IV

(Notices)

NOTICES FROM EUROPEAN UNION INSTITUTIONS, BODIES, OFFICES AND AGENCIES

EUROPEAN COMMISSION

COMMISSION NOTICE

Technical guidance on the climate proofing of infrastructure in the period 2021-2027

(2021/C 373/01)

DISCLAIMER:

The purpose of this Notice is to give technical guidance on the climate proofing of investments in infrastructure covering the programming period 2021-2027.

Article 8(6) of Regulation (EU) 2021/523 of the European Parliament and of the Council [1] (***InvestEU Regulation***) *requires the Commission to develop sustainability guidance. Article 8(6) a) sets out requirements on climate change mitigation and adaptation. Pursuant to Article 8(6) e), the sustainability guidance must include guidance to implementing partners on information to be provided for the purpose of the screening of the environmental, climate or social impact of financing and investment operations. Article 8(6) d) stipulates that the sustainability guidance shall allow to identify projects that are inconsistent with the achievement of climate objectives. This guidance on the climate proofing of infrastructure forms part of the sustainability guidance.*

Guidance by the Commission on the climate proofing of infrastructure projects, coherent with the guidance developed for other programmes of the Union where relevant, is also envisaged under Regulation (EU) 2021/1153 of the European Parliament and of the Council [2] (***CEF Regulation***).

The guidance is also deemed a relevant reference for the climate proofing of infrastructure under Article 2(37) and Article 67(3) j) of Regulation (EU) 2021/1060 of the European Parliament and of the Council [3] (***Common Provisions Regulation (CPR)***) *as well as under the Recovery and Resilience Facility* [4].

The guidance has been developed by the Commission in close cooperation with potential implementing partners for InvestEU along with the EIB Group.

This guidance may be complemented with additional national and sectoral considerations and guidance.

---

(1) Regulation (EU) 2021/523 of the European Parliament and of the Council of 24 March 2021 establishing the InvestEU Programme and amending Regulation (EU) 2015/1017 (OJ L 107, 26.3.2021, p. 30).

(2) Regulation (EU) 2021/1153 of the European Parliament and of the Council of 7 July 2021 establishing the Connecting Europe Facility and repealing Regulations (EU) No 1316/2013 and (EU) No 283/2014 (OJ L 249, 14.7.2021, p. 38).

(3) Regulation (EU) 2021/1060 of the European Parliament and of the Council of 24 June 2021 laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund and financial rules for those and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Instrument for Financial Support for Border Management and Visa Policy (OJ L 231, 30.6.2021, p. 159).

(4) Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility (OJ L 57, 18.2.2021, p. 17).

ABBREVIATIONS

AR4	IPCC Fourth Assessment Report
AR5	IPCC Fifth Assessment Report
C3S	Copernicus Climate Change Service
CC	Climate change
CBA	Cost-benefit analysis
CEF	Connecting Europe Facility
CF	Cohesion Fund
CJEU	Court of Justice of the European Union
CMIP	Coupled Model Intercomparison Projects
CO_2	Carbon dioxide
CO_2e	Carbon Dioxide Equivalent
CPR	Regulation (EU) 2021/1060
DNSH	Do no significant harm
DWL	Design working life
EAD	Expected annual damage
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EPCM	Engineering, Procurement & Construction Management
ERDF	European Regional Development Fund
ESG	Environmental, social and governance
ESIA	Environmental and Social Impact Assessment
ECP	Extended Concentration Pathway
FEED	Front end engineering design
GHG	Greenhouse gas
GIS	Geographical Information Systems
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre (European Commission)
JTF	Just Transition Fund
KPI	Key Performance Indicators
NECP	National Energy and Climate Plan
O&M	Operation and maintenance
PCM	Project Cycle Management
RRF	Recovery and Resilience Facility
RCP	Representative Concentration Pathways
SEA	Strategic Environmental Assessment
TFEU	Treaty on the Functioning of the European Union

TABLE OF CONTENTS

List of figures

List of tables

1. EXECUTIVE SUMMARY

This document provides **technical guidance** on the climate proofing of infrastructure covering the programming period 2021-2027.

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). The detailed analysis is subject to the outcome of the screening phase, which helps reduce the administrative burden.

Infrastructure is a broad concept encompassing buildings, network infrastructure, and a range of built systems and assets. For instance, the InvestEU Regulation includes a comprehensive list of eligible investments under the sustainable infrastructure policy window.

The guidance contained in this document meets the following **requirements laid down in the legislation** for several EU funds, notably InvestEU, Connecting Europe Facility (CEF), European Regional Development Fund (ERDF), Cohesion Fund (CF), and the Just Transition Fund (JTF):

— **It is consistent with the Paris Agreement and EU climate objectives**, which means it is consistent with a credible *greenhouse gas (GHG) emission reduction pathway* in line with the EU's new climate targets for 2030 and climate neutrality by 2050, as well as with climate-resilient development. Infrastructure with a *lifespan beyond 2050* should also factor in operation, maintenance and final decommissioning under conditions of climate neutrality, which may include *circular economy* considerations.

— It follows the **principle 'energy efficiency first'**, which is defined in Article 2(18) of Regulation (EU) 2018/1999 of the European Parliament and of the Council ([5]).

— It follows the **principle 'do no significant harm'**, which is derived from the EU's approach to sustainable finance and enshrined in Regulation (EU) 2020/852 of the European Parliament and of the Council ([6]) (Taxonomy Regulation). This guidance addresses two of the environmental objectives in Article 9 of the Taxonomy Regulation, i.e. climate change mitigation and adaptation.

Quantifying and monetising greenhouse gas emissions remain the basis for the cost-benefit and options analysis. The guidance includes an updated **carbon footprint methodology** and an assessment of the **shadow cost of carbon**.

The **climate vulnerability and risk assessment** remains the basis for identifying, appraising and implementing **climate change adaptation measures**.

