]

to assigning the scores. This reflects the possibility of limits being exceeded in the future, even with the implementation of air quality measures and other climate mitigation policies.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• Legal limits for air quality monitoring has been exceeded (current exposure) or expected to be exceeded (future exposure) a number of times in five years.	• Legal limits for air quality monitoring has been exceeded (current exposure) or expected to be exceeded (future exposure) twice in 10 years.	• Legal limits for air quality monitoring has been exceeded (current exposure) or expected to be exceeded (future exposure) once in 25 years.	• There is no possibility that the air quality limits can be exceeded in the project location.

Figure 4-24. Exposure scoring for air quality.

4.2.2.5 Wet and dry

- **Annual / Seasonal / Monthly average rainfall**

The latest IPCC AR6 summary for Europe concludes with medium confidence (Figure 4-8) that average precipitation has been increasing in the WCE region and that there is low confidence in the direction of future change in average and seasonal rainfall with 1.5 °C and 4.0 °C GWLs.

The analysis of the National Meteorological Authority precipitation data recorded during the interval 1901-2012 revealed a slightly decrease in the annual amount of precipitation (23.6 mm) (Figure 4-25). The annual average rainfall is 675mm across the project location over the period 1961-2016. The latest National Climate Change Communication describes an expected reduction of summer rainfall by 10% in the RCP 4.5 in the period 2021-2050 (Figure 4-26), with more pronounced decrease of 15% in higher emission scenarios (RCP 8.5 in the period 2071-2099) as collaborated in the ClimateADAPT indicator in Figure 4-27. Changes in winter precipitation are much smaller for future climate scenarios and associated uncertainties are higher.

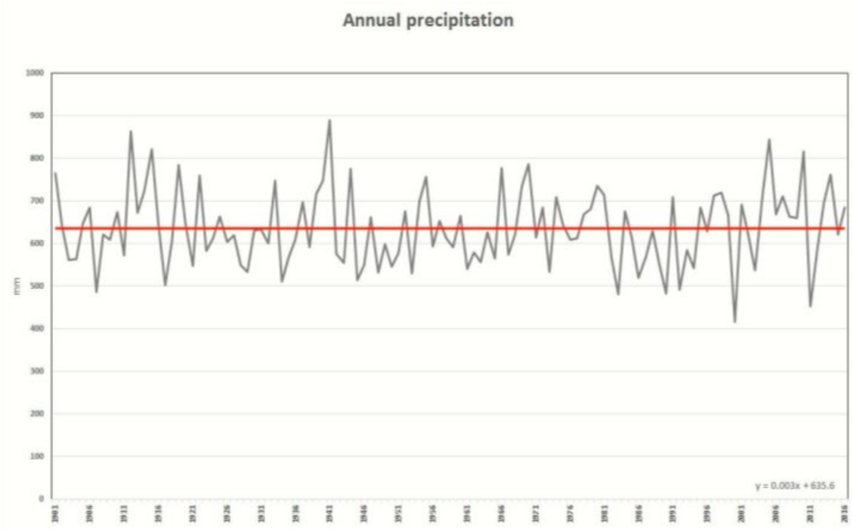


Figure 4-25: Evolutions of annual precipitation amounts (in mm)

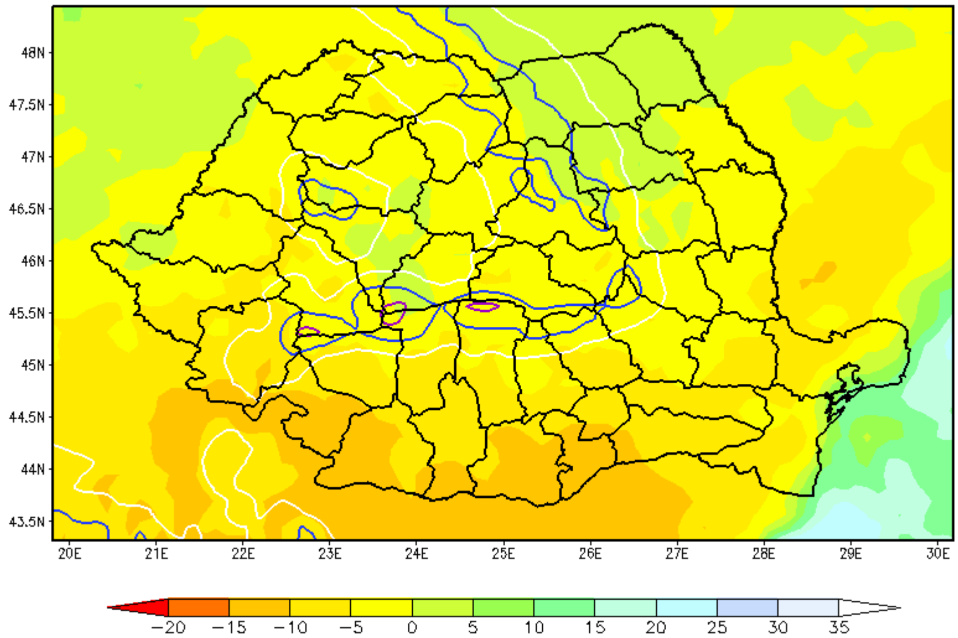


Figure 4-26: Change in the annual amount of precipitation in summer (in %) during 2021-2050 compared to the reference interval 1971-2000

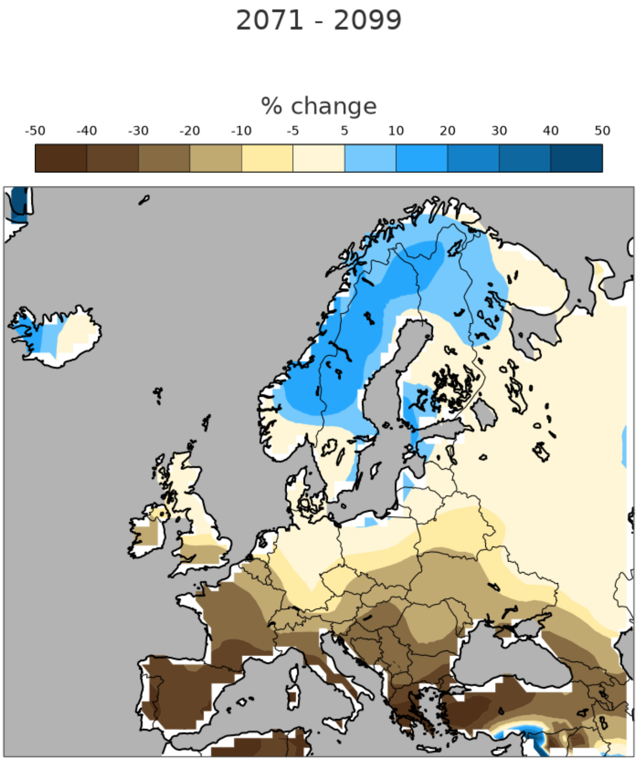


Figure 4-27. Change in summer rainfall total for 2071-2099 under RCP 8.5 (ClimateADAPT[23])

Changes to average and seasonal rainfall patterns do not result in a direct hazard to water and wastewater projects. The secondary effects of extreme rainfall, flooding and water resources are captured through the exposure to the following hazards. The exposure scoring method in Figure 4-28 related to the change in reference conditions from which the project proposed would be designed to. For this reason, the current exposure is always zero as any water or wastewater project is designed to suit the current rainfall regime.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• More than 25% change in any average / seasonal / monthly rainfall total.	• Between 10% and 25% change in any average / seasonal / monthly rainfall total.	• Less than 10% change in any average / seasonal / monthly rainfall total.	• No change in any of average / seasonal / monthly rainfall.

Figure 4-28. Exposure scoring for annual / seasonal / monthly average rainfall.

[23] Precipitation Sum, 2011-2099 — English (europa.eu)

- **Extreme rainfall (frequency and magnitude)**

Pluvial flooding has been experienced on numerous occasions throughout the project location as stormwater drainage network capacity and also when natural infiltration capacity of soils is exceeded. Recorded pluvial flooding events are listed in the 2nd cycle Preliminary Flood Risk Assessment, with one town in the project location designated as a Area for Potential Significant Flood Risk which experiences pluvial source of flooding.

The National Hydrological Institute maintains a network of rainfall gauges. The highest recorded daily rainfall in the region is 150mm recorded in July 2010. This is in excess of the 100yr rainfall total.

The trend from 1961 to 2013 in daily maximum rainfall by season can be derived from monitoring data from the National Hydrological Institute. Figure 4-29 shows that in the region the project is located within that most rainfall gauges show no statistical trend at most gauges, with two gauges showing an increase in the summer and autumn daily maximum.

Into the future the IPCC AR6 report (see Figure 4-30) projections show no change (within +/-5%) in the annual daily maximum with 1.5 °C GWL and an increase of more than 10% under a 3.0 °C GWL.

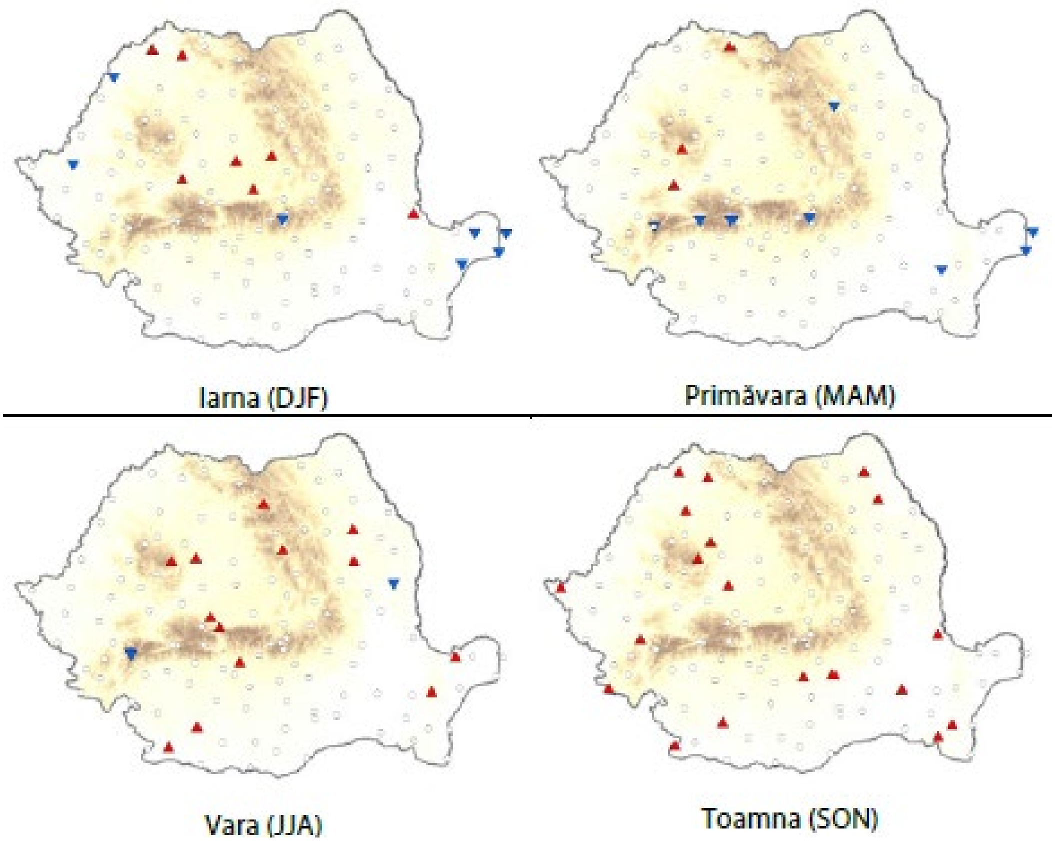


Figure 4-29: Trends of maximum daily rainfall per season, 1961 – 2013[24] (red triangle increase, blue triangle decrease, grey circle no statistically significant trend)

[24] National Hydrological Institute

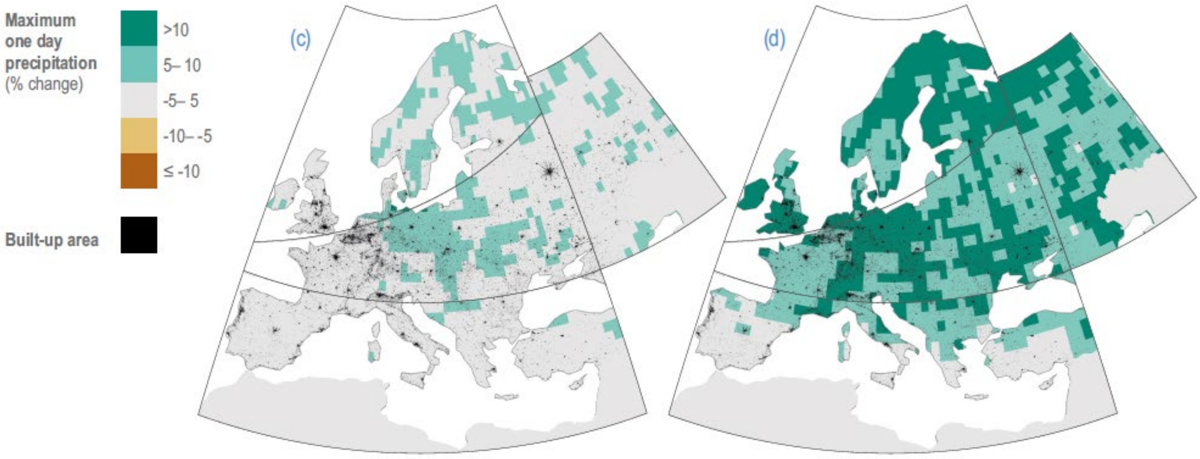


Figure 4-30. Change in Maximum one day precipitation with 1.5 °C GWL (left) and 3.0 °C GWC (right) (from IPCC AR6 Chapter 13)

The Copernicus Climate Change Data Store contains Hydrology-related climate impact indicators from 1970 to 2100 derived from bias adjusted European climate projections. The dataset provides water variables and indicators based on hydrological impact modelling, forced by bias adjusted regional climate simulations from the European Coordinated Regional Climate Downscaling Experiment (EURO-CORDEX). The dataset contains Essential Climate Variable (ECV) data in the form of daily mean river discharge and a set of climate impact indicators (CIIs) for both water quantity and quality.

Relevant EEA indicators for assessing exposure to extreme rainfall[25] are presented below. Indicators and projections at the European scale are not yet available for the SSPs and so RCPs are used for the exposure assessment.

- RCP 2.6 15th percentile in the near future (2041-2060) for the current exposure. This is because the historical data in the EEA indicator is for the period 1986-2005 and so already almost 20 years out of date.
- RCP 2.6 in the far future (2081-2100) for future exposure comparable to SSP 2.0-4.5.
- RCP 4.5 in the far future (2081-2100) for future exposure comparable to SSP 3.0-7.0.
- RCP 8.5 in the far future (2081-2100) is also considered to determine if a more significant long term exposure score should be assigned to manage the range of possible future climate impacts.
- Future exposure is based on the 85th percentile estimates to take a precautionary approach.

Maximum consecutive five-day precipitation. This is defined as the maximum consecutive five-day precipitation index accounts for the greatest precipitation total over five consecutive days in a year. The index is relevant for water management, agriculture and disaster risk assessment, in particular for the

[25] Wet and dry — heavy precipitation and river floods — European Environment Agency (europa.eu)

assessment of river flood, landslide and erosion risks. The simple definition of this index enables it to be easily applied and interpreted.

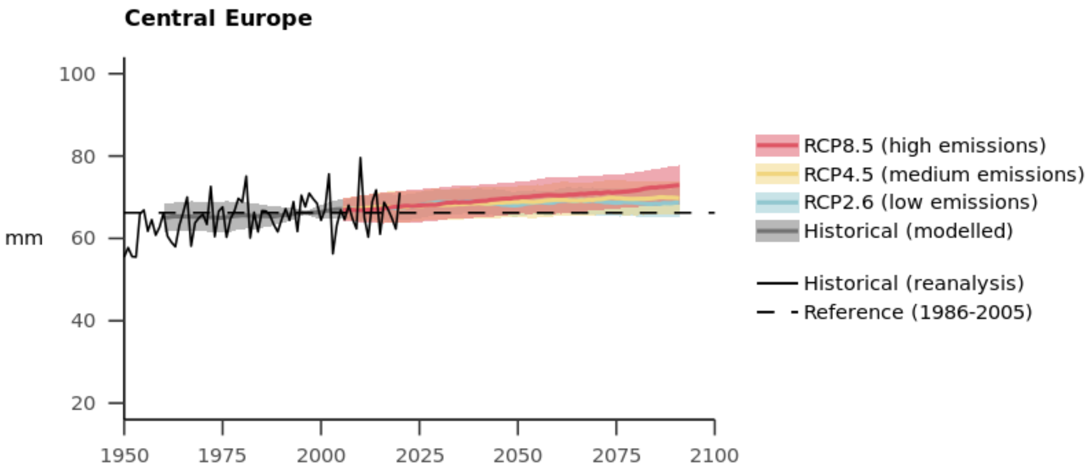
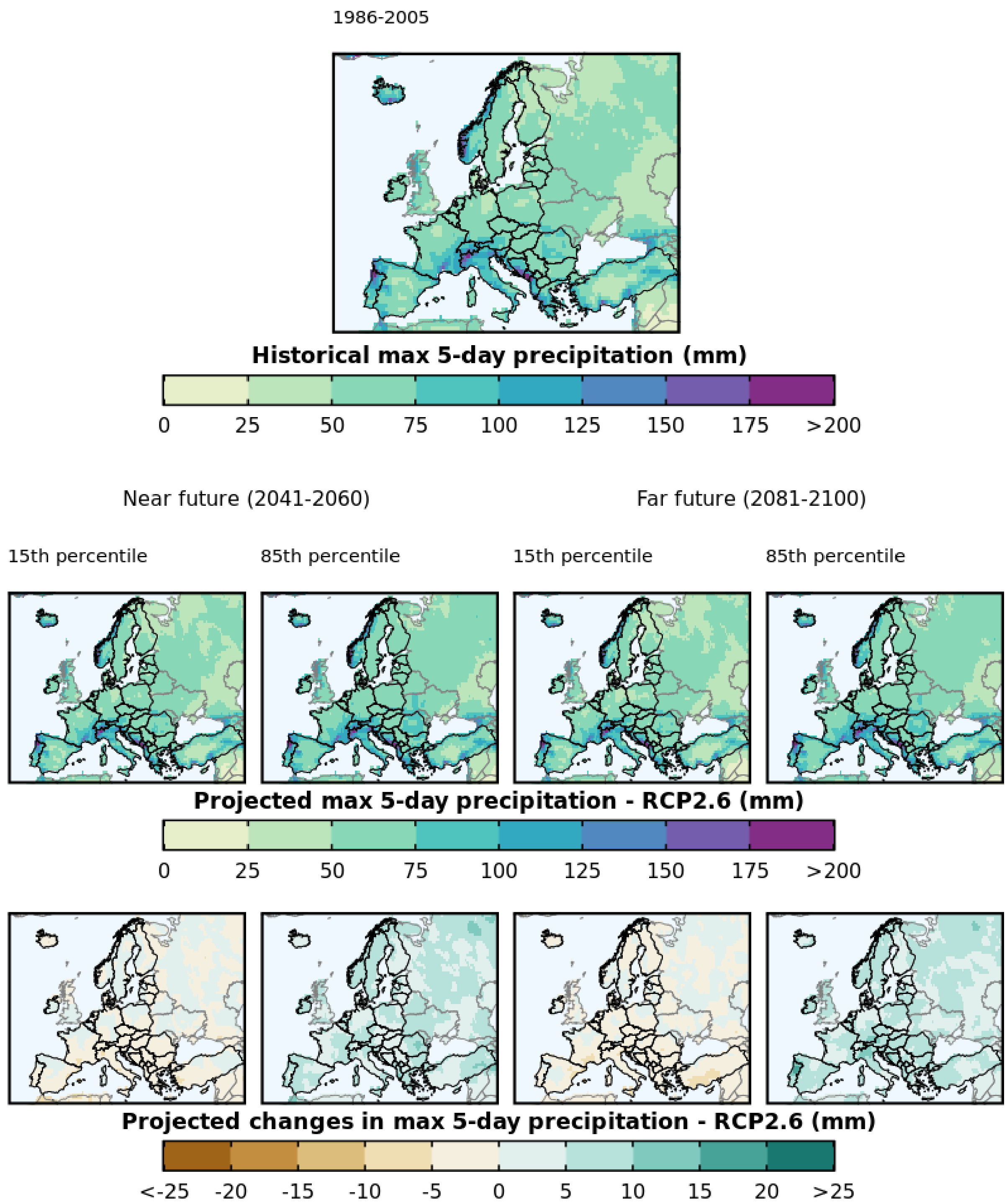
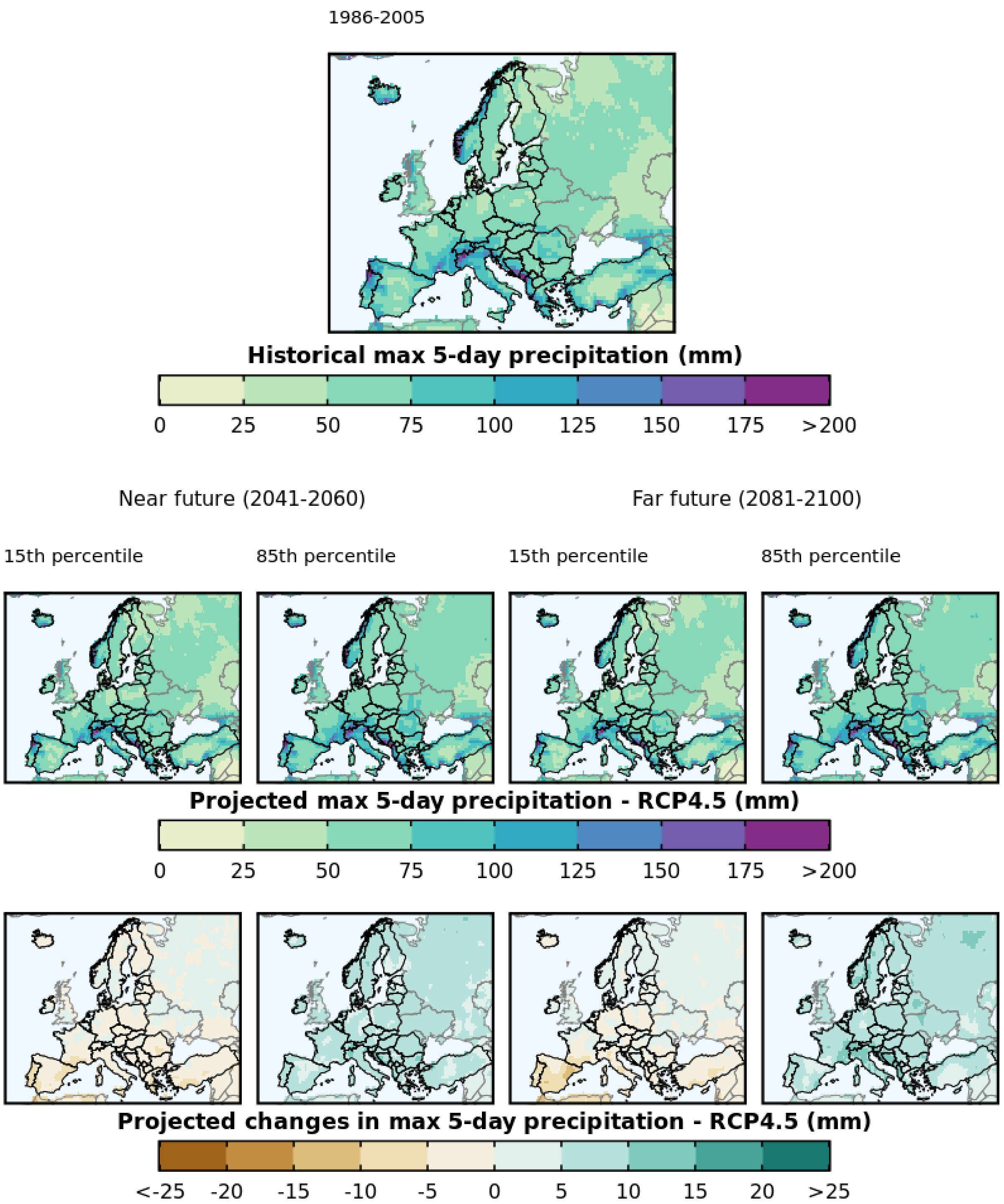
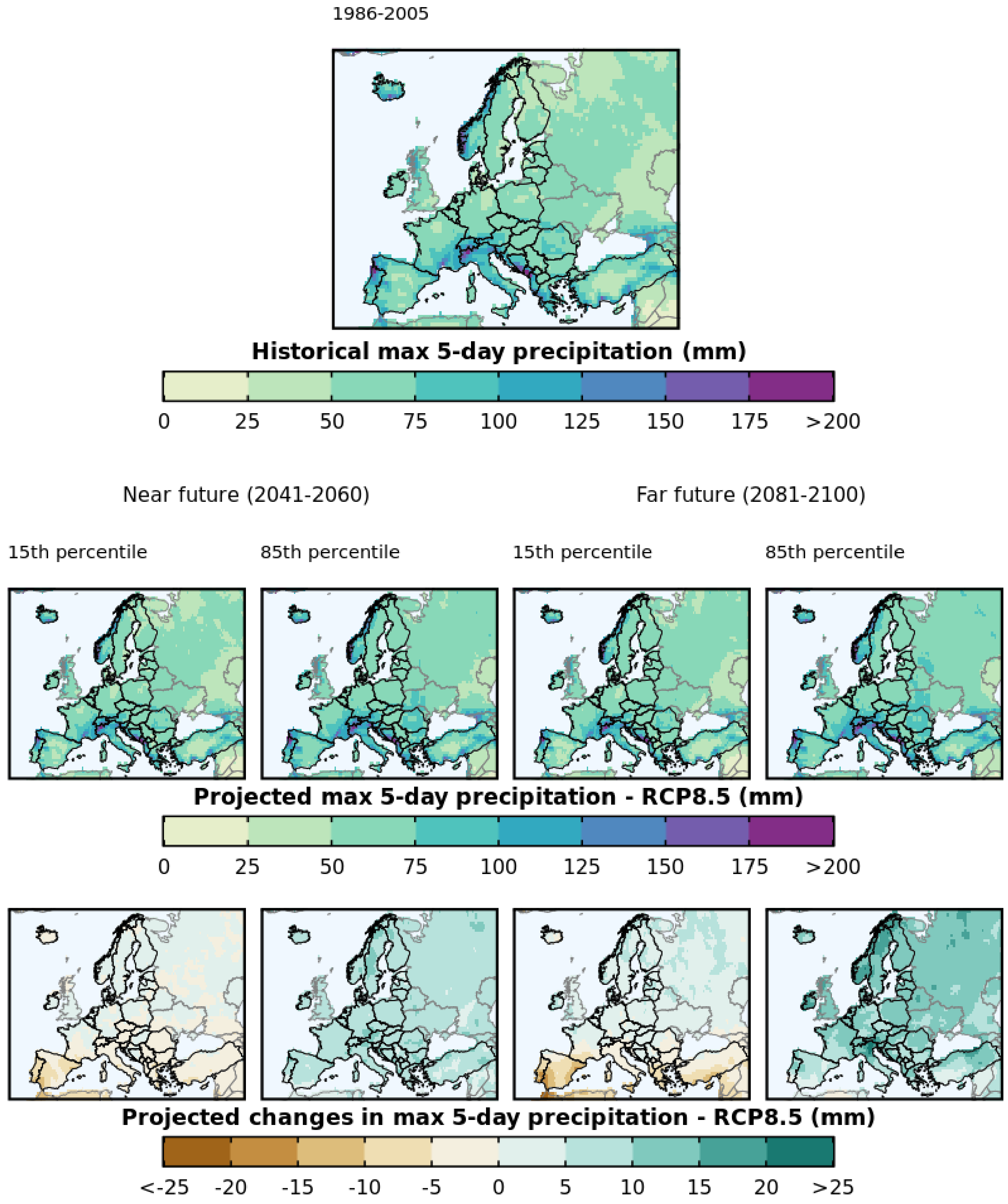


Figure 4-31. Annual maximum five-day precipitation for Central Europe.


1986-2005
Historical max 5-day precipitation (mm)
0 25 50 75 100 125 150 175 >200
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected max 5-day precipitation - RCP2.6 (mm)
0 25 50 75 100 125 150 175 >200
Projected changes in max 5-day precipitation - RCP2.6 (mm)
<-25 -20 -15 -10 -5 0 5 10 15 20 >25


1986-2005
Historical max 5-day precipitation (mm)
0
25
50
75
100
125
150
175
>200
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected max 5-day precipitation - RCP4.5 (mm)
0
25
50
75
100
125
150
175
>200
Projected changes in max 5-day precipitation - RCP4.5 (mm)
<-25
-20
-15
-10
-5
0
5
10
15
20
>25


1986-2005
Historical max 5-day precipitation (mm)
0 25 50 75 100 125 150 175 >200
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected max 5-day precipitation - RCP8.5 (mm)
0 25 50 75 100 125 150 175 >200
Projected changes in max 5-day precipitation - RCP8.5 (mm)
<-25 -20 -15 -10 -5 0 5 10 15 20 >25

Extreme precipitation total. The extreme precipitation total index represents the total precipitation on all days with heavy precipitation, defined as precipitation exceeding the 99th percentile of daily precipitation values over the reference period. Therefore, the index accounts for both the frequency and the magnitude of unusual precipitation events identified with respect to baseline conditions. The index is mainly relevant for water-related sectors, agriculture, transport and urban-related applications. It provides information on changes in the overall amount of rain falling during intense precipitation events, which can affect the risk of floods, landslides and erosion.

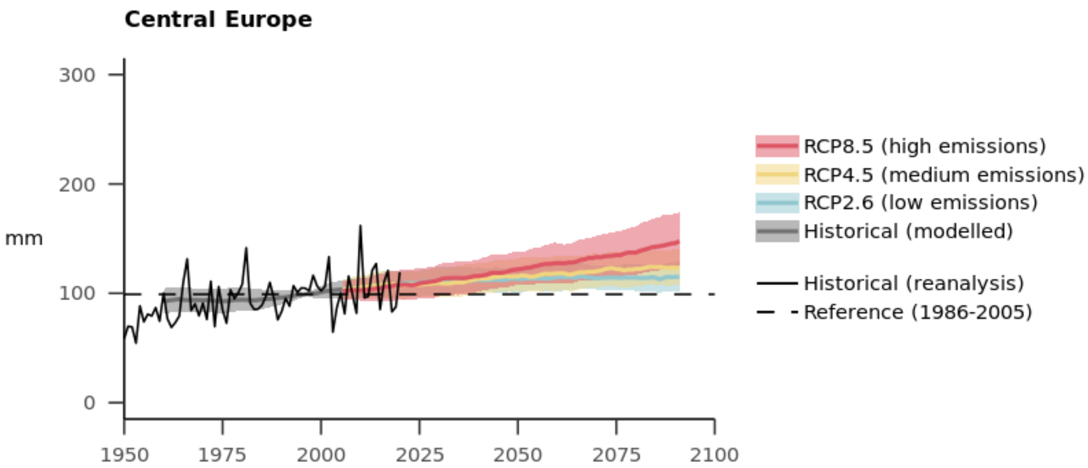
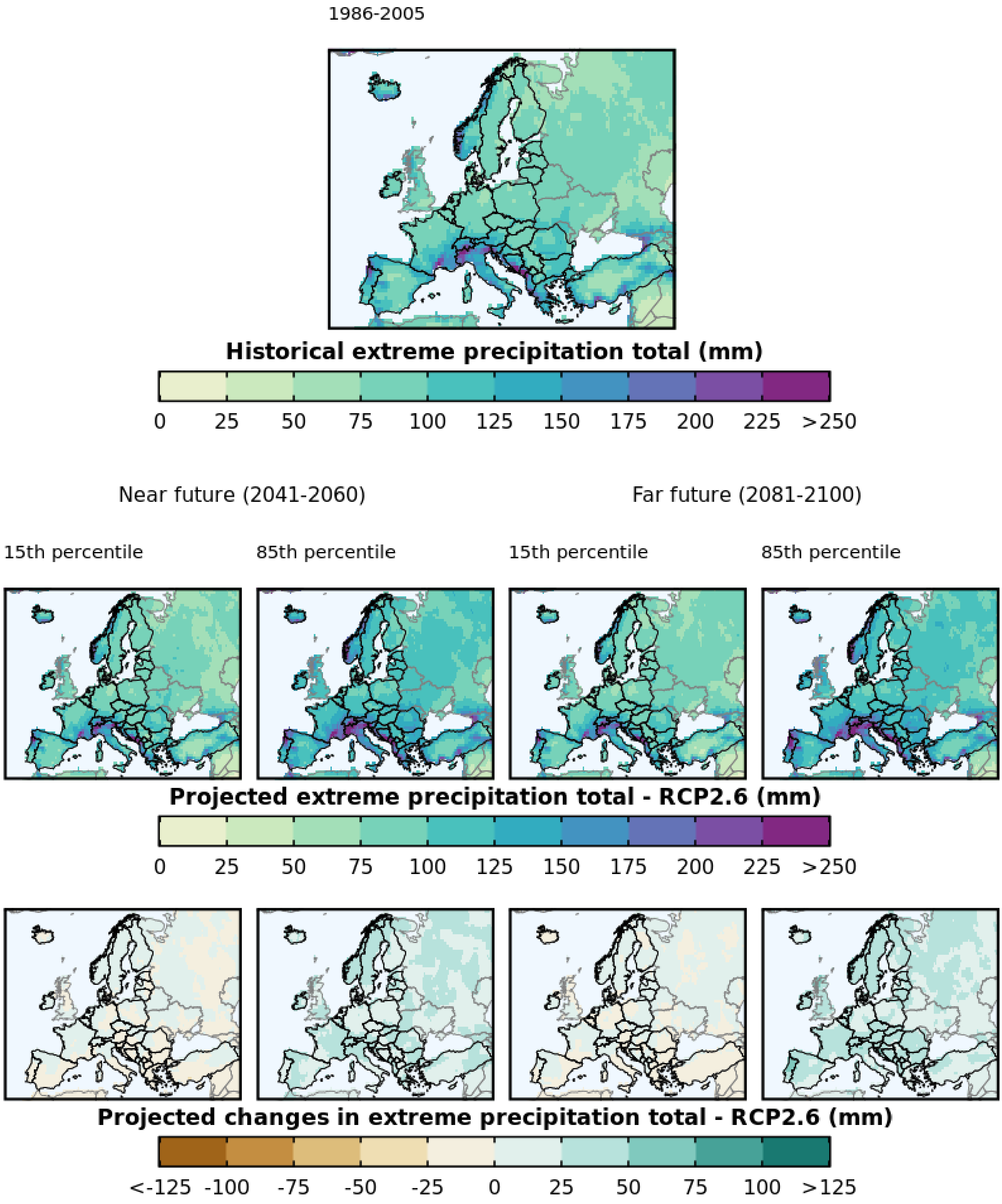
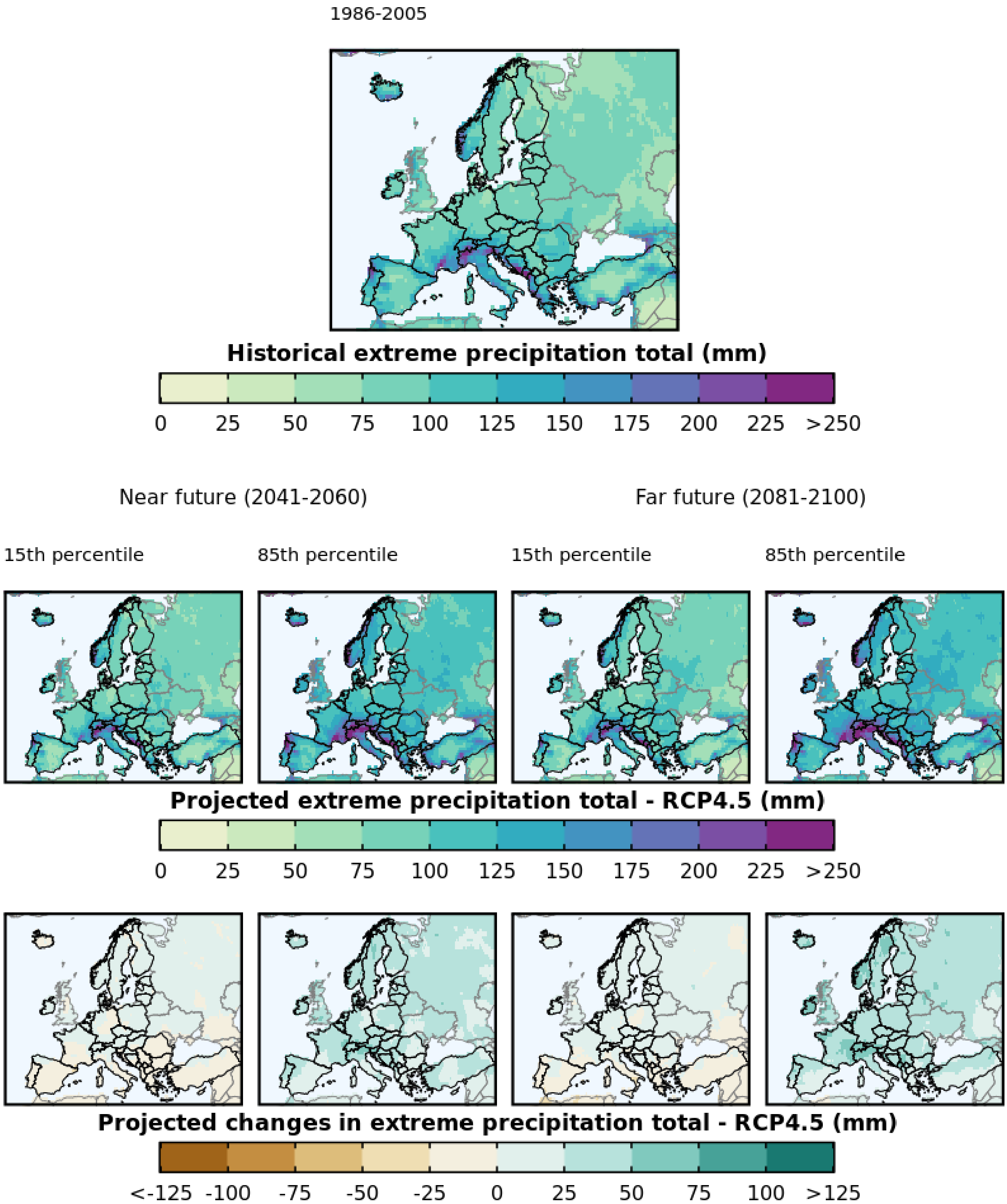
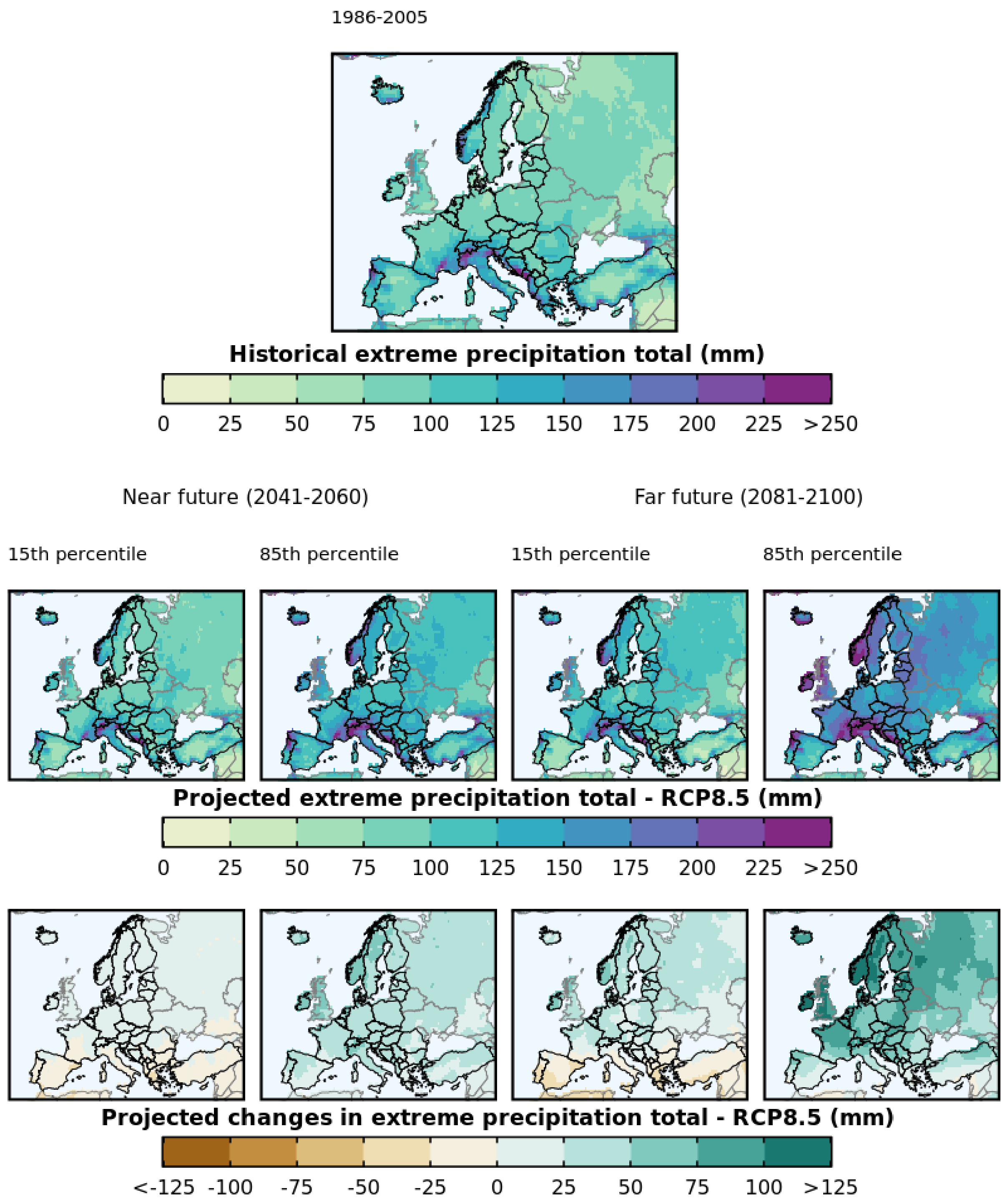


Figure 4-32. Extreme precipitation total for Central Europe.



1986-2005
Historical extreme precipitation total (mm)
0
25
50
75
100
125
150
175
200
225
>250
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected extreme precipitation total - RCP2.6 (mm)
0
25
50
75
100
125
150
175
200
225
>250
Projected changes in extreme precipitation total - RCP2.6 (mm)
<-125
-100
-75
-50
-25
0
25
50
75
100
>125


1986-2005
Historical extreme precipitation total (mm)
0 25 50 75 100 125 150 175 200 225 >250
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected extreme precipitation total - RCP4.5 (mm)
0 25 50 75 100 125 150 175 200 225 >250
Projected changes in extreme precipitation total - RCP4.5 (mm)
<-125 -100 -75 -50 -25 0 25 50 75 100 >125


1986-2005
Historical extreme precipitation total (mm)
0 25 50 75 100 125 150 175 200 225 >250
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected extreme precipitation total - RCP8.5 (mm)
0 25 50 75 100 125 150 175 200 225 >250
Projected changes in extreme precipitation total - RCP8.5 (mm)
<-125 -100 -75 -50 -25 0 25 50 75 100 >125

Frequency of extreme precipitation. The frequency of extreme precipitation index refers to the total number of days in a year with total precipitation exceeding the 99th percentile of daily precipitation values during the reference period. This index is relevant for water management, urban planning, transport and agriculture, in particular for assessing risks related to floods, landslides and erosion.

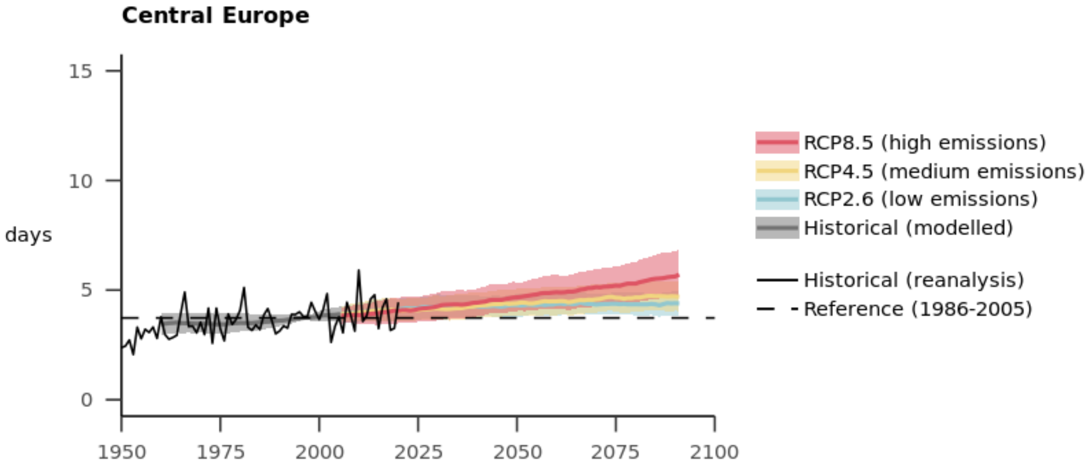
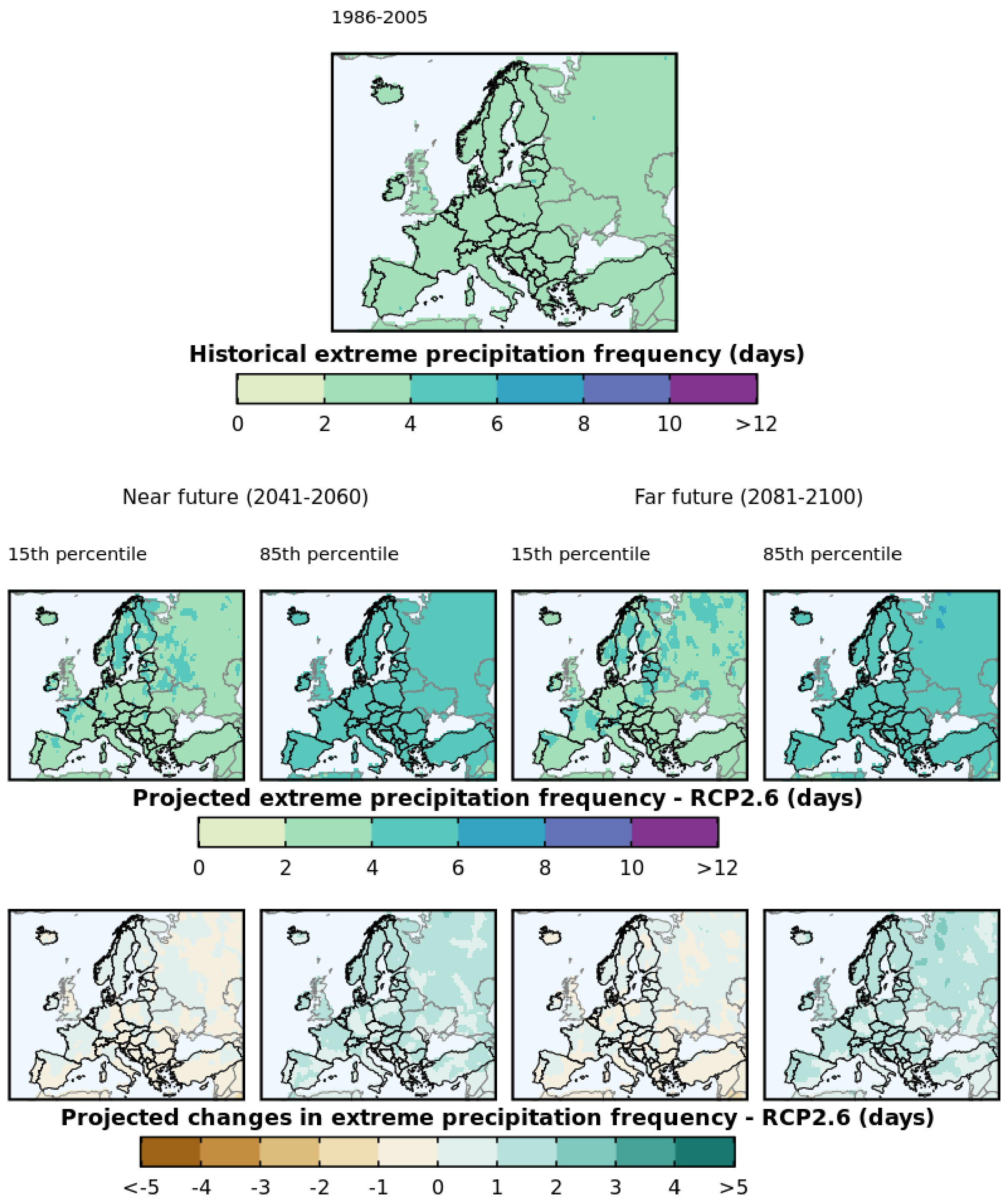
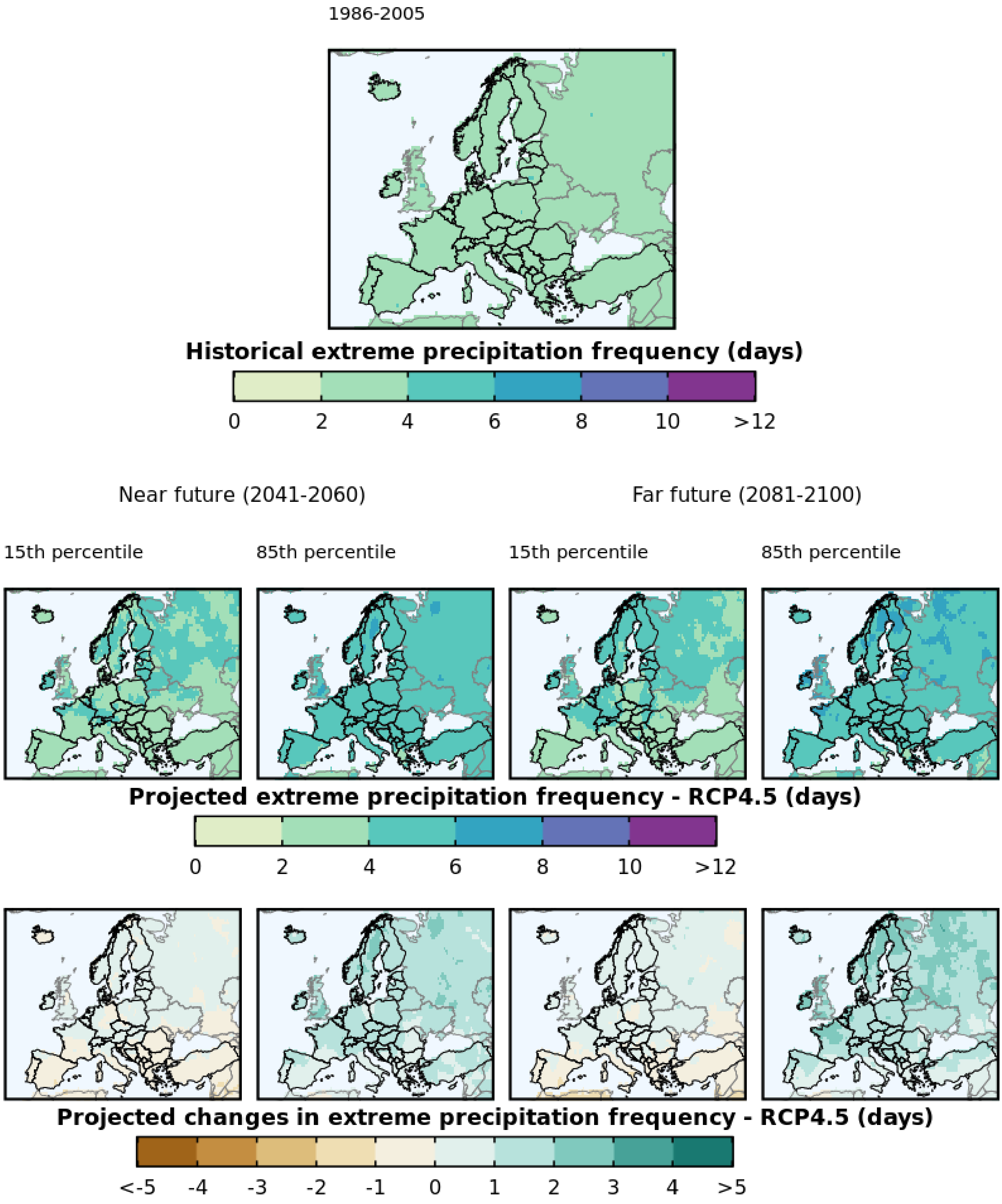
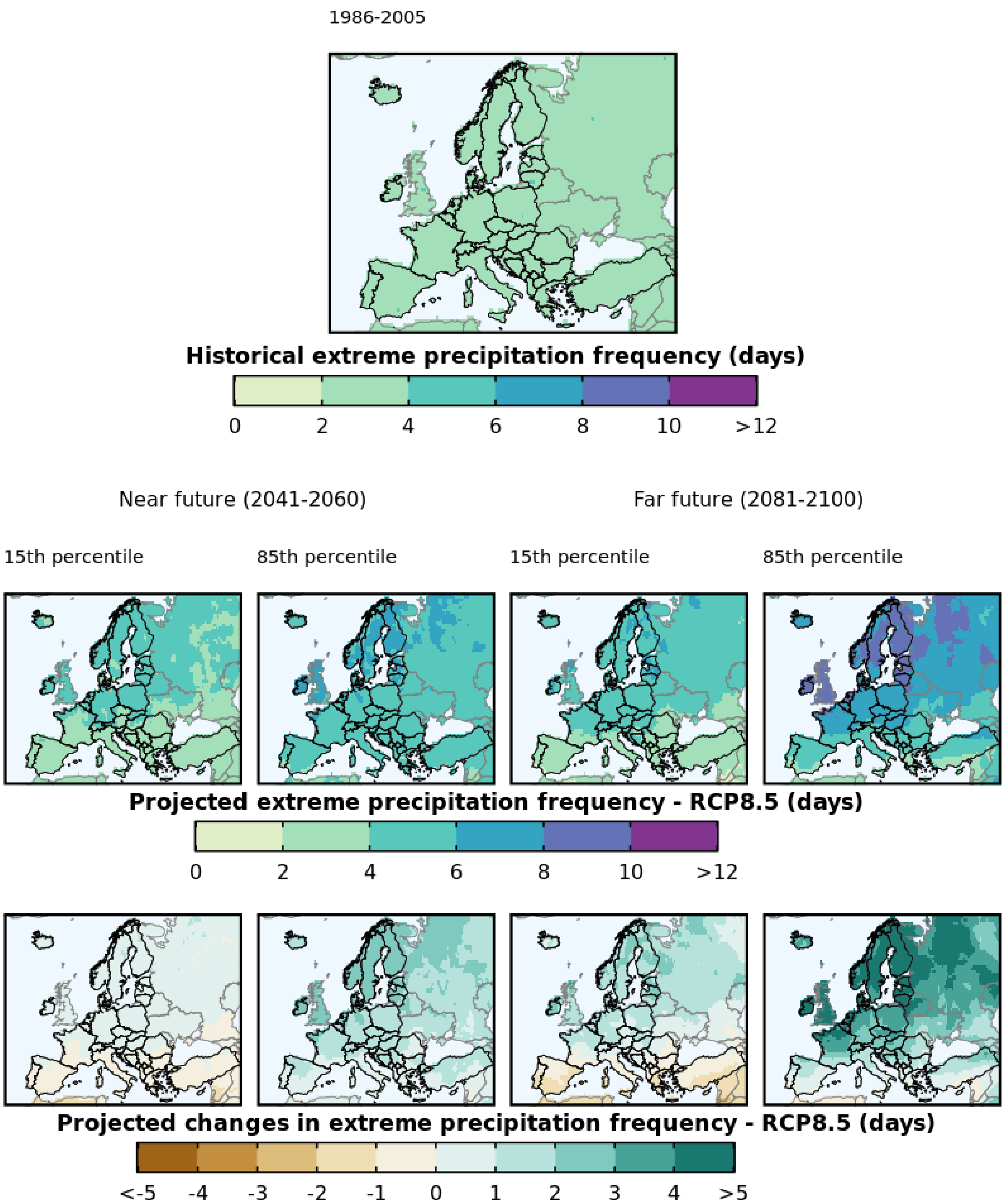