It is important to specifically and credibly document climate-proofing practices and processes, in particular as **documentation and verification** of climate proofing forms an essential part of the rationale for making investment decisions.

Based on lessons learnt from climate proofing major projects over the period 2014-2020, this guidance integrates climate proofing with **project cycle management (PCM)**, **environmental impact assessments (EIA)**, and **strategic environmental assessment (SEA)** processes, and it includes recommendations to **support national climate-proofing** processes in Member States.

([5]) Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (OJ L 328, 21.12.2018, p. 1), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018R1999

([6]) Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (OJ L 198, 22.6.2020, p. 13), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020R0852

Table 1

Summary of climate proofing of infrastructure projects

Climate neutrality Mitigation of climate change	Climate resilience Adaptation to climate change
Screening – Phase 1 (mitigation): Compare the project with the screening list in Table 2 of this guidance: — If the project does not require a carbon footprint assessment, summarise the analysis in a *climate neutrality screening statement*, which in principle ([1]) gives a conclusion on climate proofing as regards climate neutrality; — If the project requires a carbon footprint assessment, proceed to phase 2 below.	**Screening – Phase 1 (adaptation)**: Carry out a climate sensitivity, exposure and vulnerability analysis in line with this guidance: — If there are no significant climate risks warranting further analysis, compile the documentation and summarise the analysis in a climate resilience screening statement, which in principle gives a conclusion on climate proofing as regards climate resilience; — If there are significant climate risks warranting further analysis, proceed to phase 2 below.
Detailed analysis – Phase 2 (mitigation): — Quantify GHG emissions in a typical year of operation using the carbon footprint method. Compare with the thresholds for absolute and relative GHG emissions (see Table 4). If the GHG emissions exceed any of the thresholds, carry out the following analysis: — Monetise GHG emissions using the shadow cost of carbon (see Table 6) and firmly integrate the 'energy efficiency first' principle in the project design, options analysis, and cost-benefit analysis. — Verify the project's compatibility with a credible pathway to achieve the overall 2030 and 2050 GHG emission reduction targets. As part hereof, for infrastructure with a lifespan beyond 2050, verify the project's compatibility with operation, maintenance and final decommissioning under conditions of climate neutrality. Compile the documentation and summarise the analysis in the *climate neutrality proofing statement*, which in principle gives a conclusion on climate proofing as regards climate neutrality.	**Detailed analysis – Phase 2 (adaptation)**: — Carry out the climate risk assessment including the likelihood and impact analyses in line with this guidance. — Address significant climate risk by identifying, appraising, planning and implementing relevant and suitable adaptation measures. — Assess the scope and need for regular monitoring and follow-up, for example critical assumptions in relation to future climate change. — Verify consistency with EU and, as applicable, national, regional and local strategies and plans on the adaptation to climate change, and other relevant strategic and planning documents. Compile the documentation and summarise the analysis in the *climate resilience proofing statement*, which in principle gives a conclusion on climate proofing as regards climate resilience.
Compile the above-mentioned documentation and summaries into a consolidated climate screening / proofing documentation, which in most cases will be an important part of the rationale for making investment decisions. Include information on planning and implementing the climate-proofing process.	

([1]) Fund-specific requirements on e.g. the cost-benefit analysis may include GHG emissions.

2. SCOPE OF THE GUIDANCE

Infrastructure – our built environment – is essential for the functioning of our modern society and economy. It provides the basic physical and organisational structures and facilities that underpin many of our activities.

Most **infrastructure has a long lifespan** or service life. Many infrastructures in service today in the EU were designed and built many years ago. In addition, most of the infrastructure funded over the period 2021-2027 will remain in service well into the second half of the century and beyond. In parallel, the economy will undergo a transition to net zero GHG emissions by 2050 (climate neutrality) in line with the Paris Agreement and with the European Climate Law, including meeting the new GHG emission targets for 2030. However, climate change will continue to increase the frequency and severity of a range of climate and weather extremes, so the EU will pursue the aim to become a climate-resilient society, fully adapted to the unavoidable impacts of climate change, building up its adaptive capacity and minimising its vulnerability in line with the Paris Agreement, the European Climate Law and the EU strategy on adaptation to climate change [7]. **It is therefore essential to clearly identify – and consequently to invest in – infrastructure** [8] **that is prepared for a climate-neutral and climate-resilient future.** The two pillars of climate proofing are illustrated in Figure 1.

Infrastructure is a broad concept, which includes:

— *buildings*, from private homes to schools or industrial facilities, which are the most common type of infrastructure and the basis for human settlement;

— *nature-based infrastructures* such as green roofs, walls, spaces, and drainage systems.

— *network infrastructure* crucial for the functioning of today's economy and society, notably energy infrastructure (e.g. grids, power stations, pipelines), transport [9] (fixed assets such as roads, railways, ports, airports or inland waterways transport infrastructure), information and communication technologies (e.g. mobile phone networks, data cables, data centres), and water (e.g. water supply pipelines, reservoirs, waste water treatment facilities);

— *systems* to manage the waste generated by businesses and households (collecting points, sorting and recycling facilities, incinerators and landfills);

— other *physical assets* in a wider range of policy areas, including communications, emergency services, energy, finance, food, government, health, education and training, research, civil protection, transport, and waste or water;