Figure 4-33. Frequency of extreme precipitation for Central Europe.


1986-2005
Historical extreme precipitation frequency (days)
0 2 4 6 8 10 >12
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected extreme precipitation frequency - RCP2.6 (days)
0 2 4 6 8 10 >12
Projected changes in extreme precipitation frequency - RCP2.6 (days)
<-5 -4 -3 -2 -1 0 1 2 3 4 >5


1986-2005
Historical extreme precipitation frequency (days)
0
2
4
6
8
10
>12
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected extreme precipitation frequency - RCP4.5 (days)
0
2
4
6
8
10
>12
Projected changes in extreme precipitation frequency - RCP4.5 (days)
<-5
-4
-3
-2
-1
0
1
2
3
4
>5



The scoring method for current and exposure uses a simple absolute indicator as opposed to the relative hydrological indicator. The detailed risk assessment takes account of the technical norms for stormwater design are to design systems to accommodate the 30yr 24-hour storm. This sets the threshold for which extreme rainfall exceeds the capacity of systems to cope and may result in flooding. This means that the size of stormwater drainage network components will be larger in locations with higher rainfall extremes than lower rainfall extremes.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• Max five-day precipitation index greater than 150 mm. • Extreme precipitation total index greater than 150 mm. • Extreme precipitation frequency greater than 10 days.	• Max five-day precipitation index greater than 100 mm. • Extreme precipitation total index greater than 100 mm. • Extreme precipitation frequency greater than 6 days.	• Max five-day precipitation index greater than 50 mm. • Extreme precipitation total index greater than 50 mm. • Extreme precipitation frequency greater than 2 days.	• Max five-day precipitation index less than 50 mm. • Extreme precipitation total index less than 50 mm. • Extreme precipitation frequency less than 2 days.

Figure 4-34. Exposure scoring method for extreme rainfall. The highest score from the three indicators is used as the exposure score for extreme rainfall.

- **River flooding**

Flood hazard varies significantly across the project area. The Danube and two other rivers within the project area are designated in the 2nd Preliminary Flood Risk Assessment as Areas of Significant Potential Flood Risk. Flood Hazard and Risk Maps are available for five flood probabilities in present day conditions, and a climate change scenario for the 1% Annual Exceedance Probability event. The climate change scenario is based on a 10% increase in peak discharge and is based on the National Climate Change Study on hydrological extremes. This climate change factor is reflective of possible conditions in 2100 under an RCP 4.5 climate projection.

The hazard maps available on the National Flood Authority website have been used to determine if the location of the proposed project infrastructure is exposed to flooding.

For assessing the exposure to more extreme climate change, and to verify the 10% climate change factor used in the Flood Hazard and Risk Maps the Copernicus Climate Change Data Store contains Hydrology-related climate impact indicators from 1970 to 2100 have been used. The dataset provides water variables and indicators based on hydrological impact modelling, forced by bias adjusted regional climate simulations from the European Coordinated Regional Climate Downscaling Experiment (EURO-CORDEX). The dataset contains Essential Climate Variable (ECV) data in the form of daily mean river discharge and a set of climate impact indicators (CIIs) for both water quantity and quality.

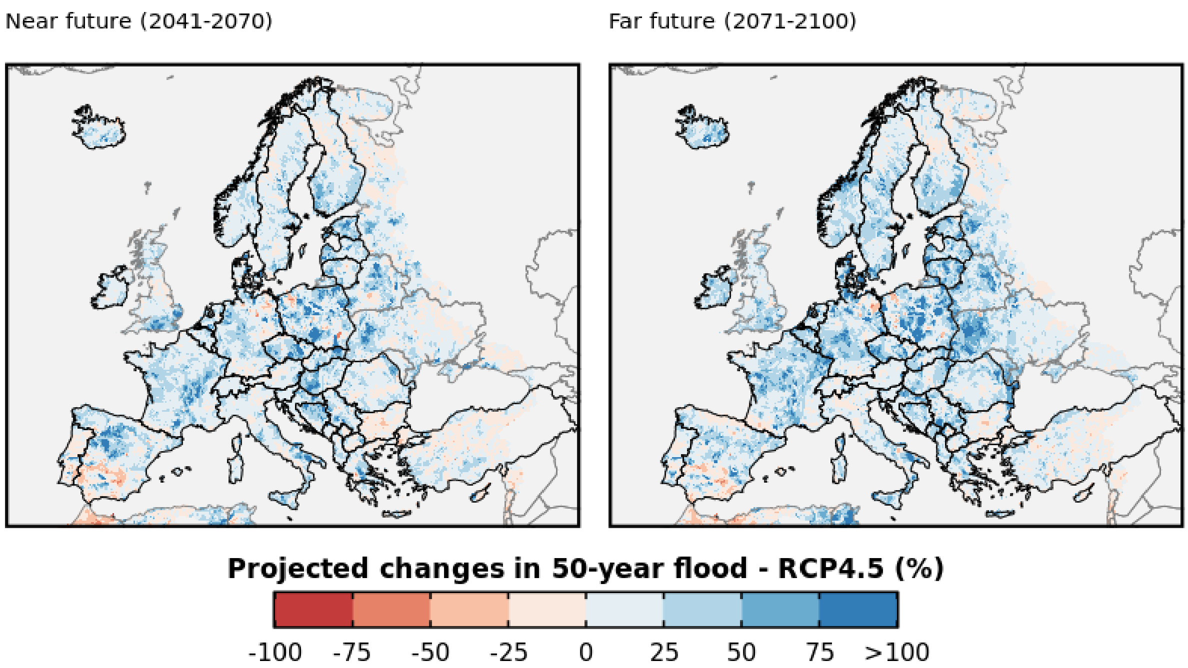
Relevant EEA indicators for assessing exposure to river flood[26] is the river flood index using runoff This is defined as the maximum daily river discharge for a given return period (typically 50 or 100 years, depending on the specific application). The index is computed using river flow data, which are derived

[26] Wet and dry — heavy precipitation and river floods — European Environment Agency (europa.eu)

from hydrological models. Indicators and projections at the European scale are not yet available for the SSPs and so RCPs are used for the exposure assessment.

- RCP 4.5 in the far future (2081-2100) for future exposure comparable to SSP 3.0-7.0. This validates the climate change factor used in the Flood Hazard Maps.
- RCP 8.5 in the far future (2081-2100) is also considered to determine if a more significant long term exposure score should be assigned to manage the range of possible future climate impacts.

The 2nd cycle Flood Risk Management Plan does not propose any flood management measures to protect localities and infrastructure from exposure to flooding. A flood forecasting and warning system, with an associated emergency response plan, is proposed to be implemented before 2030.



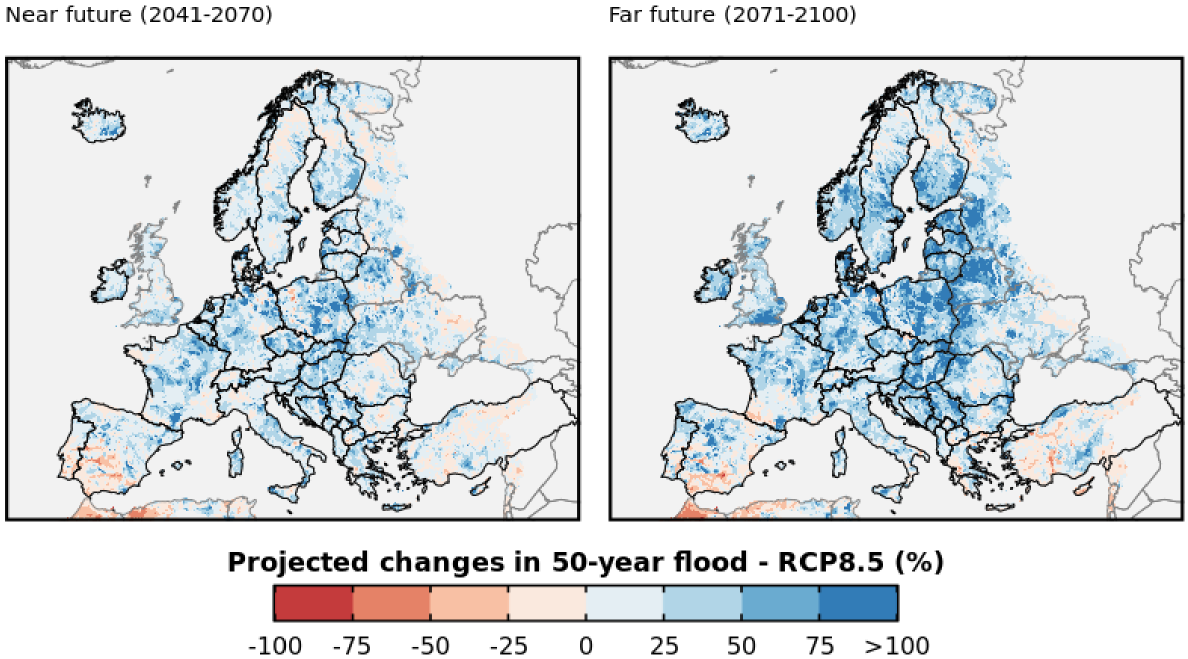


Figure 4-35. EEA indicators for projected change in 50-year flood (RCP 4.5 top, RCP 8.5 bottom)

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
•**Flood hazard**: For climate hazards where hazard or risk mapping is available this would be exposure in the high probability maps (e.g. for flood hazard and risk maps this may be the 10% AEP (Annual Exeedence Probability))	•**Flood hazard**: For climate hazards where hazard or risk mapping is available this would be exposure in the medium probability maps (e.g. for flood hazard and risk maps this may be the 1% AEP)	•**Flood hazard**: For climate hazards where hazard or risk mapping is available this would be exposure in the low probability maps (e.g. for flood hazard and risk maps this may be the 0.1% AEP)	•**Flood hazard**: For climate hazards where hazard or risk mapping is available the project location is outside of the low probability maps (e.g. for flood hazard and risk maps this may be the 0.1% AEP).

Figure 4-36. Exposure scoring method for flood hazard.

- **Aridity and drought / Water availability**

From 1901 to 2022 the National Meteorological Authority records state the project area, including the contributing catchment and groundwater bodies, have experienced between one and four droughts each decade. There is a trend for increasing frequency in droughts since 1981.

In near future (2011 - 2040), under climate change conditions, stronger and more spatially extended droughts will likely affect the territory in the growing season, with significant impact on agriculture activities.

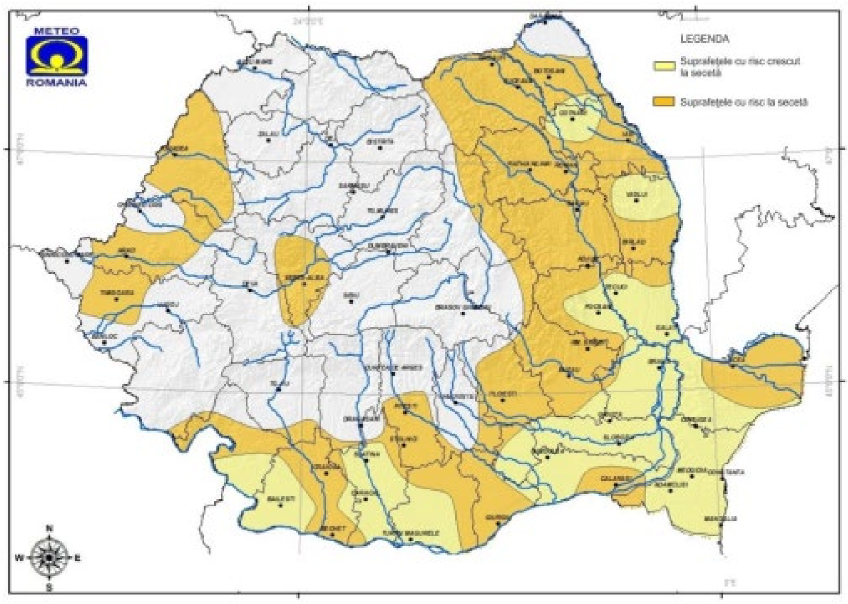


Figure 4-37: Agricultural surfaces affected by drought.

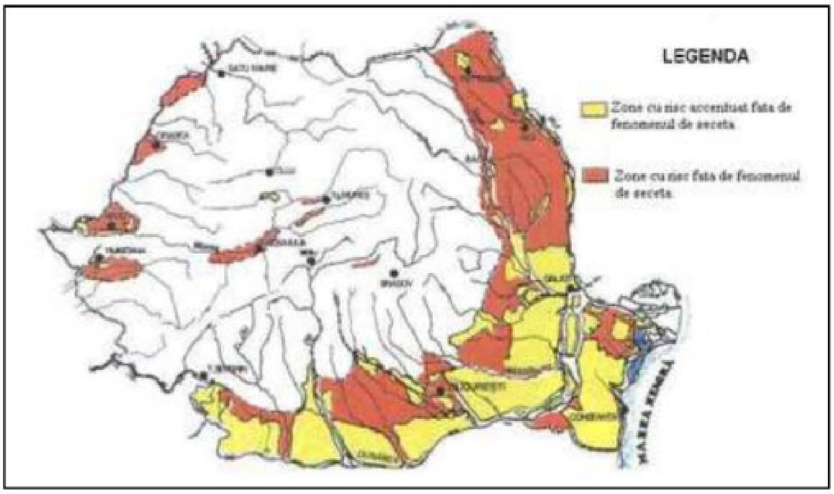


Figure 4-38: The areas affected by the drought on the territory.

As part of the Feasibility Study detailed analysis of groundwater resources has been undertaken. Within the project area two groundwater bodies have been identified and both are proposed by the project to be used as aquifer water sources. Both groundwater bodies are currently in good condition in terms of quality and quantity.

- Groundwater body A is set in Triassic limestone deposits located south of the main urban areas and has an average global protection class (PM). The hydrological parameters provided by wells unevenly distributed on the surface above the groundwater body are: K = 0.2 – 250 m/day and T = 2 – 6500 m^2/day. These are typical ranges for the karst systems in the wider region. The water is of potable quality with only minor treatment required. The upstream contributing catchment does not have any point source pollution sources. The main pressures on the water body are the urban area to the north, which do contain industrial sites. However, there is no indication of industrial pollutants in the water body monitoring data.
- Groundwater body B is of porous-permeable type, located in silt and loess deposits with limestone and green shales. Due to the lithographic form and tectonic structure the groundwater body presents significant variation of quantitative and qualitive quality both horizontally and vertically. This water body is currently the main supply of water abstracted.

The effect of drought and arid conditions is an increase in demand for irrigation water. Associated with this is a further increase in water demand for cooling and domestic water supply in response to heat conditions that are often associated with droughts.

The Copernicus Climate Change Data Store contains Hydrology-related climate impact indicators from 1970 to 2100 derived from bias adjusted European climate projections. The dataset provides water variables and indicators based on hydrological impact modelling, forced by bias adjusted regional climate simulations from the European Coordinated Regional Climate Downscaling Experiment (EURO-CORDEX). The dataset contains Essential Climate Variable (ECV) data in the form of daily mean river discharge and a set of climate impact indicators (CIIs) for both water quantity and quality.

Relevant EEA indicators for assessing exposure to aridity and drought[27] are presented below. Indicators and projections at the European scale are not yet available for the SSPs and so RCPs are used for the exposure assessment.

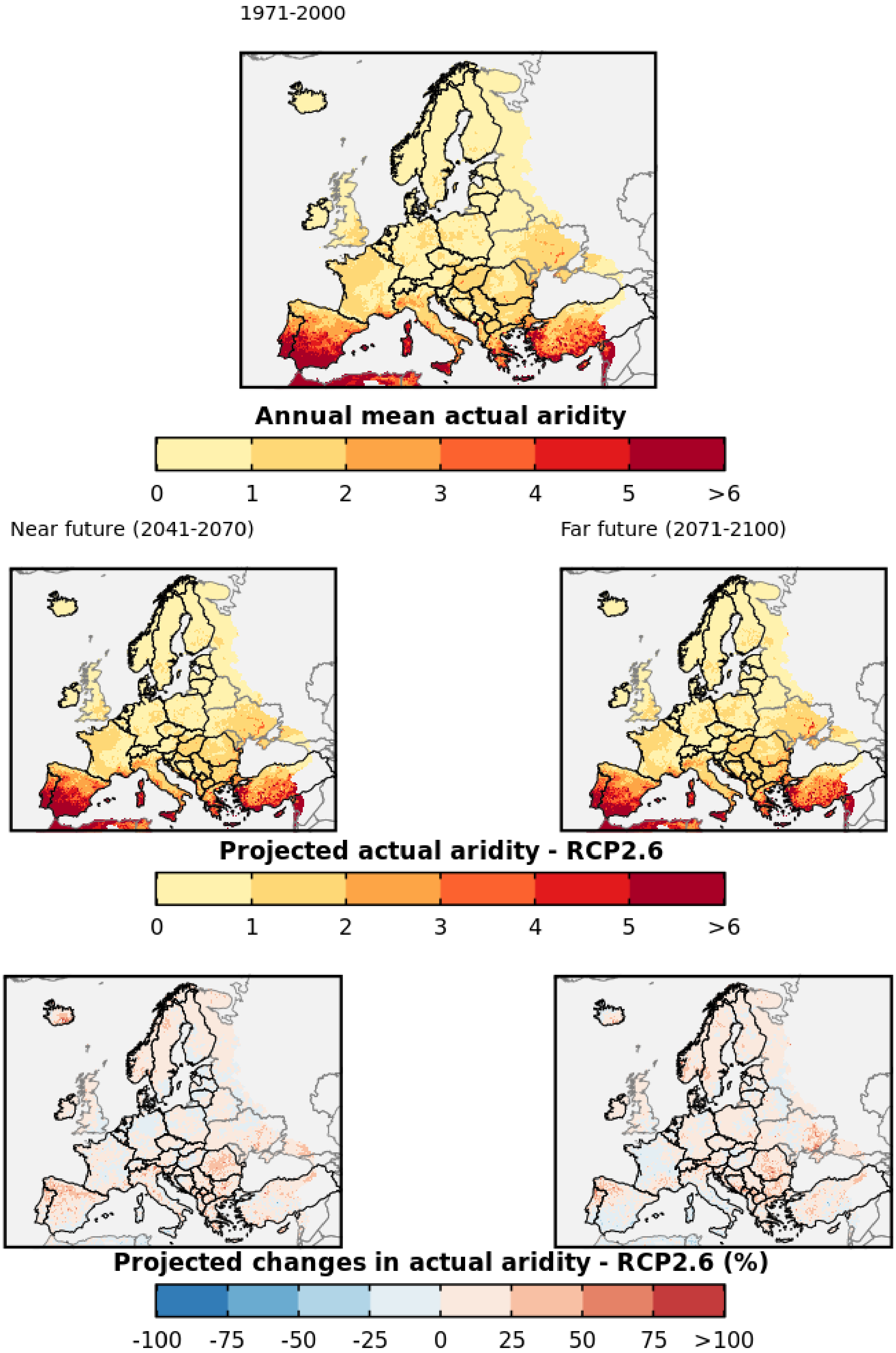
- RCP 2.6 15th percentile in the near future (2041-2060) for the current exposure. This is because the historical data in the EEA indicator is for the period 1986-2005 and so already almost 20 years out of date.
- RCP 2.6 in the far future (2081-2100) for future exposure comparable to SSP 2.0-4.5.
- RCP 4.5 in the far future (2081-2100) for future exposure comparable to SSP 3.0-7.0.
- RCP 8.5 in the far future (2081-2100) is also considered to determine if a more significant long term exposure score should be assigned to manage the range of possible future climate impacts.
- Future exposure is based on the 85th percentile estimates to take a precautionary approach.

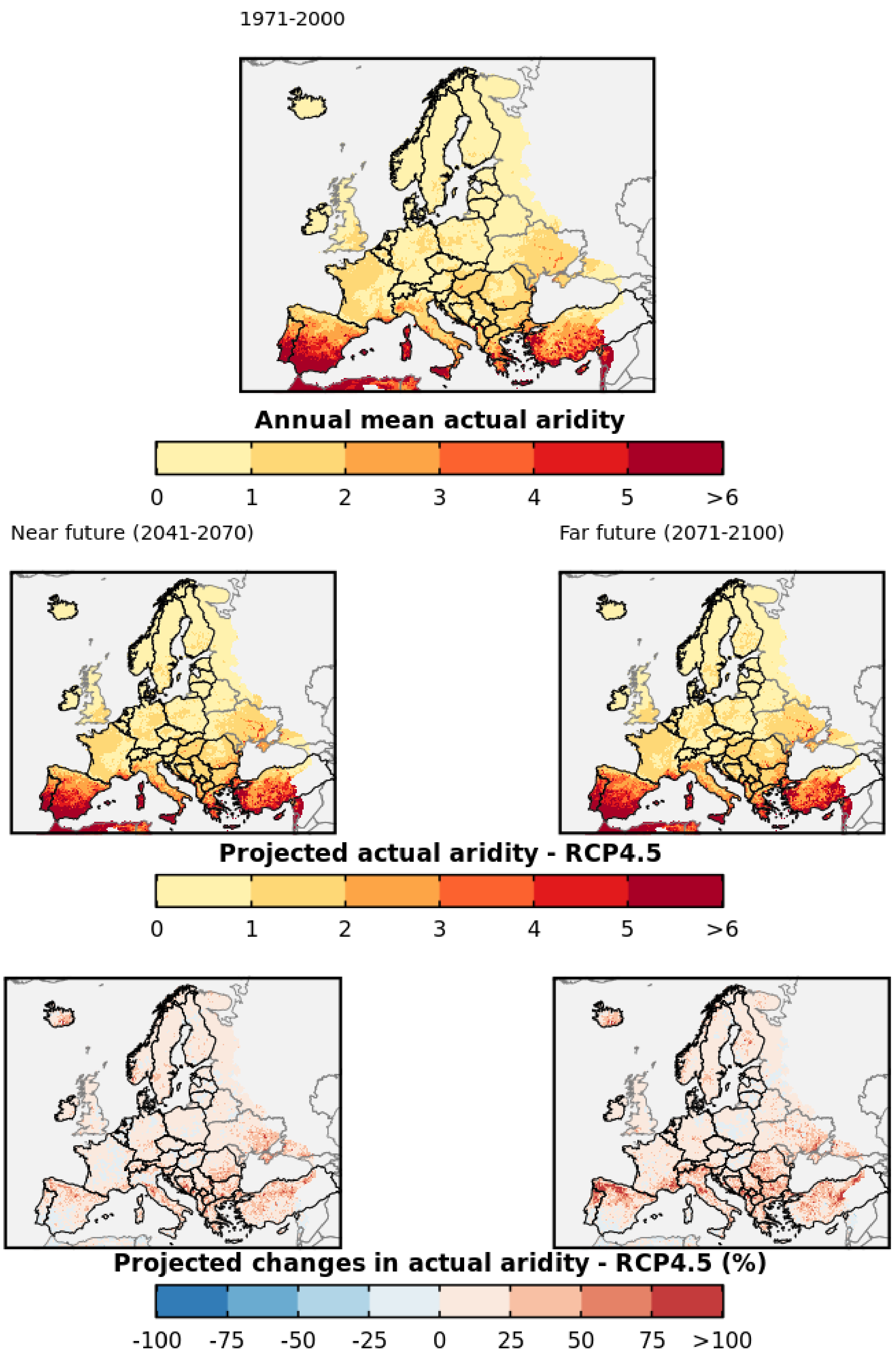
The IPCC AR6 (section 13.2.1.2.2) confirms the projected trends in aridity, drought and water resources, and increase the confidence level in the expected impacts.