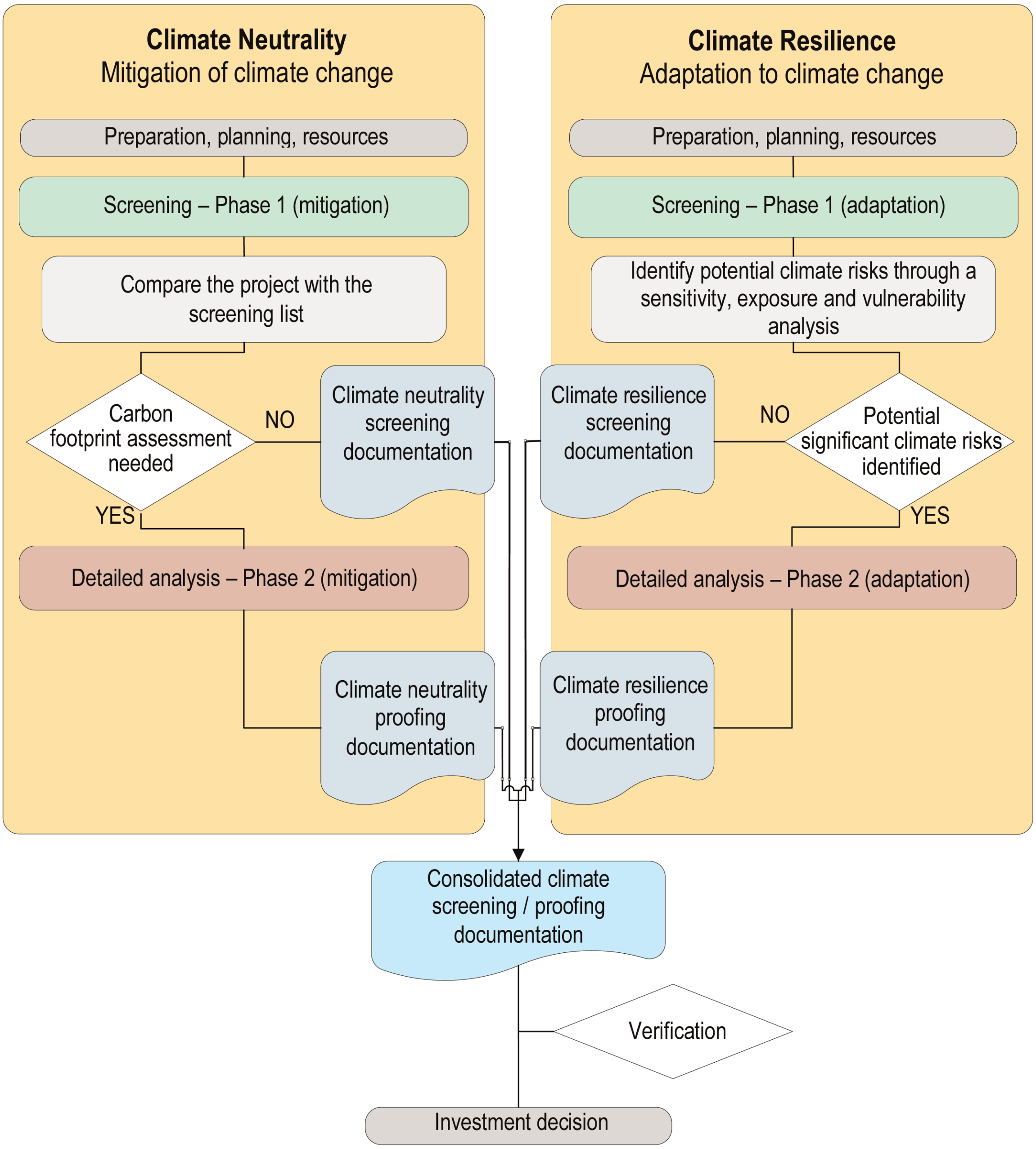
— *other eligible types of infrastructure* may also be laid down in the fund-specific legislation, for instance, the InvestEU Regulation includes a comprehensive list of eligible investments under the sustainable infrastructure policy window.

With due regard to the competences of the concerned public authorities, this guidance is primarily intended for project promoters and experts involved in the preparation of infrastructure projects. It may also be a useful reference for public authorities, implementing partners, investors, stakeholders, and others. For instance, it includes guidance on how to integrate climate change issues in environmental impact assessments (EIA) and strategic environmental assessments (SEA).

(7) EU adaptation strategy: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN
(8) New infrastructure as well as e.g. renewal, upgrading and extension of existing infrastructure.
(9) As reference on sustainable connectivity, see e.g. the Joint Communication 'Connecting Europe and Asia – Building blocks for an EU Strategy', JOIN(2018) 31 final, 19.9.2019.

Figure 1

Climate proofing and the pillars on 'climate neutrality' and 'climate resilience'



In general, the project promoter will include in the project organisation the expertise needed for climate proofing and coordinate with other work in the project development process, for instance, environmental assessments. Depending on the specific nature of the project, this may include bringing in a **climate-proofing manager and a team of experts in climate change mitigation and adaptation**.

From the date of its initial publication by the European Commission, this guidance should be integrated in the preparation and climate proofing of infrastructure projects for the period 2021-2027. Infrastructure projects that have completed the environmental impact assessment (EIA) and received the development consent **no later than by the end of 2021**, have concluded the necessary funding agreements (including for EU-funding) and that will begin the **construction works not later than in 2022**, are strongly encouraged to carry out climate proofing following this guidance.

During the **operation and maintenance of infrastructure**, it may often be relevant to revisit the climate proofing and any critical assumptions. This can be carried out at regular intervals (e.g. 5-10 years) as part of the asset management. Complementary measures may be taken to further reduce GHG emissions and address evolving climate risks.

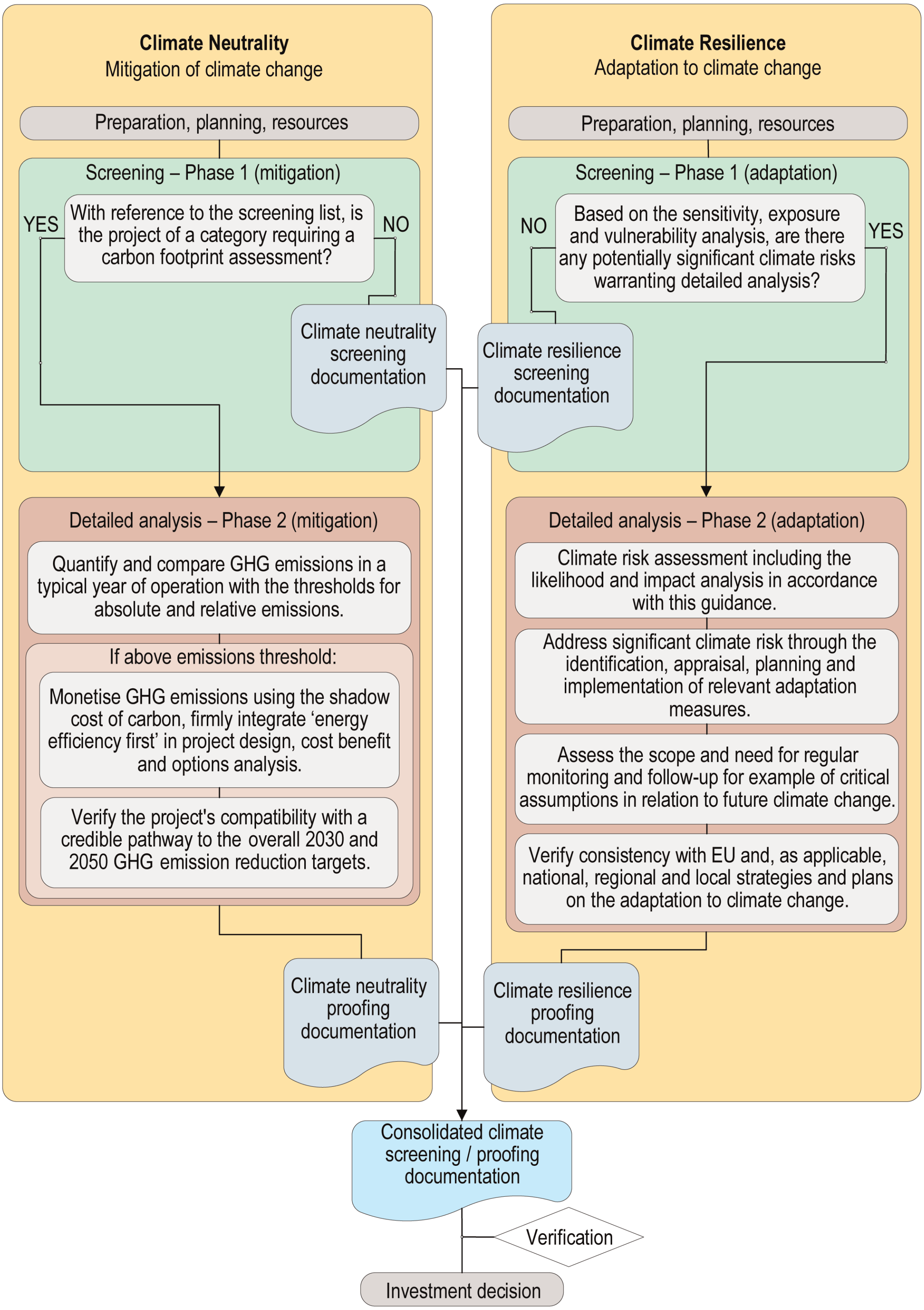
The **time, cost and effort put into climate proofing** should be proportionate to the benefits. This is reflected, for instance, in the way the climate proofing process is divided into two phases, with screening in phase 1 and a detailed analysis only carried out in phase 2 where warranted. Planning and integration into the project development cycle should help avoiding duplication of work, for instance between climate proofing and environmental assessments, reduce cost and the administrative burden.

3. CLIMATE PROOFING OF INFRASTRUCTURE

Figure 2 illustrates the two pillars and main steps of climate proofing. Each pillar is divided in two phases. The first phase is screening and the outcome determines whether the second phase should be carried out.

Figure 2

Overview of the climate-proofing process from Table 1



As shown in Figure 2, the climate-proofing process should be documented in a *consolidated climate screening / proofing documentation*, which differs according to the phases carried out (see Annex B).

3.1. Preparing for climate proofing

When applying for support under specific instruments, the project promoter **prepares, plans and documents** the climate-proofing process covering mitigation and adaptation. This includes:

— assessing and specifying the project context, and project boundaries and interactions;

— selecting the assessment methodology, including key parameters for the vulnerability and risk assessment;

— identifying who should be involved and allocating resources, time and budget;

— compiling key reference documents such as the applicable national energy and climate plan (NECP) and relevant adaptation strategies and plans, including for instance National and local disaster risk reduction strategies;

— ensuring compliance with applicable legislation, rules and regulations, for example on structural engineering and the environmental impact assessment (EIA), and, where available, the strategic environmental assessment (SEA).

In this guidance, climate proofing is described as a linear approach taken by following a sequence of specific steps. However, often it will be necessary to return to an earlier step in the **project development cycle**, for instance if an adaptation measure is included in the project, making it relevant to revisit the sensitivity analysis. It may also be necessary to go back a step to ensure that any changes (e.g. new requirements) are properly integrated.

It is important to have a good understanding of the **project context**, i.e. the proposed project and its objectives, including all ancillary activities needed to support the project's development and operation. An impact of climate change on any of the project activities or components may undermine the success of the project. It is essential to understand the overall importance and functionality of the project itself and its part in the overall context/system and to assess how essential ([10]) this infrastructure is.

The **methodology** and approach to climate proofing should be planned and explained in a logical and clear manner, including its main limitations. It should specify the sources of data and information. It should also explain the level of detail, steps to follow, and level of uncertainty of the underlying data and analysis. The aim is provide accessible, transparent and comparable validation of the climate-proofing process to feed into the decision making process.