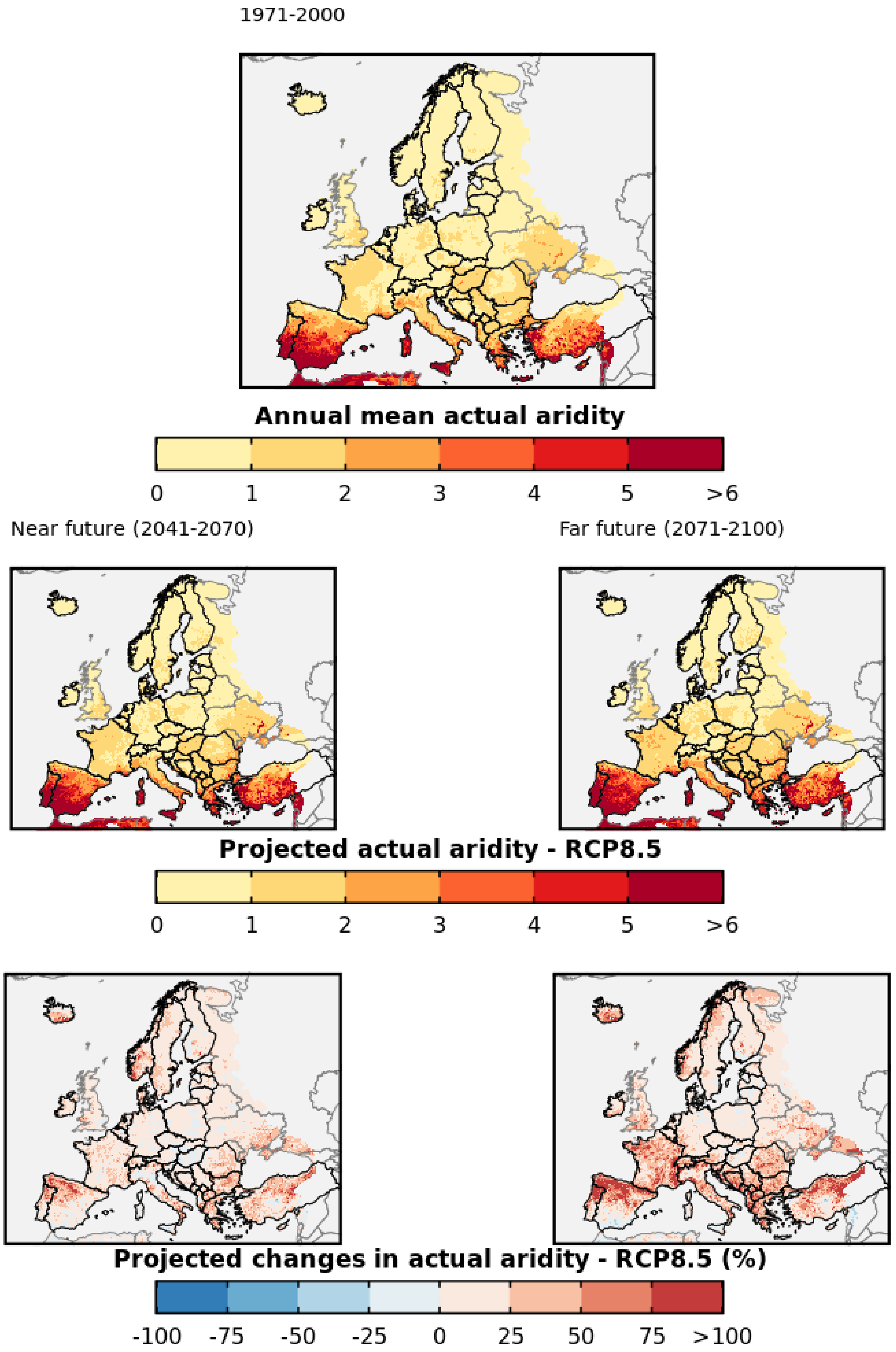
Aridity. The aridity actual index is defined as the ratio between mean annual actual evapotranspiration and mean annual precipitation, typically calculated over a reference period of 30 years. Actual evapotranspiration is estimated using hydrological models and, in contrast to potential

[27] Wet and dry — heavy precipitation and river floods — European Environment Agency (europa.eu)

evapotranspiration, accounts for the limited water content actually available in the soil when estimating the evapotranspiration demand.




1971-2000
Annual mean actual aridity
0
1
2
3
4
5
>6
Near future (2041-2070)
Far future (2071-2100)
Projected actual aridity - RCP4.5
0
1
2
3
4
5
>6
Projected changes in actual aridity - RCP4.5 (%)
-100
-75
-50
-25
0
25
50
75
>100


1971-2000
Annual mean actual aridity
0 1 2 3 4 5 >6
Near future (2041-2070)
Far future (2071-2100)
Projected actual aridity - RCP8.5
0 1 2 3 4 5 >6
Projected changes in actual aridity - RCP8.5 (%)
-100 -75 -50 -25 0 25 50 75 >100

Consecutive dry days. The consecutive dry days index reports the longest consecutive period in a year with daily precipitation below 1 mm. The index measures the persistence of dry conditions in a region.

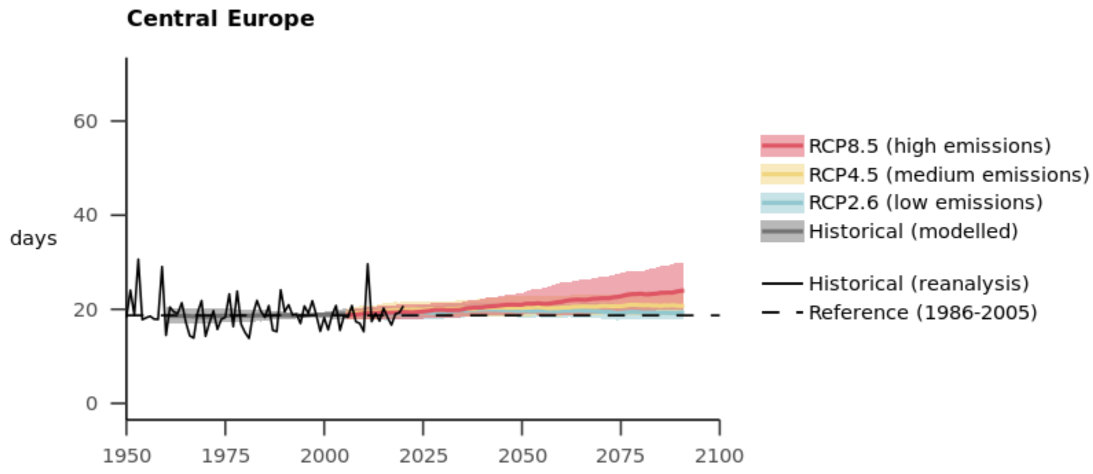
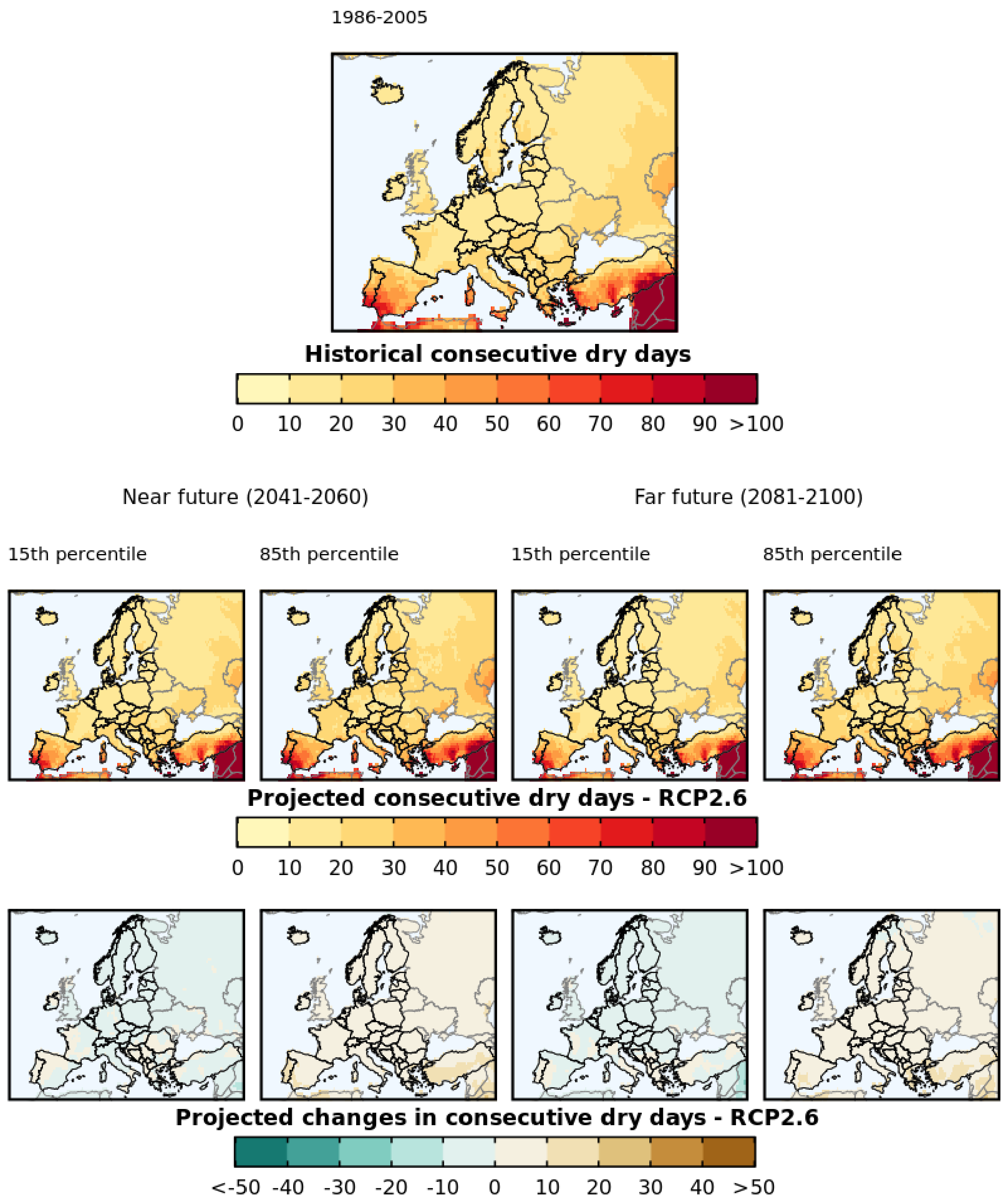
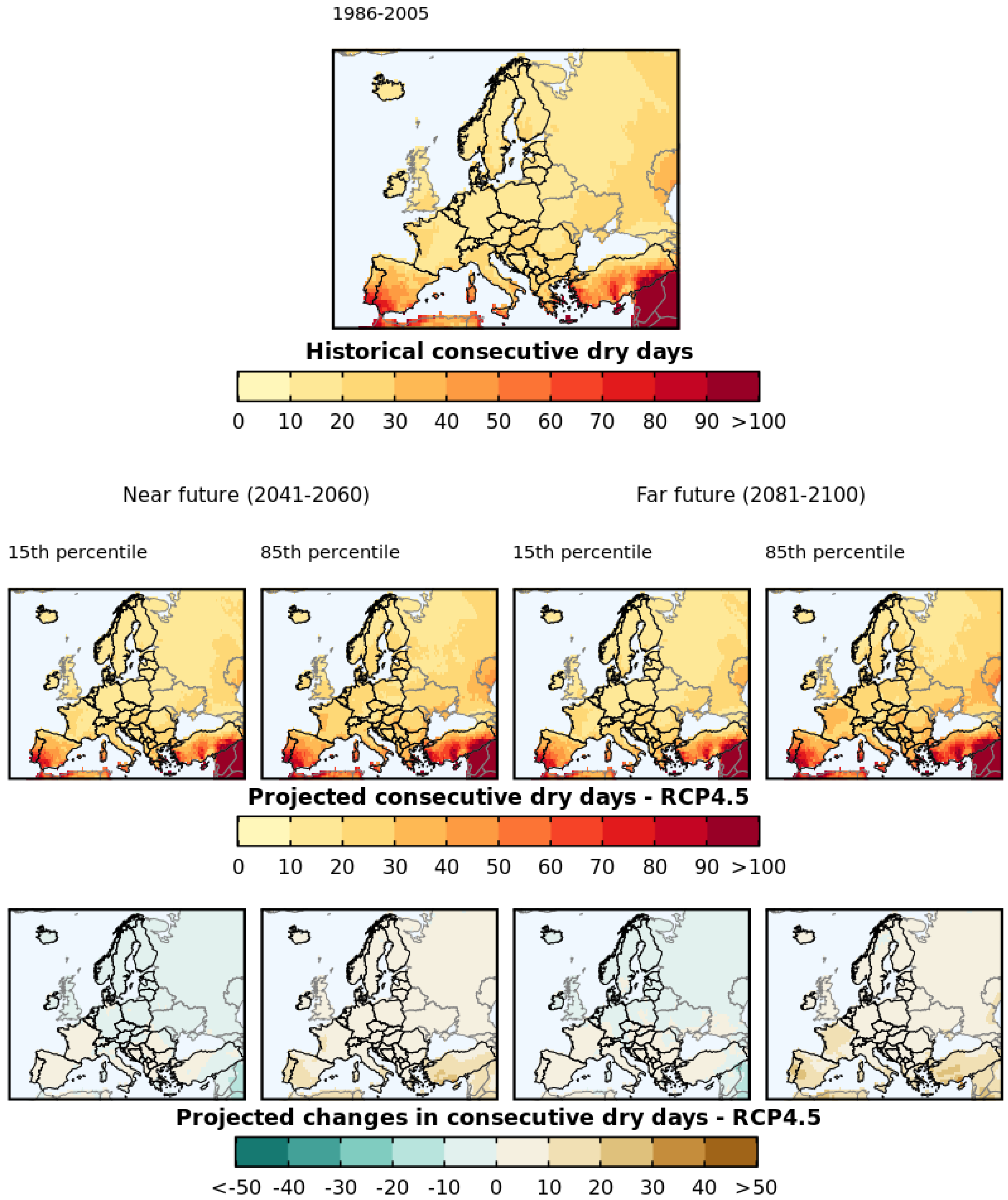
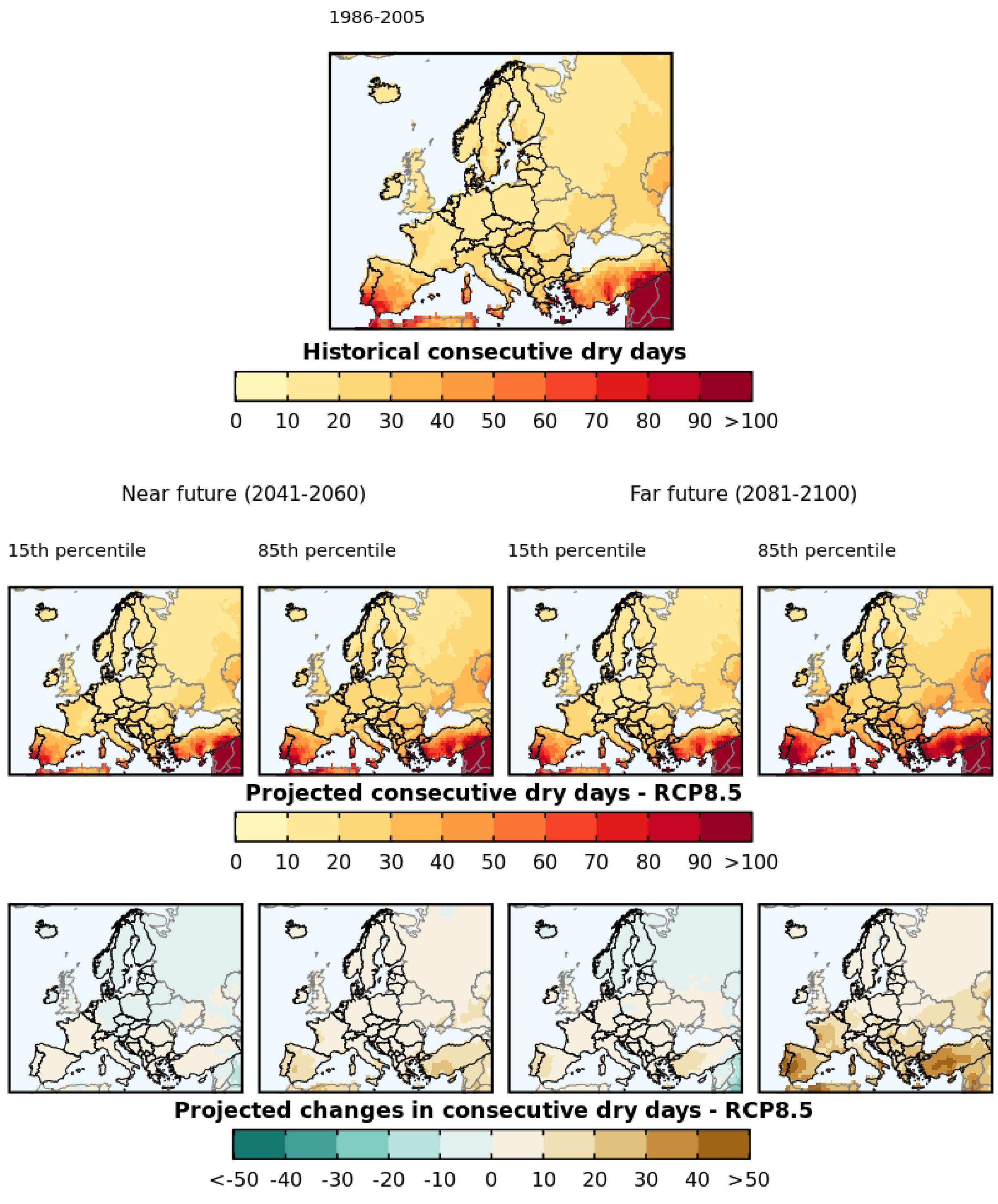


Figure 4-39. Projected change in the longest number of consecutive dry days per year for Central Europe.


1986-2005
Historical consecutive dry days
0 10 20 30 40 50 60 70 80 90 >100
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected consecutive dry days - RCP2.6
0 10 20 30 40 50 60 70 80 90 >100
Projected changes in consecutive dry days - RCP2.6
<-50 -40 -30 -20 -10 0 10 20 30 40 >50


1986-2005
Historical consecutive dry days
0 10 20 30 40 50 60 70 80 90 >100
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected consecutive dry days - RCP4.5
0 10 20 30 40 50 60 70 80 90 >100
Projected changes in consecutive dry days - RCP4.5
<-50 -40 -30 -20 -10 0 10 20 30 40 >50


1986-2005
Historical consecutive dry days
0 10 20 30 40 50 60 70 80 90 >100
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected consecutive dry days - RCP8.5
0 10 20 30 40 50 60 70 80 90 >100
Projected changes in consecutive dry days - RCP8.5
<-50 -40 -30 -20 -10 0 10 20 30 40 >50

Duration of meteorological drought. The duration of meteorological droughts index represents the average number of months in a year in which drought conditions are experienced as determined by anomalously low precipitation values. The index is based on the Standardized Precipitation Index aggregated over three months (SPI-3), which represents the deficit or surplus of precipitation with respect to a reference period. Alternative aggregation periods for the SPI can be used depending on the type of drought considered and the specific applications. SPI values represent standard deviations of precipitation from the long-term mean. A drought event is considered to have started when SPI values fall below -1 for at least two consecutive months and to have ended when the index value returns to a positive number.