The preparation of climate proofing includes selecting a **credible pathway to achieve the EU's 2030 and 2050 GHG emission reduction targets** in line with the goals of the Paris Agreement and the European Climate Law. This will typically require an expert assessment ([11]) taking into account targets and requirements. The aim is to ensure that the GHG emission reduction targets and the *energy efficiency first* principle are integrated into the project development cycle.

Note that the timescale for the climate vulnerability and risk assessment should correspond to the intended **lifespan** of the investment being financed under the project. The lifespan is often (considerably) longer than the reference period used in the cost-benefit analysis, for example.

For instance, one of the main concepts of the Eurocodes ([12]) is the **design working life** (DWL), defined as the period for which the structure will be used with anticipated maintenance but without major repair. The DWL of buildings and other common structures designed using Eurocodes is 50 years, and the DWL of monumental buildings and bridges is envisaged as 100 years. In this way, structures designed in 2020 will withstand climatic actions (e.g. snow, wind, thermal) and extreme events expected up to 2070 (as for buildings), and up to 2120 for bridges and monumental buildings.

([10]) Certain infrastructure is designated 'critical infrastructure' in accordance with Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection (OJ L 345, 23.12.2008, p. 7) includes the following definition. This guidance on climate proofing can be applied to infrastructure irrespective of whether it is designated 'critical infrastructure' or not.

([11]) Taking into account, for instance, the guidance on *aligning new projects with pathways towards low GHG emissions* in the EIB Climate Bank Roadmap: https://www.eib.org/en/publications/the-eib-group-climate-bank-roadmap

([12]) The Eurocodes are state-of-the-art reference design codes for buildings, infrastructures and civil engineering structures. They are the recommended reference for technical specifications in public contracts and designed to result in more uniform levels of safety in construction throughout Europe.

The **climatic data** on which the current generation of the Eurocodes is based are mostly 10-15 years old, with some exceptions of recent updates of national data. National uptake of the Eurocodes – as regards the choice of nationally determined parameters (NDPs) relevant to selecting climatic actions – is analysed in the recent JRC report [13] on the state of harmonised use of the Eurocodes. The JRC also provides guidance for countries adopting the Eurocodes on how to map seismic and climatic action on structural design [14].

In 2016, work started on the second generation of the Eurocodes (expected by 2023). This should include revising and updating snow, wind and thermal-related measures, converting ISO standards on actions from waves and currents and on atmospheric icing; and preparing a document with the probabilistic basis for calculating partial safety factors and load combination factors, taking into account the variability and interdependence of climatic actions.

During the intended lifespan of the infrastructure project there could be **significant changes in the frequency and intensity of extreme weather events due to climate change**, which should be taken into account. Projects should also factor in potential sea-level rise, which is projected to continue into the future even if global warming stabilises in accordance with the temperature goals of the Paris Agreement.

It is among the initial tasks of the project promoter and expert team to decide on the **climate projection dataset(s) to be used for the climate vulnerability and risk assessment** – and this should be documented.

In most cases, the required datasets may be available in the Member State concerned [15]. If these national/regional datasets are not available, the following climate change information sources could be considered as an alternative basis for the analysis:

— Copernicus Climate Change Service [16] (C3S), offering inter alia climate projections within the Copernicus Climate Data Store [17] (CDS);

— Other credible national/regional sources [18] of climate change information, data and projections [19], e.g. for outermost regions data from the concerned Regional Climate Models [20].

— In addition to the Copernicus Climate Change Service [21], the Copernicus [22] programme includes the Copernicus Atmosphere Monitoring Service [23], Copernicus Marine Environment Monitoring Service [24], Copernicus Land Monitoring Service [25], Copernicus Security Service [26], and the Copernicus Emergency Management Service [27]. These services may provide useful data complementing C3S;

— National risk assessments [28] where relevant and available;

[13] JRC Report: Sousa, M.L., Dimova, S., Athanasopoulou, A., Iannaccone, S. Markova, J. (2019), *State of harmonised use of the Eurocodes*, EUR 29732, doi:10.2760/22104, https://publications.jrc.ec.europa.eu/repository/handle/JRC115181

[14] JRC Report: P. Formichi, L. Danciu, S. Akkar, O. Kale, N. Malakatas, P. Croce, D. Nikolov, A. Gocheva, P. Luechinger, M. Fardis, A. Yakut, R. Apostolska, M.L. Sousa, S. Dimova, A. Pinto, *Eurocodes: background and applications. Elaboration of maps for climatic and seismic actions for structural design with the Eurocodes*, EUR 28217, doi:10.2788/534912, JRC103917, https://publications.jrc.ec.europa.eu/repository/handle/JRC103917

[15] 2018 Study on 'Climate change adaptation of major infrastructure projects' undertaken for DG REGIO: https://ec.europa.eu/regional_policy/en/information/publications/studies/2018/climate-change-adaptation-of-major-infrastructure-projects

[16] Copernicus C3S: https://climate.copernicus.eu/

[17] Copernicus CDS: https://cds.climate.copernicus.eu/#!/home

[18] 2018 Study on 'Climate change adaptation of major infrastructure projects' undertaken for DG REGIO: https://ec.europa.eu/regional_policy/en/information/publications/studies/2018/climate-change-adaptation-of-major-infrastructure-projects

[19] Horizon 2020 projects on climate and water resilience, for instance, CLAIRCITY, ICARUS, NATURE4CITIES, GROWGREEN, CLARITY, CLIMATE-FITCITY.

[20] https://cordex.org/

[21] Copernicus Climate Change: https://www.copernicus.eu/en/services/climate-change

[22] Copernicus: https://www.copernicus.eu/en

[23] Copernicus Atmosphere: https://www.copernicus.eu/en/services/atmosphere

[24] Copernicus Marine: https://www.copernicus.eu/en/services/marine

[25] Copernicus Land: https://www.copernicus.eu/en/services/land

[26] Copernicus Security: https://www.copernicus.eu/en/services/security

[27] Copernicus Emergency: https://www.copernicus.eu/en/services/emergency

[28] Under Decision No 1313/2013/EU of the European Parliament and of the Council of 17 December 2013 on the Union Civil Protection Mechanism (OJ L 347, 20.12.2013, p. 924), http://ec.europa.eu/echo/what/civil-protection/mechanism_en and http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32013D1313

— Overview [29] of disaster risks the European Union may face;

— European Climate Adaptation Platform (Climate-ADAPT [30]);

— European Commission Joint Research Centre [31] (JRC);

— Disaster Risk Management Knowledge Centre (DRMKC) e.g. Risk Data Hub [32], PESETA IV datasets hosted and downloadable on the Risk Data Hub, with projections of potential impacts and methodologies [33]; and Disaster Loss data [34];

— European Environment Agency [35] (EEA);

— IPCC Data Distribution Centre (DDC [36]), and the IPCC [37] Fifth Assessment Report (AR5 [38]), IPCC Special Report on Global Warming of 1,5 °C [39], IPCC Special Report on Climate Change and Land [40], preparation of the 6th Assessment Report (AR6 [41]));

— World Bank Climate Change Knowledge Portal [42].

The **Paris Agreement** aims in Article 2(a) to 'Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1,5 °C above pre-industrial levels'.

An infrastructure project that is adapted to 2 °C global warming would in principle be consistent with the agreed temperature goal. However, each individual Party (country) to the Paris Agreement must calculate how it will contribute to the worldwide temperature goal. The **current pledges**, in the form of the existing and submitted *nationally determined contributions (NDCs)* may still lead to about 3 °C global warming if the level of ambition does not increase [43], which is 'far beyond the Paris Agreement goals of limiting global warming to well below 2 °C and pursuing 1,5 °C'. Therefore, it may be relevant to consider stress testing infrastructure projects – through the climate vulnerability and risk assessment – for higher levels of global warming. The current set of NDCs is subject to review ahead of COP26 in Glasgow November 2021, and the EU has already formally submitted [44] to the UN its higher level of ambition to achieve at least 55 % reduction by 2030 compared to 1990 levels.

The expected increase in the ***global average temperature*** is often essential to select the global and regional climate datasets. However, for a specific project location, the local climate variables may change in a different manner than the global average. For instance, the temperature increase is usually higher over land (where most infrastructure projects are located) than over the sea. For instance, the increase in the average temperature over land in Europe is generally higher than the increase in the global average temperature. Hence, the most adequate climate datasets must be selected, be them for a specific region or projections from downscaled models.

(29) SD(2020) 330 final, https://ec.europa.eu/echo/sites/echo-site/files/overview_of_natural_and_man-made_disaster_risks_the_european_union_may_face.pdf
(30) Climate-ADAPT: https://climate-adapt.eea.europa.eu/
(31) JRC: https://ec.europa.eu/jrc/en/research-topic/climate-change and https://data.jrc.ec.europa.eu/collection?q=climate and the JRC paper: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC109146/mapping_of_risk_web-platforms_and_risk_data_online_final.pdf (the latter includes a list of exposure/vulnerability datasets at EU level but also used by Member States).
(32) Risk Data Hub: https://drmkc.jrc.ec.europa.eu/risk-data-hub/#/
(33) PESETA IV: https://ec.europa.eu/jrc/en/peseta-iv
(34) Disaster Loss data: https://drmkc.jrc.ec.europa.eu/risk-data-hub#/damages
(35) EEA: https://www.eea.europa.eu/
(36) IPCC Data Distribution Centre (DDC): http://www.ipcc-data.org/ and https://www.ipcc.ch/data/
(37) IPCC: The Intergovernmental Panel on Climate Change, https://www.ipcc.ch/
(38) IPCC 5th Assessment Report (AR5): https://www.ipcc.ch/report/ar5/syr/
(39) IPCC Special Report on Global Warming of 1,5 °C: https://www.ipcc.ch/sr15/
(40) IPCC Special Report on Climate Change and Land: https://www.ipcc.ch/report/srccl/
(41) IPCC 6th Assessment Report (AR6) (planned for 2021 and 2022): https://www.ipcc.ch/reports/
(42) World Bank Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/
(43) UN Environment Programme (UNEP, UNEP DTU) – The Emissions Gap Report 2020: https://www.unep.org/emissions-gap-report-2020
(44) https://www.consilium.europa.eu/en/press/press-releases/2020/12/18/paris-agreement-council-transmits-ndc-submission-on-behalf-of-eu-and-member-states/ and https://data.consilium.europa.eu/doc/document/ST-14222-2020-REV-1/en/pdf

Recent climate projection datasets refer to the underlying *representative concentration pathway (RCP)*. Four pathways have been selected for climate modelling and for the GHG trajectories used by the IPCC ([45]) in the fifth Assessment Report (AR5) ([46]). Virtually all currently available climate projections are based on these four RCPs. A fifth RCP1.9 ([47]) was published in relation to the IPCC Special Report on global warming of 1,5 °C (SR15 ([48])).

The pathways are designated RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5. Figure 3 shows the projection of global warming up to 2100 (*relative to the period 1986-2005 for which the average global warming is about 0,6 °C above preindustrial levels* ([49])).