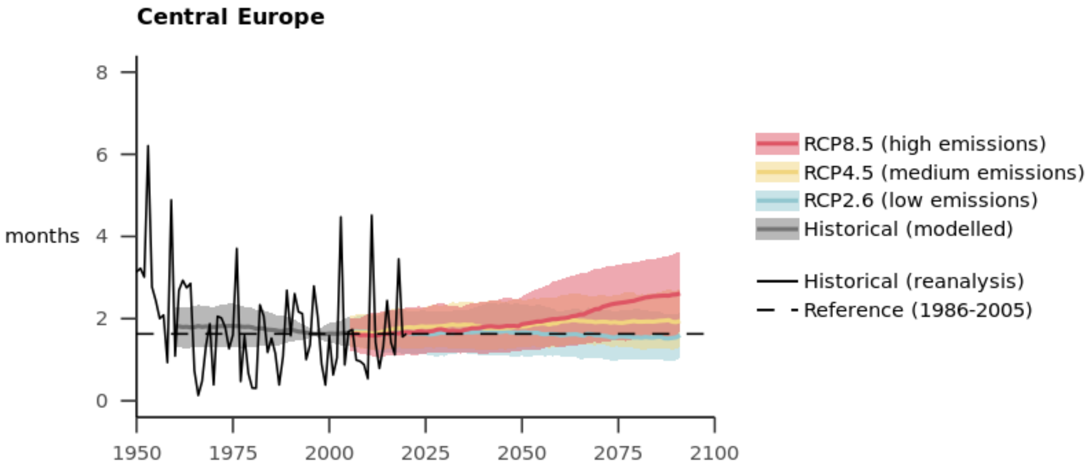
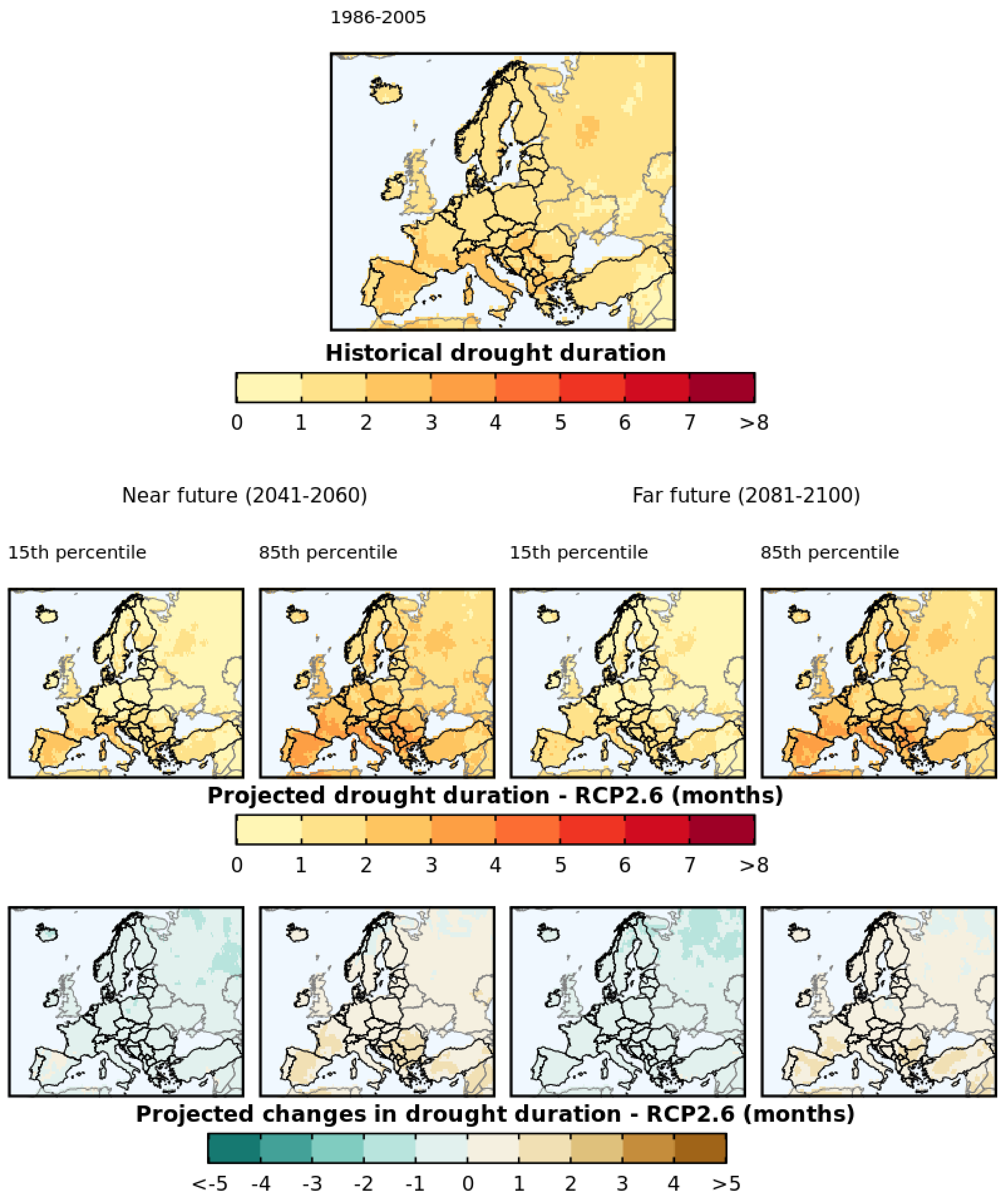
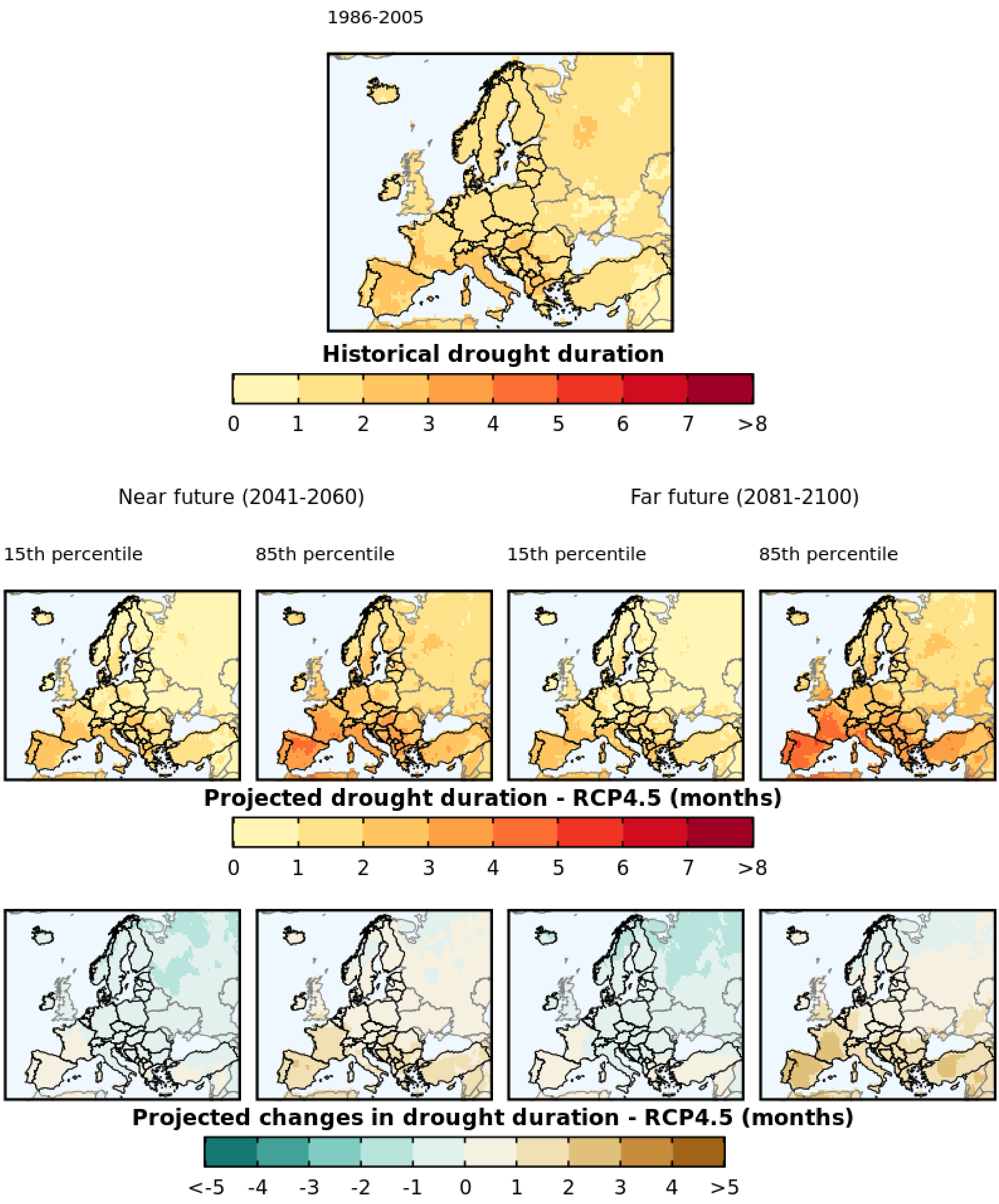
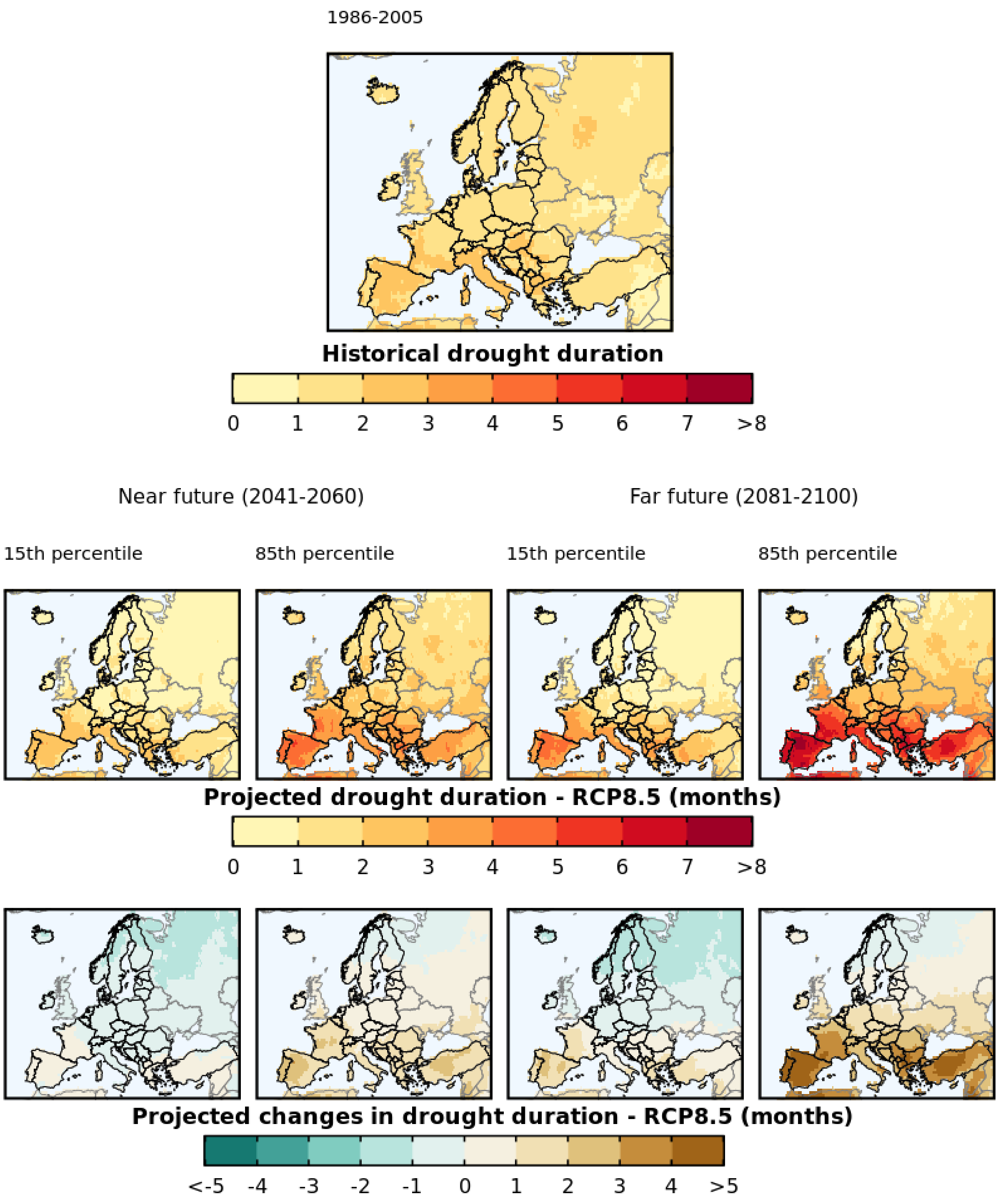


Figure 4-40. Projected change in the duration of meteorological droughts for Central Europe.



1986-2005
Historical drought duration
0
1
2
3
4
5
6
7
>8
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected drought duration - RCP2.6 (months)
0
1
2
3
4
5
6
7
>8
Projected changes in drought duration - RCP2.6 (months)
<-5
-4
-3
-2
-1
0
1
2
3
4
>5


1986-2005
Historical drought duration
0 1 2 3 4 5 6 7 >8
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected drought duration - RCP4.5 (months)
0 1 2 3 4 5 6 7 >8
Projected changes in drought duration - RCP4.5 (months)
<-5 -4 -3 -2 -1 0 1 2 3 4 >5


1986-2005
Historical drought duration
0 1 2 3 4 5 6 7 >8
Near future (2041-2060)
Far future (2081-2100)
15th percentile
85th percentile
15th percentile
85th percentile
Projected drought duration - RCP8.5 (months)
0 1 2 3 4 5 6 7 >8
Projected changes in drought duration - RCP8.5 (months)
<-5 -4 -3 -2 -1 0 1 2 3 4 >5

Magnitude of meteorological drought. The magnitude of meteorological droughts index combines information about the duration and severity of droughts. It is defined as the positive sum of the Standardized Precipitation Index (SPI) for all months within drought events in a given year, thereby giving more weight to months with severe droughts than those with less severe droughts. For consistency with the duration of meteorological droughts index above, this index is also based on the SPI aggregated over three months (SPI-3) and a threshold of -1 is used to identify drought occurrences. Alternative aggregation periods for the SPI can be used depending on the type of drought considered and the specific applications.

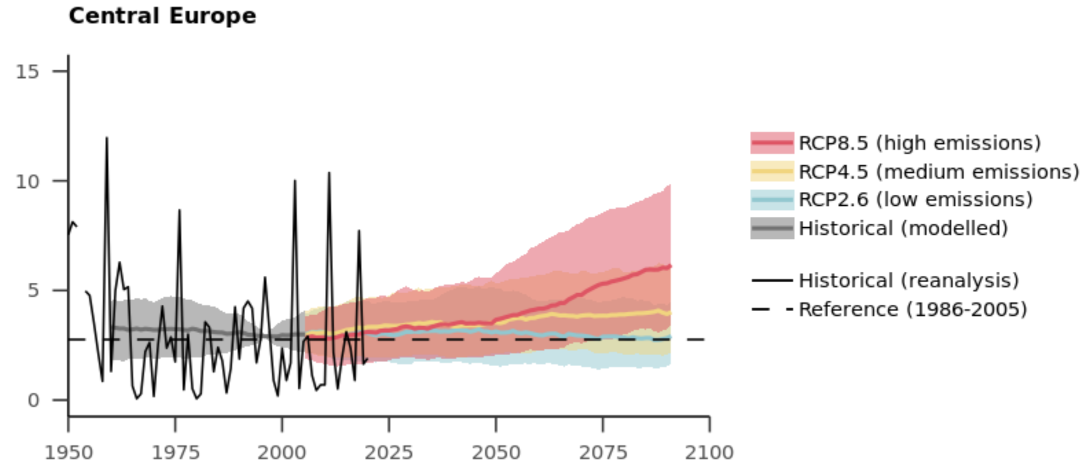


Figure 4-41. Projected change in the magnitude of meteorological droughts for Central Europe (note the units are a dimensionless index).

Duration of soil moisture droughts. The duration of soil moisture droughts index represents the total number of months in a year where soil water content, as estimated from hydrological models, is below the 20th percentile of soil moisture in the same calendar month during a reference period. The depth of the soil column considered may vary depending on the desired application. Estimates of soil water content derived from hydrological models are considered more accurate and are therefore preferred over the direct outputs of climate models.

Modelled soil moisture content, which is considered here as a proxy for the proposed index, has significantly decreased in southern Europe and increased in parts of northern Europe since the 1950s, because of past warming and precipitation changes. Significant decreases in soil moisture content are projected for southern Europe, in particular in summer, whereas increases are projected for north-eastern Europe. Changes in the duration of soil moisture droughts are expected to follow a similar regional pattern. Further information on projections is not yet available as an EEA indicators.

The IPCC AR6 states in chapter 13.2.1.2.2 that the risks for soil moisture drought are projected to increase in WCE for all climate scenarios. At 3°C GWL compared with 1.5°C GWL, the drought area will increase by 40% and the population under drought by up to 42%, especially affecting SEU, and to a lesser extent in WCE.

The exposure score method for aridity and droughts is focused on the main effects of these climate hazards on water and wastewater projects which is the availability of water for abstraction, the demand for irrigation water and the availability of sufficient flow in waterbodies for assimilating discharge of treated water.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• More than 60 consecutive dry days. • Annual mean actual aridity greater than 4.	• Between 40 and 60 consecutive dry days. • Annual mean actual aridity between 2 and 4.	• Between 20 and 40 consecutive dry days. • Annual mean actual aridity between 1 and 2.	• Less than 20 consecutive dry days. • Annual mean actual aridity of less than 1.

Figure 4-42. Exposure scoring method for aridity. The highest score from the two indicators is used as the exposure score for aridity.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• Duration of meterological droughts longer than 4 months. • Magnitude of meterological droughts is greater than 10	• Duration of meterological droughts of between 2 and 4 months. • Magnitude of meterological droughts is between 5 and 10.	• Duration of meterological droughts is less than 2 months. • Magnitude of meterological droughts is less than 5.	• Meteriological droughts do not occur in the project location.

Figure 4-43. Exposure scoring method for drought. The highest score from the two indicators is used as the exposure score for drought.

- **Wildfire**

Forest fires causing damage and endangering human lives can be started by high temperatures and / or extreme weather events (lightning, storms, etc.). Most forest fires are caused by people, especially in spring and autumn when the crop residues are burning on adjacent to national forest lands.

Solar radiation, precipitation, and maximum temperature have the highest correlation to the cumulative burned area fraction reported for the 2015–2019 fire season. The vegetated surfaces in eastern and southern regions face the highest wildfire spreading capacity index values.

There is a total of 75,000 hectares of forest land cover in the project area.

The frequency of wildfires has increased lately and is expected to continue increasing in future. Figure 4-44 maps the forest fire risk for the country from the National Emergency Planning Institute.

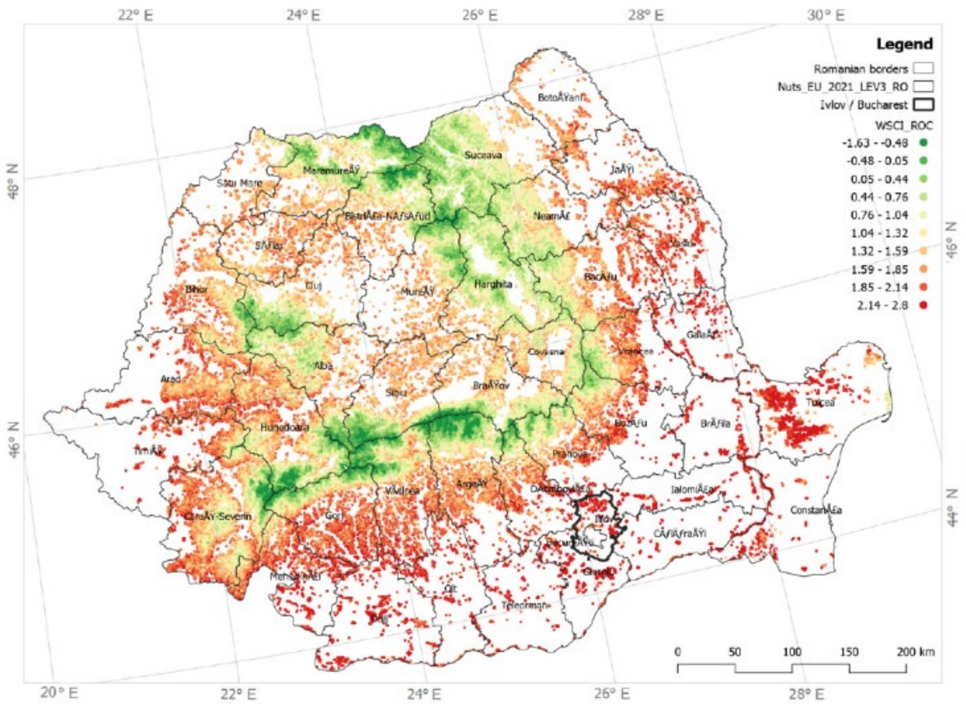


Figure 4-44: Map with the sources of risk to forest fires (dark green areas)

The Copernicus Climate Change Data Store contains Hydrology-related climate impact indicators from 1970 to 2100 derived from bias adjusted European climate projections. The dataset provides water variables and indicators based on hydrological impact modelling, forced by bias adjusted regional climate simulations from the European Coordinated Regional Climate Downscaling Experiment (EURO-CORDEX). The dataset contains Essential Climate Variable (ECV) data in the form of daily mean river discharge and a set of climate impact indicators (CIIs) for both water quantity and quality.

This dataset includes a wildfire danger index[28]. This index reports the total number of days per year with a critical level of fire danger. Fire danger is based on the Canadian Fire Weather Index (FWI), which is one of the most commonly used fire indices globally. It is based on a numerical rating of the potential frontal fire intensity and combines the rate of fire spread with the amount of fuel being consumed. The calculation of the FWI requires several meteorological input variables.

FWI values are classified into several fire danger classes. According to the classification of the European Forest Fire Information System (EFFIS), FWI values in the ranges 11.2-21.3, 21.3-38 and 38-50 represent ‘moderate’, ‘high’ and ‘very high’ fire risks, respectively. However, different classifications are used at national levels. The index presented here shows the annual number of days with high fire danger conditions (defined as daily FWI values above 30 in the underlying Copernicus Climate Change Service (CS3) Climate Data Store (CDS) data set).

- RCP 2.6 15th percentile in the near future (2041-2060) for the current exposure. This is because the historical data in the EEA indicator is for the period 1986-2005 and so already almost 20 years out of date.

[28] Wet and dry — heavy precipitation and river floods — European Environment Agency (europa.eu)

- RCP 2.6 in the far future (2081-2100) for future exposure comparable to SSP 2.0-4.5.
- RCP 4.5 in the far future (2081-2100) for future exposure comparable to SSP 3.0-7.0.
- RCP 8.5 in the far future (2081-2100) is also considered to determine if a more significant long term exposure score should be assigned to manage the range of possible future climate impacts.
- Future exposure is based on the 85th percentile estimates to take a precautionary approach.

Figure 4-45 shows how the number of days with high fire danger is projected to increase in Central and Southern Europe. The project is located within Central Europe but the wildfire risk analysis of the present situation undertaken by the National Emergency Planning Institute suggests the project region is more similar to Southern Europe in terms of wildfire conditions.

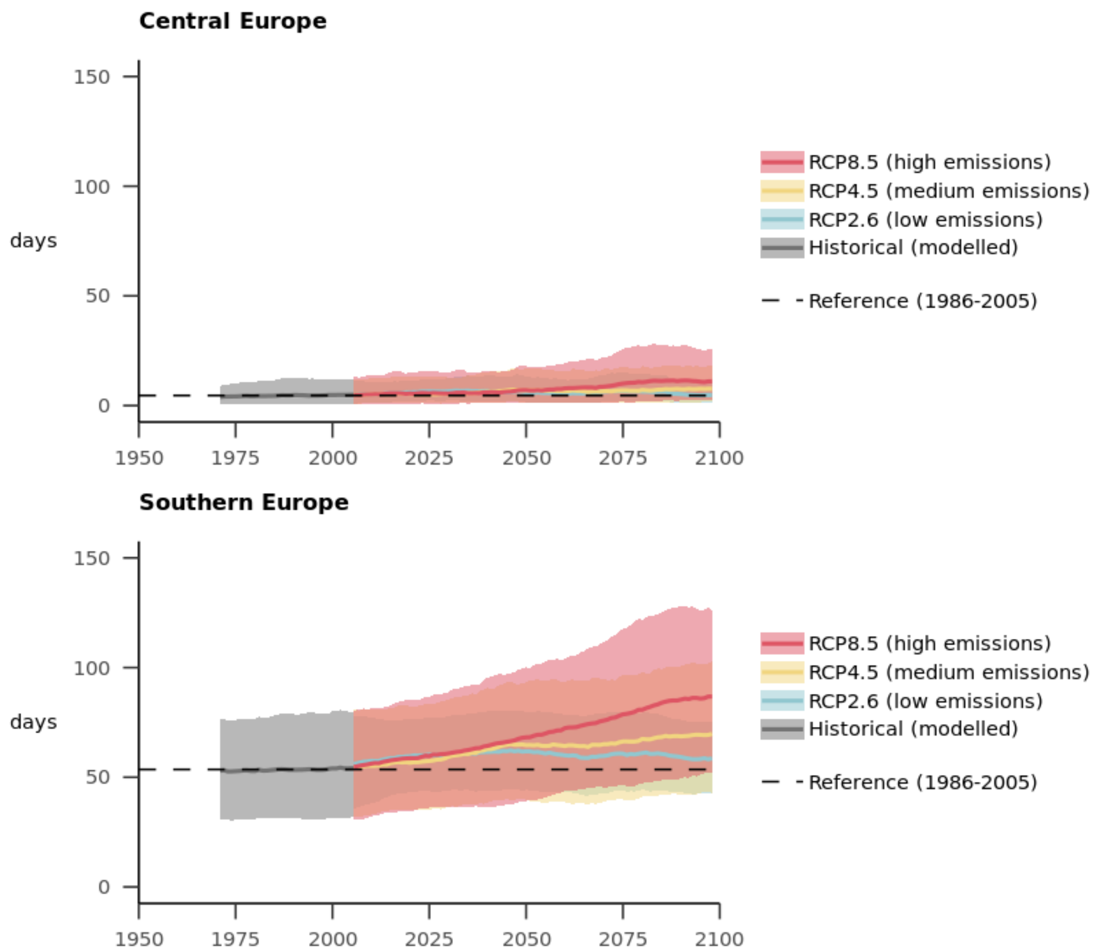


Figure 4-45. Projected change in the number of days with high fire danger (FWI value > 30) Central and Southern Europe.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• More than 80 days of high fire danger.	• Between 20 and 80 days of high fire danger	• Less than 20 days of high fire danger.	• No days of wildfire danger.

Figure 4-46. Exposure scoring method for wildfire.

4.2.2.6 Snow and ice

Snow depth is significantly decreasing over large areas in the central, Western and Northern part of the country; downward trends of snow depth are also present over smaller areas in Southern and Eastern regions. Figure 4-47 shows the trend in snow depth for the period 1961-2012 from National Meteorological Institute data. In the project location there is a clear decrease in snow depth over this period. The IPCC AR6 (section 13.1.4) states with high confidence that Projections suggest a substantial reduction in European ice glacier volumes and in snow cover below elevations of 1500–2000 m, as well as further permafrost thawing and degradation, during the 21st century, even at a low GWL.

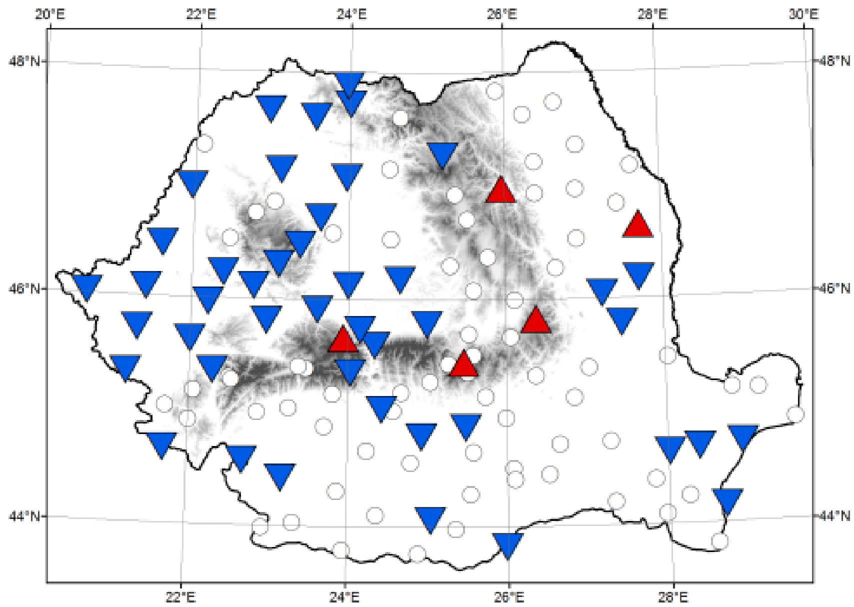


Figure 4-47: Trends of snow depth for the cold season (December to February) at 123 meteorological stations for the interval 1961-2012 [Significant trends (at the 90%confidence level) are represented by red triangle for increasing temperatures and blue triangles for decreasing ones. Grey circles illustrate locations without significant trends]

- **Avalanche**

The project is not located within a mountainous region and so snow accumulation cannot result in an avalanche.

- **Melting permafrost**

There is no permafrost in the project area or region and so there is no possibility of exposure to the effects of this hazard on infrastructure stability.

- **Ice flow in rivers**

The rivers in the project area have frozen before with two records in the past 10 years in 2012 and 2008. With the increasing trend in minimum temperature (section 4.2.2.2) the exposure to ice flows is expected to decrease but there is significant uncertainty due to the lack of reliable modelling of the effect of climate change scenarios. The generic exposure scoring method in Figure 4-10 is applied.

4.2.2.7 Coastal and Oceanic

The project is not located in a coastal region. A check of the coastal flood hazard, and coastal erosion risk map climate change scenarios confirms that there is no exposure now or in the future to coastal hazards.

There is no discharge of treated effluent to coastal or transitional waterbodies. There is no abstraction of coastal or transitional water.

4.2.2.8 Other water

- **Fresh water temperature**

IPCC AR6 report (section 13.2.1.2.3) states that water temperatures in rivers and lakes have increased over the past century by ~1–3°C in major European rivers. Warming is accelerating for all European river basins increasing by 0.8°C in response to 1.5°C GWL and 1.2°C for 3°C GWL relative to 1971–2000 aggravated by declines in summer river flow.

Water Framework Directive water body monitoring data of the rivers within the project area confirms an increase in surface water and groundwater temperature over the period 2005 to 2022.

The effect of water temperature climate hazard to a water or wastewater project is through changes in the treatment process efficiency and the level of treatment required. The exposure score only relates to long term trend in water temperature.

- **Fresh water quality**

IPCC AR6 report (section 13.2.1.2.3) states (Ground)water extractions or drainage have caused saltwater intrusions. During summer, seawater will also penetrate estuaries further upstream in response to reduced river flow and SLR, resulting in more frequent closure of water inlets in the downstream part of the rivers in a period when water is most needed (high agreement, low evidence).

Groundwater modelling carried out during the project Feasibility Study confirms that saline intrusion from seawater will not affect the proposed aquifer water source. However, the project is exposed to other hazards associated with water quality. These include:

- Assimilative capacity (both quality and quantity of flow) of receiving waterbodies to discharges or treated water,
- Changes in groundwater body quality and recharge regime.

Water Framework Directive water body monitoring data of the rivers within the project area confirms an overall decrease in all elements of water quality for surface water and groundwater bodies. The latest River Basin Management Plan states that climate change is projected to increase pressures on water body status.

There are secondary or knock-on effects as a result of the current and proposed water supply and treatment processes and systems on water quality and the effect of this water quality on water dependent ecosystems. The demand for water abstraction results in reduced water quality and availability to support healthy ecosystems. This is not a climate hazard to the proposed project location but is an element of exposure to how climate change may alter the limits and thresholds in which the project can operate. The proposed project should seek to reduce the effects of these hazards and contribute to improved resilience to climate change across many sectors of society and the environment. Examples of these include:

- Maximum abstraction rates for irrigation, industry or human consumption during low flow periods.
- Combined sewer discharges following extreme rainfall.
- Level of treatment required prior to discharge into waterbodies or for reuse in irrigation.

Given these uncertainties for water temperature and water quality a qualitative scoring approach is used as presented in Figure 4-48.

High exposure (score 3)	Medium exposure (score 2)	Low exposure (score 1)	No exposure (score 0)
• Significant pressures on water quality. • Continued decline in water body status as a result of climate change which would cause an impediment to achieve WFD objectives.	• Uncertainty in the future pressures and water body status as a result of climate change which would cause an impediment to achieve WFD objectives.	• Possibility of decline in water body status as a result of climate change which would cause an impediment to achieve WFD objectives.	• There is no possibility that the hazard can occur in the project location (e.g. an inland project cannot be exposed to coastal erosion).

Figure 4-48. Exposure scoring for water temperature and quality.

4.2.2.9 Land, soil and geotechnical

- **Soil erosion, saline intrusion and soil salinity**

The effect of soil erosion related climate hazard on water and wastewater projects is through changes in water quality from mobilised soil and sediment at the catchment scale.

The regional state of the environment report describes the soil conditions in the project area and catchment as dark grey soils with various cohesiveness. There are some areas of alluvial and fluvial deposits in the river valleys and historic river terraces. The thickness of soils varies between 1.7 and 3.85 m deep, with mostly neutral pH between 6.7 and 7.1.

The following processes over the last 5 years have affected soil quality and are causes of soil erosion:

- Saturation of soils following heavy rain for a period of at least two weeks in both 2019 and 2020.
- Erosion by rivers and fluvial processes during normal and flood flow conditions.
- Wind erosion on soils with higher sand contend. Especially during drought and arid periods where the soil is exposed outside of the growing season.
- Ploughing of soils.

The National Soil Strategy published in 2019 estimates annual soil loss from agricultural soils in the region to be less than 0.5 tonnes per hectare per year. This is considered as a low risk and so a low exposure score is assigned. The strategy has identified the effects of climate change under medium and high impact climate scenarios. In both scenarios, and with the strategy measures implemented, the strategy expects future pressure on soil to increase and the likelihood of soil erosion to continue.

Increases in river flow variation are predicted in all climate projections and so fluvial process erosion will increase in the future. Given the uncertainty a medium exposure score is assigned.

In the absence of any other more specific analysis the medium impact climate can be used to inform future exposure in 2081-2099 with SSP 2-4.5 and the high impact for SSP 3-7.0.

As stated above the groundwater bodies are not subject to saline intrusion now or in the future.

Soil salinity will increase in the future in response to drier conditions, increased evapotranspiration and reduced water availability. There is no possible effect of soil salinity on the proposed project and so exposure is not scored.

- **Ground Instability / landslides**

The project location has experienced landslides after heavy rains. The factors that influence landslide exposure are gradient of the slope, rainfall intensity and saturated soils, snowmelt, deforestation and other changes in land use and earthquakes. Figure 4-49 shows that the project location is covered by areas at both very low and medium landslide danger. The medium danger areas are on and immediately below steep slopes in the project area. Some of the proposed project infrastructure is located within this zone. Most proposed project infrastructure is located in the very low danger zones.

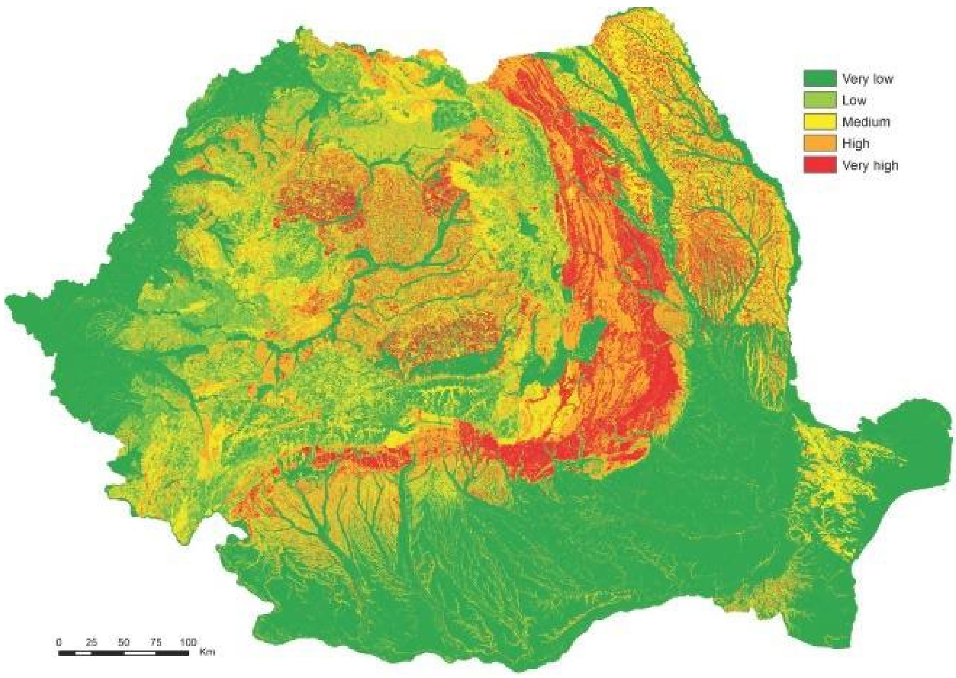


Figure 4-49. Landslide danger map (National Emergency Planning Institute)

The exposure scores in Figure 4-50 for landslide danger is based on the danger categories as mapped by the National Emergency Planning Institute. There is no available information on how climate change alters the danger zone classifications. The drivers of landslides related to climate change are all projected to increase but the slope and land cover are the main characteristics of landslide danger in the project location. For this reason, the future exposure is the same as the present exposure.

Figure 4-50. Exposure scoring for landslide.

- **Dust storms**

There are no records of dust storms or sandstorms in the project location.

- **Earthquake**

The project region has experienced a number of earthquakes between 5 and 6.7 on the Richter scale in 1812, 1932, 1970, 1989, 1991 and 2005. The project location is within a medium risk zone. Climate change will not alter the frequency or magnitude of earthquakes and so the future exposure is given the same score as the current exposure. Exposure is scored using the generic method in Figure 4-10.

4.2.2.10 Exposure assessment

The exposure assessment is for all climate hazards and is summarised in Table 4-4. This is based on the conversion of the climate indicator and projection to an exposure score.

Table 4-4. Exposure assessment for the project location

Hazard Category	Climate Hazard	Exposure score Current exposure (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	Score justification and data sources
Heat and cold	Annual / seasonal / monthly average (air) temperature	2	3	3	Global and European temperatures (EEA climate change indicators). Data available for SSP 1-2.6 used for current exposure, and SSP 5-8.5 used for both future exposure scores.
	Extreme temperature occurrences (including heat waves)	2	2	3	EURO-CORDEX CMIP5 data. Number of days human health heat wave per year. Data available for RCP4.5 used for current exposure and future exposure comparable to SSP 2-4.5, with 6 days and 23 days respectively. RCP8.5 used for future exposure comparable to SSP 3-7.0 with 40 days.
	Cold spells	2	1	1	National meteorological institute data for current exposure to cold spells. Future projections in all scenarios have an increase in winter temperatures. Cold spells are still possible, but the likelihood is reduced.
	Freeze-thaw damage	2	1	1	Current exposure is based on the number of frost days per year in the 1981-2010 period from National Meteorological Authority data and adjusted by the ClimateADAPT indicator for RCP 2.6 in the period 2011-2040. Future exposure is based on the ClimateADAPT projections with RCP 2.6 being used as a comparable source for SSP 2-4.5 and RCP 8.5 for SSP 3-7.0 conditions.
Wind	Average wind speed	0	0	0	National meteorological authority records. EEA climate indicators for Central Europe.

Hazard Category	Climate Hazard	Exposure score			Score justification and data sources
		Current exposure (2021-2040 period) SSP 1-1.9, 1.5⁰C GWL or equivalent	Future exposure (2081-2100 period) SSP 2-4.5, 3⁰C GWL or equivalent	Future exposure (2081-2100 period) SSP 3-7.0, 4⁰C GWL or equivalent	
	Maximum wind speed / Storms (tracks and intensity)	2	2	2	National Meteorological Authority records of severe storms in the period 1990-2020. Climate projections show significant change in the frequency of Mediterranean storms.
Other air and atmospheric	Air quality	1	2	2	National Air Quality Monitoring Network. There is uncertainty in all climate projections and so an exposure score of 2 has been assigned on a precautionary basis.
Wet and dry	Annual / seasonal / monthly average rainfall	0	1	2	Change in annual and summer rainfall totals of up to 10% is expected, however there is significant uncertainty in the projection. Data from the National Meteorological Authority, IPCC AR6 and ClimateADAPT indicator (RCP 8.5 in 2071-2099 as comparable for SSP 3-7.0).
	Extreme rainfall (frequency and magnitude)	2	3	3	Worst score from Hydrology-related climate impact indicators (EURO-CODEX). See section 4.2.2.5 for details. Of the three extreme rainfall indicators the maximum daily extreme precipitation total had the highest score for current and future exposure.
	River flooding	1	2	3	Intersection of the location of project infrastructure with 2nd cycle Floods Directive Flood Hazard and Risk Maps that cover the three main rivers within the project area. Projected increase in peak river flows in RCP 8.5 is more than 25% which following consultation with the National Hydrological Institute would result in the current 0.1% AEP flood hazard extent becoming a 10% AEP flood hazard extent and potentially result in frequent flooding to the location of project infrastructure.

Hazard Category	Climate Hazard	Exposure score Current exposure (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	Score justification and data sources
	Aridity	1	2	2	Worst score from Hydrology-related climate impact indicators (EURO-CODEX). See section 4.2.2.5 for details. The scores are consistent for both of the two drought indicators available.
	Drought	2	3	3	Worst score from Hydrology-related climate impact indicators (EURO-CODEX). See section 4.2.2.5 for details. The scores are consistent for both of the two drought indicators available.
	Wild Fire	2	2	3	Data from the EEA wildfire indicator (RCP 4.5 in 2071-2099 as comparable for SSP 2-4.5, RCP 8.5 in 2071-2099 as comparable for SSP 3-7.0). Applying projections for Southern Europe as this region has closer conditions in the present day to the project location as confirmed in communication with the National Emergency Planning Institute.
Snow and ice	Avalanche	0	0	0	The project area does not include any mountainous terrain.
	Melting permafrost	0	0	0	There is no permafrost in the project area.
	Ice flows in rivers	2	1	1	Two records of ice flows in rivers are held by the National Hydrological Institute. Expert judgement is applied to predict that exposure to the hazard will decrease in response to warming of the minimum annual temperate and reduction in snow depth.
Coastal	Sea level rise	0	0	0	Project location is not in a coastal area. There are no discharges of treated effluent to transitional or coastal waterbodies. Confirmed by inspection of coastal flood and erosion hazard maps with climate change scenario.
	Coastal flooding	0	0	0	

Hazard Category	Climate Hazard	Exposure score Current exposure (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	Score justification and data sources
	Coastal erosion	0	0	0	
Oceanic	Sea water temperature	0	0	0	Project has no interaction with ocean waters. There are no discharges of treated effluent to transitional or coastal waterbodies.
	Ocean acidity	0	0	0	
	Ocean oxygen level	0	0	0	
	Ocean salinity	0	0	0	
Other water	Fresh water temperature	1	2	2	Current exposure is based on latest RBMP and WFD status data. Effect of future climate change on water temperature and quality is highly uncertain and so given a medium score.
	Fresh water quality	1	2	2	
Land, soil and geotechnical	Soil erosion	1	2	2	Based on National Soil Strategy analysis. Future exposure given a score of 2 to reflect uncertainty.
	Saline intrusion	0	0	0	Project location is not in a coastal area.
	Soil salinity	0	0	0	No possible effect of soil salinity related hazard on water or wastewater projects.

Hazard Category	Climate Hazard	Exposure score			Score justification and data sources
		Current exposure (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent	Future exposure (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	
	Ground Instability / landslides	2	2	2	Some of the proposed project is located in a medium landslide danger zone (National Emergency Planning Institute maps).
	Dust storms	0	0	0	There are no records of dust storms in the project location and aridity is not expected to result in desertification.
	Earthquake	1	1	1	Earthquakes greater than 5 on the Richter scale occur on overage once every 25 years.

4.2.3 Vulnerability

The overall vulnerability of the project is based on the sensitivity of the typical instances of the proposed project components, and the exposure of the project location. The scoring of vulnerability is based on the methodology in Figure 4-51. The vulnerability of the overall project and project components is set out in Tables 4-5 to 4-10.

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Vulnerability = Sensitivity score x Exposure score

		Exposure score			
		0	1	2	3
Sensitivity score	0	0	0	0	0
	1	0	1	2	3
	2	0	2	4	6
	3	0	3	6	9

High vulnerability (score ≥6)

- Project is vulnerable to this climate hazard
- Take forward to detailed assessment (phase 2)

Medium vulnerability (score 3<6)

- Project may be vulnerable to this climate hazard
- Consider taking forwards to detailed assessment (phase 2)

Low (or zero) vulnerability (score ≤2)

- Project is not vulnerable to this climate hazard
- Do not progress to detailed assessment

Figure 4-51. Vulnerability scoring approach (top: score formula, left: score matrix, right: score description and implication)

Table 4-5. Vulnerability table for the water supply project components

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	
			Exposure	Vulnerability	Exposure	Vulnerability	Exposure	Vulnerability
Heat and cold	Annual / seasonal / monthly average (air) temperature	2	2	**4**	3	**6**	3	**6**
	Extreme temperature occurrences (including heat waves)	2	2	**4**	2	**4**	3	**6**
	Cold spells	2	2	**4**	1	**2**	1	**2**
	Freeze-thaw damage	2	2	**4**	1	**2**	1	**2**
Wind	Average wind speed	0	0	**0**	0	**0**	0	**0**
	Maximum wind speed / Storms (tracks and intensity)	3	2	**6**	2	**6**	2	**6**
Other air and atmospheric	Air quality	1	1	**1**	2	**2**	2	**2**
Wet and dry	Annual / seasonal / monthly average rainfall	2	0	**0**	1	**2**	2	**4**
	Extreme rainfall (frequency and magnitude)	3	2	**6**	3	**9**	3	**9**
	River flooding	3	1	**3**	2	**6**	3	**9**

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	
			Exposure	**Vulnerability**	**Exposure**	**Vulnerability**	**Exposure**	**Vulnerability**
	Aridity	2	1	**2**	2	**4**	2	**4**
	Drought	3	2	**6**	3	**9**	3	**9**
	Wild Fire	3	2	**6**	2	**6**	3	**9**
Snow and ice	Avalanche	3	0	**0**	0	**0**	0	**0**
	Melting permafrost	3	0	**0**	0	**0**	0	**0**
	Ice flows in rivers	3	2	**6**	1	**3**	1	**3**
Coastal	Sea level rise	3	0	**0**	0	**0**	0	**0**
	Coastal flooding	3	0	**0**	0	**0**	0	**0**
	Coastal erosion	3	0	**0**	0	**0**	0	**0**
Oceanic	Sea water temperature	0	0	**0**	0	**0**	0	**0**
	Ocean acidity	1	0	**0**	0	**0**	0	**0**
	Ocean oxygen level	1	0	**0**	0	**0**	0	**0**
	Ocean salinity	1	0	**0**	0	**0**	0	**0**

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	
			Exposure	**Vulnerability**	**Exposure**	**Vulnerability**	**Exposure**	**Vulnerability**
Other water	Fresh water temperature	2	1	**2**	2	**4**	**2**	**4**
	Fresh water quality	3	1	**3**	2	**6**	**2**	**6**
Land, soil and geotechnical	Soil erosion	1	1	**1**	2	**2**	2	**2**
	Saline intrusion	3	0	**0**	0	**0**	0	**0**
	Soil salinity	0	0	**0**	0	**0**	0	**0**
	Ground Instability / landslides	3	2	**6**	2	**6**	2	**6**
	Dust storms	1	0	**0**	0	**0**	0	**0**
	Earthquake	3	1	**3**	1	**3**	1	**3**

Table 4-6. Vulnerability summary for water supply components

		CURRENT EXPOSURE				FUTURE EXPOSURE (worst case)			
SENSITIVITY		0	1	2	3	0	1	2	3
	0	Average wind speed Sea water temperature Soil salinity				Average wind speed Sea water temperature Soil salinity			
	1	Ocean acidity, pH and salinity Dust storms	Air quality Soil erosion			Ocean acidity, pH and salinity Dust storms		Air quality Soil erosion	
	2	Annual / seasonal / monthly average rainfall	Aridity Fresh water temperature	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves) Cold spells Freeze-thaw damage			Cold spells Freeze-thaw damage	Annual / seasonal / monthly average rainfall Aridity Fresh water temperature	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves)
	3	Avalanche Melting permafrost All Coastal Hazards Saline intrusion	River flooding Earthquake Fresh water quality	Maximum wind speed / Storms (tracks and intensity) Extreme rainfall (frequency and magnitude) Drought Wildfire Ice flows in rivers Ground Instability / landslides		Avalanche Melting permafrost All Coastal Hazards Saline intrusion	Ice flows in rivers Earthquake	Maximum wind speed / Storms (tracks and intensity) Ground Instability / landslides Fresh water quality	Extreme rainfall (frequency and magnitude) River flooding Drought Wildfire

Table 4-7. Vulnerability table for the wastewater project components

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	
			Exposure	Vulnerability	Exposure	Vulnerability	Exposure	Vulnerability
Heat and cold	Annual / seasonal / monthly average (air) temperature	2	2	**4**	3	**6**	3	**6**
	Extreme temperature occurrences (including heat waves)	2	2	**4**	2	**4**	3	**6**
	Cold spells	2	2	**4**	1	**2**	1	**2**
	Freeze-thaw damage	2	2	**4**	1	**2**	1	**2**
Wind	Average wind speed	1	0	**0**	0	**0**	0	**0**
	Maximum wind speed / Storms (tracks and intensity)	1	2	**2**	2	**2**	2	**2**
Other air and atmospheric	Air quality	2	1	**2**	2	**4**	2	**4**
Wet and dry	Annual / seasonal / monthly average rainfall	2	0	**0**	1	**2**	2	**4**
	Extreme rainfall (frequency and magnitude)	3	2	**6**	3	**9**	3	**9**
	River flooding	3	1	**3**	2	**6**	3	**9**

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5⁰C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3⁰C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4⁰C GWL or equivalent	
			Exposure	Vulnerability	Exposure	Vulnerability	Exposure	Vulnerability
	Aridity	2	1	**2**	2	**4**	2	**4**
	Drought	3	2	**6**	3	**9**	3	**9**
	Wild Fire	3	2	**6**	2	**6**	3	**9**
Snow and ice	Avalanche	3	0	**0**	0	**0**	0	**0**
	Melting permafrost	3	0	**0**	0	**0**	0	**0**
	Ice flows in rivers	3	2	**6**	1	**3**	1	**3**
Coastal	Sea level rise	3	0	**0**	0	**0**	0	**0**
	Coastal flooding	3	0	**0**	0	**0**	0	**0**
	Coastal erosion	3	0	**0**	0	**0**	0	**0**
Oceanic	Sea water temperature	0	0	**0**	0	**0**	0	**0**
	Ocean acidity	0	0	**0**	0	**0**	0	**0**
	Ocean oxygen level	0	0	**0**	0	**0**	0	**0**
	Ocean salinity	0	0	**0**	0	**0**	0	**0**

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5⁰C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3⁰C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4⁰C GWL or equivalent	
			Exposure	**Vulnerability**	**Exposure**	**Vulnerability**	**Exposure**	**Vulnerability**
Other water	Fresh water temperature	2	1	**2**	2	**4**	**2**	**4**
	Fresh water quality	3	1	**3**	2	**6**	**2**	**6**
Land, soil and geotechnical	Soil erosion	2	1	**2**	2	**4**	2	**4**
	Saline intrusion	2	0	**0**	0	**0**	0	**0**
	Soil salinity	3	0	**0**	0	**0**	0	**0**
	Ground Instability / landslides	2	2	**4**	2	**4**	2	**4**
	Dust storms	3	0	**0**	0	**0**	0	**0**
	Earthquake	3	1	**3**	1	**3**	1	**3**

Table 4-8. Vulnerability summary for wastewater components

	CURRENT EXPOSURE		FUTURE EXPOSURE (worst case)

SENSITIVITY		0	1	2	3	0	1	2	3
	0	Average wind speed All Oceanic Hazards				Average wind speed All Oceanic Hazards			
	1			Maximum wind speed / Storms (tracks and intensity)				Maximum wind speed / Storms (tracks and intensity)	
	2	Annual / seasonal / monthly average rainfall Saline intrusion	Air quality Aridity Soil erosion Fresh water temperature	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves) Cold spells Freeze-thaw damage Ground Instability / landslides		Saline intrusion	Cold spells Freeze-thaw damage	Annual / seasonal / monthly average rainfall Air quality Aridity Fresh water temperature Soil erosion Ground Instability / landslides	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves)
	3	Avalanche Melting permafrost All Coastal Hazards Soil salinity Dust storms	River flooding Earthquake Fresh water quality	Extreme rainfall (frequency and magnitude) Drought Wildfire Ice flows in rivers		Avalanche Melting permafrost All Coastal Hazards Soil salinity Dust storms	Ice flows in rivers Earthquake	Maximum wind speed / Storms (tracks and intensity) Ground Instability / landslides Fresh water quality	Extreme rainfall (frequency and magnitude) River flooding Drought Wildfire

Table 4-9. Vulnerability table for the interdependencies for water and wastewater project

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5⁰C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3⁰C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4⁰C GWL or equivalent	
			Exposure	Vulnerability	Exposure	Vulnerability	Exposure	Vulnerability
Heat and cold	Annual / seasonal / monthly average (air) temperature	2	2	**4**	3	**6**	3	**6**
	Extreme temperature occurrences (including heat waves)	0	2	**0**	2	**0**	3	**0**
	Cold spells	2	2	**4**	1	**2**	1	**2**
	Freeze-thaw damage	0	2	**0**	1	**0**	1	**0**
Wind	Average wind speed	0	0	**0**	0	**0**	0	**0**
	Maximum wind speed / Storms (tracks and intensity)	2	2	**4**	2	**4**	2	**4**
Other air and atmospheric	Air quality	0	1	**0**	2	**0**	2	**0**
Wet and dry	Annual / seasonal / monthly average rainfall	1	0	**0**	1	**1**	2	**2**
	Extreme rainfall (frequency and magnitude)	2	2	**4**	3	**6**	3	**6**
	River flooding	2	1	**2**	2	**4**	3	**6**
	Aridity	0	1	**0**	2	**0**	2	**0**

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5^{0}C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3^{0}C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4^{0}C GWL or equivalent	
			Exposure	Vulnerability	Exposure	Vulnerability	Exposure	Vulnerability
	Drought	0	2	**0**	3	**0**	3	**0**
	Wild Fire	3	2	**6**	2	**6**	3	**9**
Snow and ice	Avalanche	3	0	**0**	0	**0**	0	**0**
	Melting permafrost	0	0	**0**	0	**0**	0	**0**
	Ice flows in rivers	0	2	**0**	1	**0**	1	**0**
Coastal	Sea level rise	3	0	**0**	0	**0**	0	**0**
	Coastal flooding	2	0	**0**	0	**0**	0	**0**
	Coastal erosion	3	0	**0**	0	**0**	0	**0**
Oceanic	Sea water temperature	0	0	**0**	0	**0**	0	**0**
	Ocean acidity	0	0	**0**	0	**0**	0	**0**
	Ocean oxygen level	0	0	**0**	0	**0**	0	**0**
	Ocean salinity	0	0	**0**	0	**0**	0	**0**
Other water	Fresh water temperature	**0**	1	**0**	2	**0**	**2**	**0**

Hazard Category	Climate Variables	Global Sensitivity	Current (2021-2040 period) SSP 1-1.9, 1.5⁰C GWL or equivalent		Future (2081-2100 period) SSP 2-4.5, 3⁰C GWL or equivalent		Future (2081-2100 period) SSP 3-7.0, 4⁰C GWL or equivalent	
			Exposure	Vulnerability	Exposure	Vulnerability	Exposure	Vulnerability
	Fresh water quality	**0**	1	**0**	2	**0**	**2**	**0**
Land, soil and geotechnical	Soil erosion	**0**	1	**0**	2	**0**	2	**0**
	Saline intrusion	**0**	0	**0**	0	**0**	0	**0**
	Soil salinity	**0**	0	**0**	0	**0**	0	**0**
	Ground Instability / landslides	**3**	2	**6**	2	**6**	2	**6**
	Dust storms	**1**	0	**0**	0	**0**	0	**0**
	Earthquake	**3**	1	**3**	1	**3**	1	**3**

Table 4-10. Vulnerability summary for project interdependencies

		CURRENT EXPOSURE					FUTURE EXPOSURE (worst case)			
SE		0	1	2	3		0	1	2	3

	0	Average wind speed Melting permafrost All Oceanic Hazards Saline intrusion Soil salinity	Air quality Aridity Soil erosion Fresh water temperature Fresh water quality	Extreme temperature occurrences (including heat waves) Freeze-thaw damage Drought Ice flows in rivers		Average wind speed Melting permafrost All Oceanic Hazards Saline intrusion Soil salinity	Freeze-thaw damage Ice flows in rivers	Air quality Aridity Soil erosion Fresh water temperature Fresh water quality	Extreme temperature occurrences (including heat waves) Drought
	1	Annual / seasonal / monthly average rainfall Dust storms				Dust storms		Annual / seasonal / monthly average rainfall	
	2	Coastal flooding	River flooding	Annual / seasonal / monthly average (air) temperature Cold spells Extreme rainfall (frequency and magnitude) Maximum wind speed / Storms (tracks and intensity)		Coastal flooding	Cold spells	Maximum wind speed / Storms (tracks and intensity)	Annual / seasonal / monthly average (air) temperature Extreme rainfall (frequency and magnitude) River flooding
	3	Avalanche Sea level rise Coastal erosion	Earthquake	Extreme rainfall (frequency and magnitude) Wildfire Ground Instability / landslides		Avalanche Sea level rise Coastal erosion	Earthquake	Ground Instability / landslides	Wildfire

The following tables describe the project components which are moderately or highly vulnerable to climate hazards and so progress to the detailed assessment.