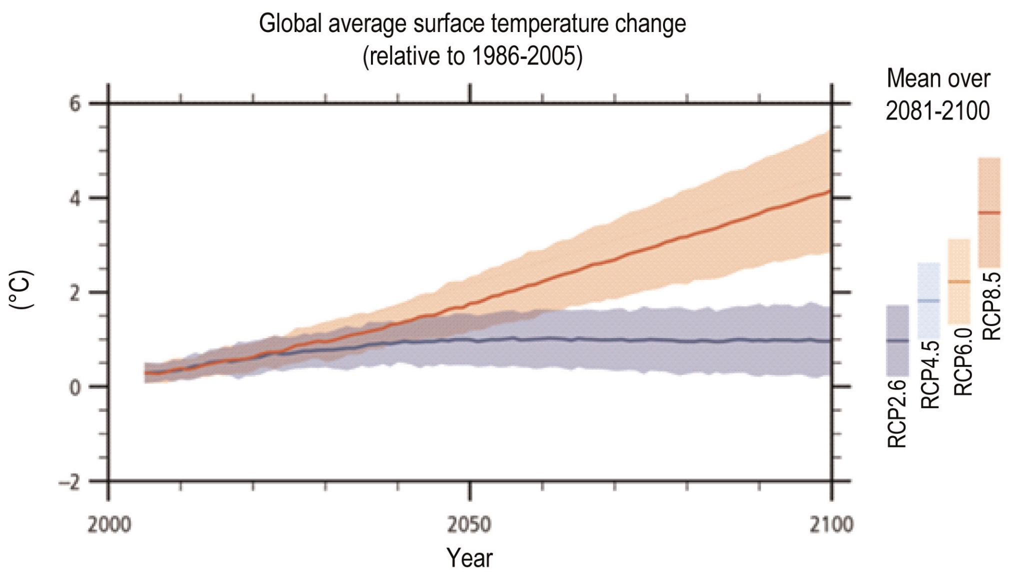
Most of the simulations for AR5 were carried out with prescribed CO_2 concentrations reaching 421 ppm (RCP 2.6), 538 ppm (RCP 4.5), 670 ppm (RCP 6.0), and 936 ppm (RCP 8.5) by 2100.

For comparison, atmospheric carbon dioxide continues to rise rapidly with the average for May 2019 peaking at 414.7 parts per million (ppm) at the Mauna Loa Observatory ([50]).

For practical applications in climate proofing, RCP 4.5 may be usable for climate projections until about 2060. However, for subsequent years, RCP 4.5 may begin to underestimate the changes – in particular if GHG emissions prove higher than anticipated. Hence, it could be more relevant to use RCP 6.0 and RCP 8.5 for current projections until 2100. Nonetheless, warming under RCP8.5 is widely considered to be greater than current business-as-usual scenarios ([51]).

Figure 3

Projections of global warming until the year 2100



Source: Figure SPM.6 from the Summary for Policymakers, Synthesis Report, IPCC 5th Assessment Report.

([45]) IPCC: United Nations Intergovernmental Panel on Climate Change: https://www.ipcc.ch/
([46]) IPCC AR5: https://www.ipcc.ch/report/ar5/syr/
([47]) https://www.carbonbrief.org/new-scenarios-world-limit-warming-one-point-five-celsius-2100
([48]) IPCC SR15: Special report on the impacts of global warming of 1,5 °C above pre-industrial levels and related global GHG emission pathways, https://www.ipcc.ch/sr15/
([49]) The period 1986-2005 is about 0,6 °C warmer than pre-industrial based on a simple comparison between figures SPM.1 and SPM.6 of the Summary for Policy Makers, IPCC 5th Assessment Report (AR5):
— SPM.1: https://www.ipcc.ch/site/assets/uploads/2018/02/SPM.1_rev1-01.png
— SPM.6: https://www.ipcc.ch/site/assets/uploads/2018/02/SPM.06-01.png
See also https://journals.ametsoc.org/doi/full/10.1175/BAMS-D-16-0007.1 (which estimates the difference to be between 0,55 °C and 0,80 °C).
([50]) https://www.esrl.noaa.gov/gmd/obop/mlo/
([51]) https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario

For initial *screening-type* analyses, it is recommended to use climate projections based on RCP 6.0 or RCP 8.5.

If RCP 8.5 is used for the detailed climate vulnerability and risk assessment, there may be no further need for stress testing ([52]).

RCP 4.5 may be more relevant for projects where it is a practical option to increase the level of climate resilience during its lifetime as and when needed. This will usually require the asset owner regularly monitoring climate change, impacts, and the level of resilience. For instance, it may be feasible to increase gradually the height of some flood defence systems.

Selecting climate projections is the responsibility of the project promoter together with the climate-proofing manager and technical specialists. It should be seen as an integrated part of project risk management. National guidance and rules must also be followed.

The **IPCC 6th Assessment Report** will use updated climate projections (based on CMIP6 ([53])) compared to the 5th Assessment Report (CMIP5) and a new set of RCPs. Once available, it will be important to integrate the newest set of climate projections into the climate-proofing process. For instance, CMIP6 added a new scenario (SSP3-7.0), right in the middle of the range of baseline outcomes produced by energy system models, which could possibly replace RCP8.5 for the purpose of climate proofing.

In terms of the timeframe, climate projections should typically cover the above-referred timescale, i.e. the anticipated lifespan of the project.

Decadal climate predictions ([54]) may be used for short-term projects, i.e. usually up to the next decade. Decadal predictions are based on current climate conditions (e.g. ocean temperatures) and recent past changes, which provides a reasonable degree of certainty for this timescale.

For **medium to longer-term projects, i.e. up to 2030 and until the end of the century** and beyond, it will be necessary to use scenario-based climate projections.

The **resources available in the Member States** to develop climate-resilient infrastructure have been mapped in a study ([55]) undertaken by the Commission and published in 2018. The study uses seven criteria (data availability, guidance, methodologies, tools, design standards, system and legal framework, institutional capacity) and covers transport, broadband, urban development, energy, and water and waste sectors.

Initial experience from major projects over the period 2014-2020, where at the beginning the climate change related requirements were new and Member States had little prior experiences, reveals demonstrable and substantial progress in the quality of climate proofing, though some issues remain:

— Beneficiaries often find it challenging to demonstrate how the projects contribute to EU and national climate policy objectives.