Table 4-11. Summary of water project component vulnerability

	Inputs	Assets and Processes			Outputs
Vulnerability	**Ground Water Aquifer (Water Source)**	**Water Distribution Network (pipes)**	**Pumping stations**	**Water treatment plant and treatment processes**	**Quantity and quality of water supplied**
High vulnerability	Extreme rainfall (frequency and magnitude) River flooding Drought Ice flows in rivers (current exposure – reduces to medium vulnerability in future) Fresh water quality Ground Instability / landslides	Extreme rainfall (frequency and magnitude) River flooding Ground Instability / landslides	Extreme rainfall (frequency and magnitude) River flooding Wildfire Ground Instability / landslides	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves) – for SSP 3-7.0 equivalent, is medium vulnerability for SSP 2-4.5 equivalent. Maximum wind speed / Storms (tracks and intensity) Extreme rainfall (frequency and magnitude) River flooding Fresh water quality Wildfire Ground Instability / landslides	Extreme rainfall (frequency and magnitude) River flooding Drought Fresh water quality Wildfire Ground Instability / landslides
Medium vulnerability	Annual / seasonal / monthly average (air) temperature Annual / seasonal / monthly average rainfall Fresh water temperature Earthquake	Earthquake	Extreme temperature occurrences (including heat waves) Freeze-thaw damage – reduces to low vulnerability in future Earthquake	Cold spells – reduces to low vulnerability in future Freeze-thaw damage – reduces to low vulnerability in future Fresh water temperature Earthquake	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves) Freeze-thaw damage – reduces to low vulnerability in future Aridity Earthquake
Note: worst case from current exposure and future exposure under two climate scenarios					

Table 4-12. Summary of wastewater project component vulnerability

Vulnerability	Inputs	Assets and Processes			Outputs		
	Raw effluent	**Sewerage networks (new and existing) including pumping stations**	**Wastewater treatment plants and treatment processes (inc. filtration and disinfection)**	**Constructed wetland**	**Receiving river water body**	**Land used for spreading of sewage sludge**	**Reuse of treated water for irrigation and irrigation channels**
High vulnerability	Extreme temperature occurrences (including heat waves) Extreme rainfall (frequency and magnitude) River flooding Drought	Extreme temperature occurrences (including heat waves) Extreme rainfall (frequency and magnitude) River flooding Ground Instability / landslides	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves) Extreme rainfall (frequency and magnitude) River flooding Wildfire Ground Instability / landslides	Extreme temperature occurrences (including heat waves) Extreme rainfall (frequency and magnitude) River flooding Drought Ground Instability / landslides	Extreme temperature occurrences (including heat waves) Extreme rainfall (frequency and magnitude) River flooding Drought Ice flows in rivers – reducing to medium vulnerability in the future Fresh water quality Ground Instability / landslides	Extreme rainfall (frequency and magnitude) River flooding Drought Wildfire Ground Instability / landslides	Extreme rainfall (frequency and magnitude) River flooding Fresh water quality
Medium vulnerability	Annual / seasonal / monthly average (air) temperature Aridity Ice flows in rivers – reducing to low vulnerability in the future Fresh water temperature	Fresh water temperature Fresh water quality Earthquake	Cold spells – reducing to low vulnerability in the future Freeze-thaw damage – reducing to low vulnerability in the future Fresh water temperature Fresh water quality Earthquake	Annual / seasonal / monthly average (air) temperature Annual / seasonal / monthly average rainfall Aridity Ice flows in rivers – reducing to low vulnerability in the future	Cold spells – reducing to low vulnerability in the future Annual / seasonal / monthly average rainfall Fresh water temperature Soil erosion	Annual / seasonal / monthly average (air) temperature Extreme temperature occurrences (including heat waves) Air quality	Annual / seasonal / monthly average (air) temperature Cold spells – reducing to low vulnerability in the future Annual / seasonal / monthly average rainfall

Vulnerability	Inputs	Assets and Processes			Outputs		
	Raw effluent	**Sewerage networks (new and existing) including pumping stations**	**Wastewater treatment plants and treatment processes (inc. filtration and disinfection)**	**Constructed wetland**	**Receiving river water body**	**Land used for spreading of sewage sludge**	**Reuse of treated water for irrigation and irrigation channels**
	Fresh water quality Ground Instability / landslides			Fresh water temperature Fresh water quality Earthquake	Earthquake	Annual / seasonal / monthly average rainfall Soil erosion Aridity Earthquake	Fresh water temperature Soil erosion Ground Instability / landslides Earthquake
Note: worst case from current exposure and future exposure under two climate scenarios							

Table 4-13. Summary of project interdependency vulnerability

Vulnerability	Interdependencies for water and wastewater aspects	
	Power supply	**Access roads**
High vulnerability	Extreme rainfall (frequency and magnitude) River flooding Wildfire Ground Instability / landslides	Extreme rainfall (frequency and magnitude) River flooding Wildfire Ground Instability / landslides
Medium vulnerability	Annual / seasonal / monthly average (air) temperature Cold spells – reducing to low vulnerability in the future Maximum wind speed / Storms (tracks and intensity) Earthquake	Maximum wind speed / Storms (tracks and intensity) Earthquake
Note: worst case from current exposure and future exposure under two climate scenarios		

4.3 Detailed Assessment - Risk Assessment and Adaptation Measures

The risk assessment is based on the probability or likelihood and consequence of the climate hazards affecting the operation of the proposed project. The level of acceptable risk needs to be determined so that climate adaptation measures can be identified so that all risks can be managed to an acceptable level. The climate proofing documentation is used to demonstrate this. Some acceptable risks may be already defined in construction standards and so are inbuilt into the project. The level of acceptable risk varies by climate hazard and can be either quantified over a range of climate change projections (or scenarios) or described in a qualitative manner.

4.3.1 Risk Assessment Methodology

4.3.1.1 Probability or Likelihood

The probability of a hazard occurring and having an effect on the proposed project is scored using the methodology in Figure 4-52. The scores are given with inbuilt resilience included.

Almost certain (score 5)

- Incident if very likely to occur, possible several times.
- 95% chance of occuring (over lifetime of project).
- Project component is shown as exposed in high probability hazard and risk maps (e.g. present day or future 10% AEP flood hazard map).

Likely (score 4)

- Incident is likely to occur.
- 80% chance of occuring (over lifetime of project).
- Project component is shown as exposed in medium probability hazard and risk maps (e.g. 2% AEP present day or future flood hazard map).

Possible (score 3)

- Incident has occured in a similar country / setting.
- 50% chance of occuring (over lifetime of project).
- Project component is shown as exposed in medium probability hazard and risk maps (e.g. 1% AEP present day or future flood hazard map).

Unlikely (score 2)

- Given current practices and procedures, this incident is unlikely to occur.
- 20% chance of occuring (over lifetime of project).
- Project component is shown as exposed in low probability hazard and risk maps (e.g. 0.1% AEP present day or future flood hazard map).

Rare (score 1)

- Highly likely to occur.
- 5% change of occuring (over lifetime of project).
- Project component is not shown as exposed in any climate hazard or risk map (e.g. less than 0.1% AEP change of flooding).

Figure 4-52. Likelihood or probability criteria and scores (from the 2014-21 programming period JASPERS CCVRA guidance and EC Climate Proofing Technical Guidance).

4.3.1.2 Severity, consequence, or magnitude

The severity, consequence or magnitude of an impact is scored based on the criteria in Table 4-14. The score is based on the worst score of the relevant indicators for each climate hazard and component. The consequence score is usually based on the worst case of relevant risk areas, however there may be exceptions and these are justified in the risk assessment tables for each climate hazard.

Table 4-14. Indicators to score the impact of climate hazards on different risk areas to a project (taken from EC Climate Proofing Technical Guidance)

	Magnitude of consequence				
Risk areas	**1** **Insignificant**	**2** **Minor**	**3** **Moderate**	**4** **Major**	**5** **Catastrophic**
Asset damage / Engineering / Operational	Impact can be absorbed through normal activity	An adverse event that can be absorbed by taking business continuity actions	A serious event that requires additional emergency business continuity actions	A critical event that requires extraordinary / emergency business continuity actions	Disaster with the potential to lead to shut down or collapse or loss of the asset / network
Safety and Health	First aid case	Minor injury, medical treatment	Serious injury or lost work	Major or multiple injuries, permanent injury or disability	Single or multiple fatalities
Environment	No impact on baseline environment. Localised in the source area. No recovery required	Localised within site boundaries. Recovery measurable within one month of impact	Moderate harm with possible wider effect. Recovery in one year	Significant harm with local effect. Recovery longer than one year. Failure to comply with environmental regulations / consent	Significant harm with widespread effect. Recovery longer than one year. Limited prospect of full recovery
Social	No negative social impact	Localised, temporary social impacts	Localised, long-term social impacts	Failure to protect poor or vulnerable groups. National, long-term social impacts	Loss of social licence to operate. Community protests
Financial (for single extreme event or annual average impact)**	x % IRR(***) < 2% of turnover	x % IRR 2-10% of turnover	x % IRR 10-25% of turnover	x % IRR 25-50% of turnover	x % IRR > 50% of turnover
Reputation	Localised, temporary impact on public opinion	Localised, short-term impact on public opinion	Local, long-term impact on public opinion with adverse local media coverage	National, short-term impact on public opinion; negative national media coverage	National, long-term impact with potential to affect the stability of the government
Cultural Heritage and cultural premises	Insignificant impact	Short term impact. Possible recovery or repair.	Serious damage with wider impact to tourism industry	Significant damage with national and international impact	Permanent loss with resulting impact on society
The ratings and values suggested here are illustrative. The project promoter and climate-proofing manager may choose to modify them. (*): Including groups that depend on natural resources for their income/livelihoods and cultural heritage (even if not considered poor) and groups considered poor and vulnerable (and often that have less capacity to adapt) as well as persons with disabilities and older persons. (**): Example indicators – other indicators that may be used including costs of: immediate / long-term emergency measures; restoration of assets; environmental restoration; indirect costs on the economy, indirect social costs. (***): Internal Rate of Return (IRR).					

4.3.1.3 Risk Assessment

The overall risk category for each climate hazard and component is derived using the matrix in Figure 4-53. A separate risk assessment table for each hazard with a medium or high vulnerability. Components are grouped together to streamline the process. These risk assessment tables include details of the approach to scoring probability and severity, relevant inbuilt resilience measures, the proposed adaptation strategies and resulting residual risk.

Extreme Risk (score ≥20)

- Mitigation measures to major risks must be considered for the project

High Risk (score ≥12)

- Mitigation measures to major risks should be considered for the project

Medium Risk (score ≥8)

- Mitigation measures to major risks should be considered for the project. Monitoring of these risks may be sufficient

Low Risk (score ≥4)

- Monitoring of these risks should be part of the project adaptation plan

Negligable Risk (score ≤3)

- No adaptation plan for these risks is likely to be necessary

		Probability score				
		1	2	3	4	5
Severity score	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Figure 4-53. Risk assessment categories and scores and risk matrix.

4.3.1.4 Adaptation Measures

All risks with a medium, high or extreme risk score need to be managed to an acceptable level through climate adaptation measures. Appropriate climate adaptation measures are described in the risk assessment tables and assigned an owner. Where these adaptation measures are to be implemented as part of the project investment the costs of these measures are listed and these costs have been included in the proposed project being put forwards for investment.

4.3.1.5 Grouping of climate hazards and project components

To simplify the risk assessment the effect of climate hazards and components have been grouped together. This enables the risk assessment to focus on the most critical hazards and describe how inbuilt resilience measures which are part of the proposed project address multiple climate hazards. The grouping of hazards and components is as follows:

- [Water quantity] Groundwater flooding
- [Heat] Annual, seasonal or monthly average air temperature and extreme temperature occurrences (including heat waves)

- [Cold] Ice flows in rivers, freeze-thaw damage, and cold spells
- [Water quantity] River flooding and extreme rainfall
- [Water quantity and quality] Drought, aridity, water quality, water temperature, and annual, seasonal or monthly average rainfall, and soil erosion (as the effect of soil erosion on the project is on receiving water body quality).
- [various hazards] Land for disposal of sewage sludge as agricultural fertiliser
- Ground instability and landslides
- Earthquake

Interdependencies to the water supply and wastewater treatment systems

- Effect on power supply from storms (wind speed), flood, intense rainfall, ground instability and landslide, and wildfire.
- Effect on access roads from storms (wind speed), flood, intense rainfall, ground instability and landslide, and wildfire.

4.3.2 Climate risk assessment and adaptation tables

Component	**Drinking water and wastewater treatment plant processes and Pumping stations**
Climate Hazards	**[Heat] Annual, seasonal or monthly average air temperature and extreme temperature occurrences (including heat waves)**
Vulnerability	**High (future)**
Description of component and inbuilt resilience	The efficiency of the drinking water and wastewater treatment process reduces with higher temperatures. There is no data available to allow for specific quantifiable impacts of this effect on system performance. The design of the process and plants has been designed to perform under a range of temperatures up to 40ºc. Moderate durations of more extreme temperature would reduce efficiency but not significantly enough to cause an inability to service the water treatment requirements. The supply of water available is more likely to be a limiting factor in extreme heat conditions. The upgraded and new wastewater treatment plants and processes are more resilient to temperature variation and efficient than the current system for wastewater treatment, so the project presents in improvement in resilience to extreme temperature change. Pumping station building will be designed to pumping machinery and electrical components can be kept cool to extreme heat up to an ambient temperature of 50ºc. The intensity of extreme heat is not projected to occur above this temperature in the SSP 1-2.6, however is possible in the more extreme SSP 5-8.5. The frequency of heat wave events does not affect the inbuilt cooling of the building. The design contains sufficient inbuilt resilience for the climate hazard. The effect of air temperature changes on water quality, temperature, availability and drought is covered in a separate risk assessment table.
Probability of the hazard affecting the project.	2 (unlikely)
Consequences if the hazard occurs.	1 (insignificant). Any reduction in efficiency can be absorbed. No environmental impact or financial implication.
Risk Score	**2 (negligible risk) – Risk is acceptable**
Adaptation strategies	No adaptation strategy required.
Residual risk score	**2 (negligible risk) – Risk is acceptable**
Adaptation Owner & costs	n/a

Component	**Drinking water and wastewater treatment systems**
Climate Hazards	**[Cold] Ice flows in rivers, freeze-thaw damage, and cold spells**
Vulnerability	**Ice flows in rivers: High (current reducing to medium in future) Groundwater Aquifer and receiving river water body for discharge of treated water**
	Ice flows in rivers: Medium (current reducing to low) Raw effluent.
	Freeze-thaw damage and Ice-flows in rivers: Medium (current reducing to low in future) Pumping stations and networks, Water and Wastewater treatment plant and processes, Quantity and quality of supplied water
	Cold spells: Medium (current reducing to low in future) Water and wastewater treatment plant and processes, constructed wetland.
Description of component and inbuilt resilience	Ice flows in rivers can reduce the discharge rate in rivers which can reduce the assimilative capacity of receiving water bodies for sufficient dilution of treated water. This would not affect treated water from WWTP A as this is to be reused for agricultural irrigation. The effect would be for treated water from WWTP B, however the inclusion of the constructed wetland provides additional filtration and buffer to ensure that the discharge of treated water to the river will require less dilution. Therefore, the design of the constructed wetland needs to ensure that processes can operate and recover for a full range of possible seasonal and daily temperature variations. The effect of freeze-thaw damage on pipes and networks is expected to reduce in all climate projections. Constructing the infrastructure to current construction standards will ensure a degree of inbuilt resilience. Freezing of water supply pipes is a risk in the current climate and may still occur in the future, albeit less frequently. The effect is a temporary disruption to water supply. This current emergency management system is able to supply emergency water to communities serviced by the proposed project and will continue to be in place. This risk can be managed through existing and ongoing procedures. The demand for irrigation water is low during cold spells and so any adaptation measure for drought should be able to ensure sufficient volume of water is available that can be transported to communities should pipes freeze. All pumping station, treatment plant machinery and equipment will be insulated from extreme cold.
Probability of the hazard affecting the project.	2 (unlikely) – due to reducing exposure to the hazard.

Consequences if the hazard occurs.	2 (minor). There is potential for environmental impacts as a result of the discharge to the receiving water body due to the inherent uncertainty in the constructed wetland performance. All other impacts can be managed through the inbuilt resilience of the project components and operation.
Risk Score	**4 (low risk) - Risk is acceptable but uncertain**
Adaptation strategies	Monitoring of flow rates is included in the proposed project design and will be used to identify possible issues as a result of cold spells or freeze-thaw damage. Monitoring of the constructed wetland condition and processes is critical to improving understanding of the performance and whether any intervention is required. There is insufficient knowledge to recommend any change to design parameters of the constructed wetland and so this would be a high-regret adaptation to be included now in the project investment. The necessity to comply with legislation will ensure that if monitoring identifies likely deficiency remedial actions will be implemented in the future.
Residual risk score	**4 (low risk) – Risk is acceptable as a result of monitoring**
Adaptation Owner	The operating authority is responsible for monitoring of the constructed wetland and implementing remedial measures throughout the lifetime of the infrastructure.
Adaptation Cost to be included in the project investment (excl. inbuilt measures)	n/a

Component	**Groundwater Aquifer (water source)**
Climate Hazards	**Groundwater flooding**
Vulnerability	**High (current and future)**
Description of component and inbuilt resilience	The proposed project design has been informed by groundwater modelling that has included groundwater flood scenarios. These scenarios include the worst groundwater flooding experienced on record as well as an estimate of a 20% increase in antecedent rainfall conditions as a climate change sensitivity test which is comparable to the RCP 4.5 pathway conditions. In these circumstances the groundwater aquifer remains accessible as a water source. However, the model shows ground-surface water interactions in agricultural areas used for intensive livestock farming, as shown by the model. This presents a potential source of contamination of groundwater during groundwater flooding in the future scenario.
Probability of the hazard affecting the project.	**5 – Almost certain.** It is almost certain that a groundwater flood event will occur in the future with a magnitude that could cause pollution of the groundwater aquifer.
Consequences if the hazard occurs.	**4 – Major Operational Impact.** Pollution of the groundwater aquifer is a critical event that requires extraordinary / emergency business continuity actions. It may take many months to recover. The environmental impact of the pollution is not analysed as the pollution is not a result of the proposed project and would occur irrespective of the proposed project.
Risk Score	**20 (Extreme risk) – unacceptable risk**
Adaptation strategies	**<u>Adaptation options</u>** The mechanism by which the groundwater body may be contaminated is outside the direct control of the operation of the infrastructure. A range of adaptation strategies have been analysed. — **Assumptive**. The extension of the current source protection zone to include future groundwater flood hazard zones, would legally require agricultural landowners to change farming practices to ensure that there is no risk of groundwater contamination. This would require legal agreements and the establishment of the appropriate compensation payment frameworks. — **Adaptive**. The above assumptive approach to extend source protection zones could be implemented as an adaptive strategy through the use of further monitoring to reduce uncertainty in climate impacts and by identifying thresholds for implementing action in the future. — **Alternatives**. Alternative water sources are available from local rivers. Additional connection to the current drinking water treatment plant is feasible through a 1km extension to the pipe network and an additional pumping station. Any alternative abstraction sources would require a license even if the abstraction is only during emergency periods. — **Acceptance**. If the risk is accepted, then contingency plans to ensure continuity of water supply would need to be established. These would

Component	Groundwater Aquifer (water source)
Climate Hazards	**Groundwater flooding**
	need to include the transfer of treated water from other water supply networks. **<u>Appraisal of adaptation options</u>** Each of the above adaptation strategies have been appraised using Multi-Criteria Analysis (MCA) and subject to Cost Effectiveness Analysis (CEA) as documented in the Feasibility Study. Given the expected growth of the towns and in conjunction with the management to the drought climate hazard both the assumptive and alternative approaches are proposed. **<u>Adaptation planning</u>** In all cases monitoring of groundwater levels, quality and upstream catchment conditions is necessary. Equipping treatment plants with on-line analytical tools that control and record the parameters of raw water and treated water is also necessary to understand the performance of the treatment and to inform if there would be any change in treatment processes should raw water quality change. Monitoring is also necessary to review in the future the potential need for wider strategic inter-basin water transfers as a back-up supply. Implementation of the intervention plan is critical in case of extreme meteorological phenomena: establishing the alert system, program of necessary measures and works, clearly assigned responsibilities.
Residual risk score	**6 (Low Risk) -** The extension of the source protection zones and the additional water abstraction point reduce the likelihood to 2 (unlikely). Monitoring and intervention planning can reduce the consequences to 3 (Moderate).
Adaptation Owners	Water Authority as infrastructure operator. Environmental Protection Agency as abstraction permit authority and authority responsible for designating source protection zones.
Adaptation Cost to be included in the project investment (excl. inbuilt measures)	The extension of the water network, extra pumping station is estimated to cost an extra €2 million in capital investment, and €150,000 annual average operating costs. The extension of the source protection zone will cost in around €2 million in lifetime compensation payments to landowners. In both of these costs are included in the proposed project investment with the source protection zone payments to be administered by the Environmental Protection Agency and not the project promoter.
Additional notes	This adaptation measure has been included in the project description for the GHG emission estimates in the climate mitigation proofing section and is part of the project description in the associated environmental assessments (EIA Screening, full EIA, WFD Article 4(7) applicability test, and AA screening).

Component	All water and wastewater supply assets and outputs
Climate Hazards	**River flooding and extreme rainfall**
Vulnerability	**High (current and future)**
Description of component and inbuilt resilience	**River Flooding** The site selection of the pumping stations, drinking water and wastewater treatment plant have been informed by the Floods Directive 2nd cycle Flood Hazard Maps to avoid locating the infrastructure in flood risk zones, taking into account climate change hazard maps. Flood Hazard and Risk Maps are available for five flood probabilities in present day conditions, and a climate change scenario for the 1% Annual Exceedance Probability event. The climate change scenario is based on a 10% increase in peak discharge and is based on the National Climate Change Study on hydrological extremes. This climate change factor is reflective of possible conditions in 2100 under an RCP 4.5 climate projection. The hazard maps available on the National Flood Authority website have been used to determine if the location of the proposed project infrastructure is exposed to flooding. Relevant EEA indicators for assessing exposure to river flood[29] is the river flood index using runoff This is defined as the maximum daily river discharge for a given return period (typically 50 or 100 years, depending on the specific application). The index is computed using river flow data, which are derived from hydrological models. Indicators and projections at the European scale are not yet available for the SSPs and so RCPs are used for the exposure assessment. — RCP 4.5 in the far future (2081-2100) for future exposure comparable to SSP 3.0-7.0. This validates the climate change factor used in the Flood Hazard Maps. — RCP 8.5 in the far future (2081-2100) is also considered to determine if a more significant long term exposure score should be assigned to manage the range of possible future climate impacts. The proposed infrastructure is located outside of flood risk zones and is resilient to the scale of projected flood risk in the SSP 3.0-7.0 scenario. In the more extreme climate scenario there is the possibility, but with a high degree of uncertainty, that some infrastructure may be exposed to flooding. The 2nd cycle Flood Risk Management Plan does not propose any flood management measures to protect localities and infrastructure from exposure to flooding. A flood forecasting and warning system, with an associated emergency response plan, is proposed to be implemented before 2030. **Extreme rainfall and stormwater management**

[29] Wet and dry — heavy precipitation and river floods — European Environment Agency (europa.eu)

Component	All water and wastewater supply assets and outputs
Climate Hazards	**River flooding and extreme rainfall**
	The stormwater drainage system for the pumping station site and drinking water treatment site has been designed to future climate change rainfall intensity. This infrastructure is not directly exposed to flooding. The sludge from the treatment plants is temporarily stored on covered platforms provided with open channels. On site of the treatment plants, rainwater collection systems are present. The operator will ensure with maximum priority the operation of the wastewater pumping stations. The water supply and foul sewer networks cannot avoid being located within pluvial flood hazard zones. The standard design of the new proposed components of the network includes the following inbuilt resilience measures: — All manholes will be placed so as not to be flooded at high waters or exceptional rains with waterproof seals, according to the design norms. Sections of old pipe network that will be retained have been constructed to older technical norms that did not require the above inbuilt resilience measures. Some sections of the existing foul sewer network include combined surface water and foul sewer pipes. The detailed hydraulic modelling of the project identifies sections most exposed to increase stormwater ingress and these are to be separated into foul and surface water drainage networks.
Probability of the hazard affecting the project.	**3 – Possible.** There is a possibility of flood water entering the water supply pipe network. There is a possibility of the drainage capacity of the WWTP site to be exceeded by more extreme rainfall. There is a possibility of combined sewer overflows.
Consequences if the hazard occurs.	**3 – Moderate.** If floodwater entered the distribution pipe network the system would need flushing. This could result in outages for sections of the system for a duration of up to 1 week. An increase in frequency of combined sewer overflows could result in pollution events that exceed the capacity of the receiving environment to dilute.
Risk Score	**9 – Medium risk (existing sections of pipe network only).** Note, there is no risk of flooding to the pumping stations and water treatment plant, or new pipe network sections.
Adaptation strategies	An assumptive approach to reducing the risk of flooding to existing sections of the pipe network is proposed to upgrade or seal manholes set below future climate change flood levels, and within surface water ponding zones (as informed by flood modelling carried out for the local municipality). Inspection and maintenance regime of the whole system will ensure all manholes and flow monitoring data are checked after heavy rains to identify possible leaks. Temporary pumping stations will be put into operation at the WWTP, with diesel pumps, to ensure sufficient evacuation capacity of any ponded rainfall or flooding if the drainage design is exceeded.

Component	All water and wastewater supply assets and outputs
Climate Hazards	**River flooding and extreme rainfall**
	Implementation of the Monitoring Plans for the quality of the raw water and of the treated water Implementation of the intervention plan in case of extreme meteorological phenomena: establishing the alert system, program of necessary measures and works, responsibilities Monitoring of the effect of future climate change on flood risk will be important to determine the hazard from a more extreme climate change scenario, and whether this is likely. This analysis should be carried out in 10 years time when there is more data available to determine the climate impacts. Including flood defences to infrastructure for a possible highly uncertain hazard that is not currently existing would be a high regret investment.
Residual risk score	**6 (Low Risk) – Acceptable risk with additional adaptation measures and monitoring**. The risk of floodwater ingress cannot be eliminated but the probability reduces with the adaptation measures.
Adaptation Owners	Water Authority as infrastructure operator.
Adaptation Cost to be included in the project investment (excl. inbuilt measures)	The cost of inspection and monitoring is already part of the proposed operation and maintenance schedule and costs. The cost of emergency pumps is included in the capital investment. A programme for modelling and upgrade of existing pipe network manholes within flood zones will cost between €500,000 and €2.5 million depending on the outcomes of the modelling. These costs are included in the economic appraisal.

Component	**Groundwater aquifer water source, Quantity and quality of water supplied, Raw effluent, Constructed wetland, Receiving water body.**
Climate Hazards	**Drought, aridity, water quality, water temperature, and annual, seasonal or monthly average rainfall, and soil erosion.**
Vulnerability	**High (current and future)**
Description of component and inbuilt resilience	**<u>Groundwater resources (quantity)</u>** The proposed project design has been informed by groundwater modelling that has included drought scenarios. These scenarios include the worst drought conditions experienced on record as well as an increase in duration of drought periods (no rain) by one month to reflect a more severe drought. The national climate impact studies concluded that drought conditions are projected to increase in frequency and duration in all climate pathways, however no quantitative projections of the scale of change are available. The model sensitivity analysis is sufficient for understanding potential climate resilience. The conclusion of the model analysis has found that in more extreme drought conditions there will be insufficient water available for groundwater abstraction. This lack of water could continue for a period of more than 2 months and occur every year. **<u>Groundwater resources (quality)</u>** The above climate hazards will have a detrimental effect on groundwater quality in all projections. No quantitative projections of the scale of change are available. Water quality modelling carried out as part to inform the project Feasibility Study identified the water quality from diffuse and known point sources across the contributing surface water catchment to the groundwater aquifers. The model included sensitivity tests to reflect different rainfall and snowmelt (water quantity) inputs and the effect on dilution of pollutants within the surface water bodies. The conclusion was that with reduced water inputs to the catchment, as predicted in all climate projections, there would be an increase in diffuse pollutant concentration which could affect groundwater quality. This in turn has an impact which could complicate or reduce the efficiency of the water treatment processes. **<u>Raw effluent</u>** Reductions in water use in response to the lack of water available will decrease wastewater flow which in turn could increase concentration of pollutants. This is expected in all climate projections and would result in difficult operating conditions of the wastewater treatment processes and collection networks due to low flow rates, accumulation of gases resulting from fermentation. The design of the proposed infrastructure includes inbuilt resilience to the range of flow conditions and required in the national technical design standards. These cover the potential change in flow for conditions comparable to the SSP 2-4.5 projection in 2081-2099, used in the sewage network model used to inform the Feasibility Study. In a more extreme climate projection the prolonged periods of low flow are likely to cause build up of gases in the network. **<u>Constructed wetland</u>** The constructed wetland is to be designed as closely as possible to a naturally functioning wetland system that can adapt to variations in water supply, infiltration rates and soil moisture. There is a possible highly uncertain effect of climate change on the hydrological regime which could alter the effectiveness

Component	**Groundwater aquifer water source, Quantity and quality of water supplied, Raw effluent, Constructed wetland, Receiving water body.**
Climate Hazards	**Drought, aridity, water quality, water temperature, and annual, seasonal or monthly average rainfall, and soil erosion.**
	of the treatment process in the wetland. The wetland is not essential for legal compliance and is a feature which increases the climate resilience of the project operation through the creation of a buffer between the discharge of treated water from the WWTP B and the receiving river water body. The limits and thresholds at which the constructed wetland can continue to function are as yet unknown. **<u>Receiving water body</u>** The effect of climate change on the receiving water body is a change to flow regime, water quality and temperature. The effect of this on the proposed project is that there may be insufficient assimilative capacity for sufficient dilution of discharged water. As noted above the proposed constructed wetland will act as a buffer for additional treatment of wastewater prior to discharge into the receiving water body. The constructed wetland is an inbuilt resilience measure for a degree of climate change impacts. **<u>Quantity and quality of water supplied</u>** All climate change projections show an increased demand for irrigation and drinking water, as well as cooling for industrial processes. The proposed project is focused on the supply if water services. Should additional supplies be required in the future to meet a change in demand as a result of climate change this would be a future investment. To facilitate potential future investment the proposed project includes design conditions to allow for easy and rapid connection to the proposed water supply networks. These reduce potential future disruption for any new add-on or new water sources. Management of water use and demand is the responsibility of Government Department and as policy measures is not part of the proposed project. **<u>Reuse of treated water for irrigation and irrigation channels</u>** The reuse of treated water for irrigation is a climate adaptation measure for the effect of climate change on agricultural p[productivity and local employment. The effect of climate change in terms of water availability, drought could affect the level of treatment of wastewater which could mean that the water for reuse does not meet minimum regulatory standards for irrigation reuse. This is unlikely but continual monitoring as part of the proposed project operating procedures will be critical to inform the need to additional filtration or treatment. Soil erosion, drought and aridity may change in demand for irrigation water. However the proposed project is only focused on the supply of water. Soil erosion and aridity may affect the conveyance, infiltration and evaporation from irrigation channels. The project proposes no change to these channels in agricultural land.
Probability of the hazard affecting the project.	**5 – Almost certain.** The severity and frequency of drought events is projected to increase. This is a key risk for Europe in the IPCC AR6 (chapter 13)

Component	**Groundwater aquifer water source, Quantity and quality of water supplied, Raw effluent, Constructed wetland, Receiving water body.**
Climate Hazards	**Drought, aridity, water quality, water temperature, and annual, seasonal or monthly average rainfall, and soil erosion.**
Consequences if the hazard occurs.	**4 – Major Operational Impact.** Lack of water resources will result in temporary inability to abstract and supply drinking water, which could last a number of months.
Risk Score	**20 – Extreme Risk. Unacceptable risk that must be managed.**
Adaptation strategies	<u>**Groundwater quantity and quality**</u> The mechanism by which groundwater quantity and quality is affected by climate change is outside the direct control of the operation of the infrastructure. A range of adaptation strategies have been analysed. — **Assumptive**. Creation of permanent water storage reservoirs will also require an alternative water source from which to store water. This is because the aquifer already provides storage of water. Groundwater recharge programmes could also be considered for viability and effectiveness. — **Adaptive**. The above assumptive approach to extend source protection zones could be implemented as an adaptive strategy through the use of further monitoring to reduce uncertainty in climate impacts and by identifying thresholds for implementing the assumptive actions (above) in the future. — **Alternatives**. Alternative water sources are available from local rivers. Additional connection to the current drinking water treatment plant is feasible through a 1 km extension to the pipe network and an additional pumping station. Any alternative abstraction sources would require a license even if the abstraction is only during emergency periods. The alternative water source is likely to experience the same drought conditions as the groundwater body and so should only be used as a source for abstracting back-up water supply to be stored in reservoirs. — **Acceptance**. If the risk is accepted, then contingency plans to ensure continuity of water supply would need to be established. These would need to include the transfer of treated water from other water supply networks. — **Acceptance**. Further acceptance of the occurrence of droughts could be managed through water use education programmes and incentives. Given the expected growth of the towns and in conjunction with the management to the groundwater flood climate hazard the alternative and adaptive approach is proposed. Securing an alternative back-up supply of water is an expensive option that should be investigated and implemented to add resilience to the system. The construction and commissioning of a back-up storage reservoir is a significant investment and needs separate planning procedure. For this reason monitoring of conditions is important to inform further studies into the viability of storage reservoirs. In all cases monitoring of groundwater levels, quality and upstream catchment conditions is necessary. Equipping treatment plants with on-line analytical tools that control and record the parameters of raw water and treated water is also necessary to understand the performance of the treatment and to inform if there would be any change in treatment processes should raw water quality change. Land in the ownership of the water authority is available at the location of the existing groundwater well pumping stations Additional water supply treatment plants can be constructed in the future should monitoring of groundwater quality

<table>
<tr><td>Component</td><td>Groundwater aquifer water source, Quantity and quality of water supplied, Raw effluent, Constructed wetland, Receiving water body.</td></tr>
<tr><td>Climate Hazards</td><td>Drought, aridity, water quality, water temperature, and annual, seasonal or monthly average rainfall, and soil erosion.</td></tr>
<tr><td></td><td>
find that the future treatment is necessary. This may be an extremely costly project and so this would be a high regret solution to implement now prior to continued monitoring of groundwater quality.
<u>Raw effluent and build-up of gases in wastewater collection networks.</u>

Assumptive. The preferred adaptation strategy is to alter design standard to accommodate a wider range of possible flow regime in the wastewater system and mitigation for managing odour at the local scale. The sizing of the pipe and collection network components will be based upon updated modelling prior to detailed design. Installing larger pipes now is significantly cheaper than replacing the pipe network in the future.
Adaptive. Adapt the pipe networks in the future. This is not desirable as would require digging up and replacement of pipes built now, which would be significantly more costly than constructing the system to accommodate a full range of future flows.
Acceptance. It is unlikely that communities will accept the build up of odour in populated areas. Not addressing this risk would result in air pollution, which may not be legally compliant.

<u>Constructed wetland and receiving water body</u>
The limits and thresholds at which the constructed wetland can continue to function are as yet unknown. Continual monitoring of the performance and ecosystem condition is required to inform whether any future adaptation is required. Including adaptation measures as part of an assumptive approach would be a high regret approach as the benefits are unknown.
<u>Quantity and quality of water supplied</u>
By incorporating easy modular extensions to the proposed water supply network (e.g. for new water sources), the propose project maximises the adaptive capacity. An assumptive approach to include full connections possible additional water sources would be high regret as there is low confidence in the need for these without further study.
<u>Reuse of treated water for irrigation and irrigation channels</u>
The filtration and storage plant for the further treatment of water prior to reuse will be designed in a modular manner with sufficient land available in the compound for future changes, such as extra filtration or storage capacity. This is an adaptive approach which will respond to monitoring as part of the proposed project operating procedures. This avoids high regret investment which may not be required.
Ongoing monitoring of the irrigation channel and network water levels and flow will be used to identify if there are any future adaptation measures to reduce water loss within the infiltration channels. These channels are outside of the proposed project boundary and so the responsibility will be with the agricultural land owners and collective irrigation board.
</td></tr>
</table>

Component	**Groundwater aquifer water source, Quantity and quality of water supplied, Raw effluent, Constructed wetland, Receiving water body.**
Climate Hazards	**Drought, aridity, water quality, water temperature, and annual, seasonal or monthly average rainfall, and soil erosion.**
	<u>**Ongoing monitoring and emergency response procedures**</u> Monitoring is also necessary to review in the future the potential need for wider strategic inter-basin water transfers as a back-up supply. Implementation of the intervention plan is critical in case of extreme meteorological phenomena: establishing the alert system, program of necessary measures and works, clearly assigned responsibilities.
Residual risk score	**Medium Risk – after proposed assumptive measures and with measures that facilitate future adaptation.** **Low Risk – after implementation of future adaptation measures, implemented in response to the findings from ongoing monitoring.** **Risk is managed to an acceptable level.** The climate risks associated with drought, water availability, aridity, water quality and temperature, will be managed through a range of assumptive and adaptive measures. High regret adaptation measures such as additional drinking water treatment plants should not be included within the project as proposed. These would be expensive infrastructure that may not be necessary due to the uncertainty in future water quality. These can be constructed in the future and would be subject to a future economic appraisal. The low regret assumptive measures proposed to be included in the project reduce the risk to High Risk. This is by reducing the likelihood of an adverse effect and reducing the magnitude of the consequences. The adaptive measures are necessary and will be based upon ongoing monitoring to ensure the most appropriate adaptation is made in the future. The proposed project includes measures to facilitate the easy extension or adaptation of the project to reduce the future costs of adaptation.
Adaptation Owner	Water Authority as infrastructure operator. Environmental Protection Agency as abstraction permit authority. National ministry of water and environment as authority who can instigate reservoir and inter-basin transfer projects, and for policy decisions in relation to water demand.
Adaptation Cost to be included in the project investment (excl. inbuilt measures)	The extension of the water network, extra pumping station is estimated to cost an extra €2 million in capital investment, and €150,000 annual average operating costs. The extension of the source protection zone will cost in around €2 million in lifetime compensation payments to landowners. Design and installation of wastewater pipe networks that can accommodate a wider range of different flow conditions is expected to cost an additional €5 million to € 10 million. The costs cannot be confirmed until after the detailed design and procurement stage and so the maximum allowance has been included in the Economic Appraisal.

Component	**Groundwater aquifer water source, Quantity and quality of water supplied, Raw effluent, Constructed wetland, Receiving water body.**
Climate Hazards	**Drought, aridity, water quality, water temperature, and annual, seasonal or monthly average rainfall, and soil erosion.**
	Monitoring of the performance of the constructed wetland is included in the proposed operational procedures for the project and is of no extra cost. The cost of modular design to the water supply network to facilitate easy and low-intervention additions to the network are negligible. The costs are included in the economic appraisal. The costs of the climate adaptation measures listed above do not alter the economic viability of the proposed project, or decision for the selection of the preferred alternative.
Notes	The changes to the size and capacity of the wastewater collection network will not cause a material change in the capacity of the wastewater system during intense rainfall or result in a material change in the project as described in the environmental procedures (EIA screening, full EIA, WFD assessments and AA screening).

Component	**Land for disposal of sewage sludge as agricultural fertiliser**
Climate Hazards	**Drought, Flooding, Landslide, Soil erosion and Wildfire**
Vulnerability	**High and Medium**
Description of component and inbuilt resilience	In general, the sludge produced in the operational wastewater treatment plants is currently temporarily stored on the platforms related to the wastewater treatment plants. There is sufficient storage capacity onsite should it not be possible to spread sludge on land for a period of up to 15 days. The lands for sewage sludge spreading include areas within future climate change flood hazard maps, drought sensitive areas, landslide risk zones and wildfire risk zones. Sufficient capacity is available for temporary storage at wastewater treatment plants in neighbouring counties.
Probability of the hazard affecting the project.	**4 – Likely.** It is likely that as a result of any individual, or combination of the hazards occurring that it will not be possible to dispose of sewage sludge on land for a period of greater than 15 days, thus exceeding the storage capacity.
Consequences if the hazard occurs.	**1 – Insignificant.** The ability to temporarily transport and store sewage sludge in wastewater plants in neighbouring counties reduces the consequence to low. There climate hazard for the ability to transport is captured in the access road hazard.
Risk Score	**4 – Low Risk. Risk is acceptable.**
Adaptation strategies	It is not viable to increase the available sludge storage capacity onsite due as further land to extend the storage facility is not available. Medium term forecasting of weather conditions is critical to the ability to forward plan and enact sewage sludge transfer. Monitoring the biological treatment process, providing activated sludge. Undertake a flood risk assessment to identify new locations for sewage sludge spreading not at risk of flooding in the future. To start landowner engagement to identify this area of future land. To monitor land being used for sewage sludge and whether conditions are changing that alter ability to take up spreading. To monitor climate change to identify when to change spreading locations. These adaptation measures are no regret as they only require slight adjustment to the current operating procedures.
Residual risk score	**1 – Negligible. Risk is acceptable and reduced with no regret adaptation measures.**
Adaptation Owner	Water Authority as operator the proposed project and neighbouring WWTPs.
Adaptation Cost to be included in the project	Costs for future adaptation and monitoring are not to be included in the project investment as they do not relate to capital investment now.

Component	**Land for disposal of sewage sludge as agricultural fertiliser**
Climate Hazards	**Drought, Flooding, Landslide, Soil erosion and Wildfire**
Investment (excl. inbuilt measures)	

Component	**Water Distribution Network (pipes), Pumping stations, Drinking water treatment plant, Wastewater treatment plant.**
Climate Hazards	**Ground Instability and Landslide**
Vulnerability	**High (current and future)**
Description of component and inbuilt resilience	The design and execution of investment works will be in accordance with the geotechnical and hydrogeological studies carried out at the feasibility study phase and detailed design phase and will comply with technical norms and be informed by geotechnical studies. The design of the proposed works has already accounted for geomorphological and lithological peculiarities of the studied sites, with consideration of the possible maximum change in ground conditions under the most extreme climate change projections (i.e., RCP 8.5). The use of specific materials for laying pipes, in compliance with the norms in force and the specifics of the area. There is no risk to any component from ground instability. No allowance for the possibility of landslide flow has been inbuilt into the design. None of the proposed infrastructure is located in a current landslide hazard zone. However, the drinking water treatment plant is located at the base of steep slopes currently used as forest plantation for timber supply in the future.
Probability of the hazard affecting the project.	**2 – Unlikely (landslide risk to drinking water treatment plant)** There is a low chance that if during the timber extraction soil could be destabilised on the slopes above the drinking water treatment plant. The increase in rainfall intensity and duration of droughts may alter the performance and effectiveness of standard forestry practices and could result in landslides after forest clearance.
Consequences if the hazard occurs.	**5 – Catastrophic** A landslide would result in significant damage to infrastructure resulting in the inability to treat drinking water. Complete destruction of the treatment plant is possible.
Risk Score	**10 – Medium Risk – Risk needs to be managed.**
Adaptation strategies	There is no space adjacent to the plant for construction of bunds with sufficient height and width to hold any landslide. Engagement with the forest landowner should be sought as an adaptive measure to ensure sufficient sediment, debris and storm water attenuation features prior to felling of forest for timber. This requires agreement with the forest landowner. Additional monitoring of soil and ground conditions on the slopes above the drinking water treatment plant should be carried out as part of the regular inspection and maintenance programme. This requires agreement with the forest landowner.
Residual risk score	**5 – Low risk. Acceptable Risk.** Monitoring and engagement does not reduce the risk score, however if the adaptive measures to reduce the likelihood of landslides are implemented then the likelihood can reduce.

Component	**Water Distribution Network (pipes), Pumping stations, Drinking water treatment plant, Wastewater treatment plant.**
Climate Hazards	**Ground Instability and Landslide**
Adaptation Owner	Water Authority as infrastructure operator. Forestry Authority.
Adaptation Cost to be included in the project investment (excl. inbuilt measures)	The costs of additional monitoring are negligible and no more than €10,000 per year. The adaptive measures to reduce landslide risk prior to forest activities are not likely to be significant and will vary depending on the felling programme. There is no capital investment required to be included in the economic appraisal of the proposed project.

Component	**All components**
Climate Hazards	**Earthquake**
Vulnerability	**High (current and future)**
Description of component and inbuilt resilience	The proposed project is located in an earthquake risk zone as described in the exposure assessment. All project infrastructure will be designed and constructed to the latest structural requirements.
Probability of the hazard affecting the project.	2 – Unlikely
Consequences if the hazard occurs.	5 – Catastrophic
Risk Score	**10 – Medium Risk – Acceptable risk** There is no other inbuilt resilience or additonal adaptive capacity possible and so the risk is considered as acceptable and managed as much as possible.
Adaptation strategies	n/a
Residual risk score	**10 – Medium Risk – Acceptable risk**
Adaptation Owner and costs	n/a

Component impacted	**Access roads**
Climate Hazard(s)	**Landslide, Soil Erosion, Storms, Floods, Intense Rainfall**
Vulnerability	**High (future)**
Description of component and inbuilt resilience	The Floods Directive Flood Hazard Mapping shows that an increased frequency and magnitude of pluvial flooding could affect a number of access roads in climate change scenarios. Intense winds may cause trees or other obstructions to road access. The development of the project has not considered the potential impact of landslides or ground instability on access roads. However, analysis of the local flash flood and landslide hazard maps shows that there are safe access routes to the key infrastructure. The development of the project has not considered the potential impact of soil erosion on access roads.
Probability of the hazard affecting the project.	**4 (likely)** – it is likely that during the lifetime of the project there will be an incident when an access road is blocked or affected by erosion, fallen trees or localised flooding of roads.
Consequences if the hazard occurs.	**2 (minor)** - An adverse event that can be absorbed by taking business continuity actions.
Risk Score	**8 (medium) – risk needs to be managed**
Adaptation strategies	A robust operation and maintenance procedure with suitable machinery and vehicles can ensure that the impact can be absorbed through business continuity actions will need to include: — Machinery and vehicles capable of passing through flood water. — Operational staff training. — Flood forecasting and warning systems. — Emergency response plans with redundancy to ensure back-up access and operation is possible. — Back-up diesel generators should power supply be cut off. — Inspection of access roads to prompt maintenance and repair work.
Residual risk score	**4 (low).** Probability of the event causing an operational issue is reduced. **Acceptable risk.**
Adaptation Owner	The operating authority will own the operational and maintenance plan which is part of the necessary elements for operating the proposed project.
Adaptation Cost to be included in the project investment (excl. inbuilt measures)	There are no additional costs other than the potential for more frequent operation of the flood management scheme. All costs are to be included in the operating authority revenue budget.

Component impacted	**Power supply**
Climate Hazard(s)	**Landslide, Soil Erosion, Storms, Floods, Intense Rainfall**
Vulnerability	**High (future)**
Description of component and inbuilt resilience	The Floods Directive Flood Hazard Mapping shows that an increased frequency and magnitude of flooding could affect some elements of the power supply network. The electricity switch board and junctions are raised well above ground level for all proposed project components. Intense winds may cause power lines to fall. The drinking water treatment plant has two power supply connections and so has some redundancy should only power supply source be cut. All pumping stations have their own source of solar power and back-up diesel generators that can operate should the grid connection be lost for up to 48 hours.
Probability of the hazard affecting the project.	**3 (possible)** – it is possible that during the lifetime of the project there will be an incident when power supply is cut to the infrastructure.
Consequences if the hazard occurs.	**2 (minor)** - An adverse event that can be absorbed by taking business continuity actions. The inbuilt resilience measures will reduce the consequences of any power outage.
Risk Score	**6 (low) - Acceptable risk**
Adaptation strategies	No additional adaptation measures are required. Monitoring of asset performance and regular engagement with the electricity network supplier should continue to ensure ongoing resilience.
Residual risk score	**6 (low) – Acceptable risk**
Adaptation Owner	The operating authority will own the operational and maintenance plan which is part of the necessary elements for operating the proposed project. This should include a requirement to engage on a regular basis with utility suppliers.
Adaptation Cost to be included in the project investment (excl. inbuilt measures)	There are no additional costs. All costs are to be included in the operating authority revenue budget.

5. CLIMATE PROOFING CONCLUSION

The proposed project is considered as climate proof because it achieves all of the following requirements:

Is consistent with the ability to achieve GHG emission and climate neutrality targets by demonstrating:	Manages all climate hazard risks to an acceptable level through:
• It will not generate significant GHG emissions, • Has considered GHG emissions from alternative means of achieving project objectives (which must be compliant with EU legislation and policy (e.g. UWWT Directive).	• inbuilt resilience of the project to climate hazards, • additional adaptation measures included within the project investment, or • a clear long term implementation plan for future adaptation measures informed by a monitoring programme (which may include measures to be implemented as part of the project investment to facilitate future adaptation).

The proposed project will not have significant GHG emissions for a typical year operation.

The proposed project takes all opportunities for inbuilt adaptation measures and includes low regret assumptive measures where these are low cost, or constructing these now will be more desirable from a social, environmental or economic view.

The adaptation plan has identified monitoring measures that will be used to inform and design future interventions to ensure the project infrastructure remains resilient to climate hazards. This avoids the risk of maladaptation if the proposed project included high regret measures that may not be necessary.

5.1 Contribution of the proposed project to climate change mitigation

The proposed project will result in a net reduction in GHG emissions in comparison to the existing system for water supply and wastewater treatment. The project therefore contributes towards the national climate action plan and towards the objectives of achieving the Paris Agreement targets.

5.2 Contribution of the proposed project to climate change adaptation and resilience

As well as the proposed project infrastructure being resilient to climate change, the proposed project significantly contributes to climate change adaptation and resilience. The contribution of the project includes the following outcomes which are all climate adaptation measures to key risks identified in the IPCC AR6 (Chapter 13 Europe):

- More sustainable use of water resources and reduction or avoidance of pressures on WFD water body status.
- More resilient water supply system to climate change to a greater proportion of the population.
- Collection and treatment of wastewater from a greater proportion of the population.
- Improved treatment of wastewater discharged to surface waterbodies.
- Reuse of treated wastewater for agricultural irrigation.
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