— Beneficiaries' knowledge of national and regional strategies and plans is often weak.

— For transport projects, a sufficiently detailed traffic model is usually needed to calculate absolute and relative GHG emissions. It should be used initially at the strategy and planning phase of the project cycle when the main choices affecting GHG emissions are made, and then later on as part of the cost-benefit analysis. Traffic models have been developed in most countries and regions/cities. A lack of traffic models can impede the analysis, e.g. the analysis of options, modal switches and relative GHG emissions.

([52]) For larger or longer-term projects in particular, the climate manager and expert(s) may consider taking a more robust approach involving additional RCPs and climate models.
([53]) CMIP6: https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained
([54]) https://www.wcrp-climate.org/dcp-overview
https://www.dwd.de/EN/research/climateenvironment/climateprediction/climateprediction_node.html;jsessionid=1994BFE322D4CE5BA377CE5F57A2FE48.live21061
https://www.dwd.de/EN/climate_environment/climateresearch/climateprediction/decadalprediction/decadalprediction_node.html;jsessionid=3165E97F071FC5301708ED4EB6F7E9E5.live21061
([55]) 2018 Study on 'Climate change adaptation of major infrastructure projects' undertaken for DG REGIO: https://ec.europa.eu/regional_policy/en/information/publications/studies/2018/climate-change-adaptation-of-major-infrastructure-projects

— Projects in the water sector had the fewest issues in terms of climate change mitigation reporting, but other sectors, such as energy, had more difficulties integrating calculations of GHG emissions into the CBA.

— The use of climate change as a criterion for *options analysis* was found lacking almost in all projects reviewed, as most projects were based on an analysis of historical options, with the exception of dedicated climate adaptation projects.

— More substantial progress was observed in countries where the largest beneficiaries (e.g. transport authorities) started collecting their own climate change data and working on scenarios and adaptation needs. In some Member States, the planning system is retroactive (responding to development proposals) rather than proactive (i.e. steering development patterns toward low-carbon and resilient forms).

Information on urban adaptation in Europe can for instance be found in EEA report No 12/2020 ([56]). The report details the climate-related impacts on European cities and towns and the effectiveness and cost efficiency of adaptation measures.

Technical guidance on the application of 'do no significant harm' is available in Commission Notice 2021/C 58/01 ([57]) under the Recovery and Resilience Facility (RRF) ([58]), which refers to this guidance on climate proofing of infrastructure 2021-2027. Commission staff working document 'Guidance to Member States – Recovery and resilience plans', SWD (2021) 12 final ([59]), encourages, as regards investments in infrastructure, to apply the guidance on climate proofing established under the InvestEU Regulation.

3.2. Mitigating climate change (climate neutrality)

Mitigating climate change involves decarbonisation, energy efficiency, energy savings, and deploying renewable forms of energy. It involves taking action to reduce GHG emissions or increase GHG sequestration and is guided by EU policy on **emission reduction targets for 2030 and 2050.**

Member States' authorities play an important role in the implementation of the EU policy objectives for reduction targets and may establish particular requirements for achieving those objectives. The guidance in this section is without prejudice of the requirements established in the Member States and of the supervision role of public authorities thereof.

The principle ([60]) of '***energy efficiency first***' emphasises the need to prioritise alternative cost-efficient energy efficiency measures when making investment decisions, in particular cost-effective end-use energy savings.

Quantifying and monetising GHG emissions can support investment decisions.

In addition, a substantial share of the infrastructure projects that will be supported in the period 2021-2027 will have a **lifespan that extends beyond 2050**. Therefore, an expert analysis is needed to verify whether the project is compatible with, for instance, operation, maintenance and final decommissioning in the overall context of net zero GHG emissions and climate neutrality.

This guidance recommends, where applicable, using the **EIB carbon footprint methodology** (to quantify GHG emissions) and the **EIB shadow cost of carbon** method (to monetise GHG emissions).

In this guidance, carbon foot printing is used not only to estimate the greenhouse gas emissions for a project when it is ready to be implemented, but more importantly, to support the analysis and integration of low-carbon solutions during the planning and design stages. It is therefore essential to integrate climate proofing in the project cycle management from the outset. Having carried out a thorough climate-proofing process can determine a project's eligibility for funding.

([56]) EEA Report No 12/2020, *Urban adaptation in Europe: how cities and towns respond to climate change, European Environment Agency*, https://www.eea.europa.eu/publications/urban-adaptation-in-europe

([57]) DNSH: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2021.058.01.0001.01.ENG

([58]) RRF: https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en

([59]) https://ec.europa.eu/info/sites/info/files/document_travail_service_part1_v2_en.pdf and https://ec.europa.eu/info/sites/info/files/document_travail_service_part2_v3_en.pdf

([60]) *Energy efficiency first* is defined in Article 2(18) of Regulation (EU) 2018/1999, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0001.01.ENG

It does not, however, prescribe a specific **cost-benefit analysis** methodology as this may depend on fund-specific lending requirements and other factors. For CEF Energy projects, for instance, the main references are the ENTSO-E and ENTSO-G cost-benefit analysis methodologies, in accordance with Regulation (EU) No 347/2013 of the European Parliament and of the Council ([61]). The European Commission's *Guide to Cost-Benefit Analysis of Investment Projects* ([62]) is used for major projects in the period 2014-2020, and remains a relevant reference (for mitigation as well as adaptation).

In many Member States, a cost-benefit analysis is also used for **smaller projects** to capture and assess all externalities created by a project and its comprehensive impact and value for money from the point of view of the public. In 2021, the European Commission will publish a guide to **economic appraisals**, with a simplified toolkit, for optional use by financing institutions in the period 2021-2027.

Early-stage and consistent assessment of a project's expected greenhouse gas emissions over the many development stages will help mitigate its impact on climate change. A range of choices, notably during the planning and design stages, may affect the project's overall GHG emissions over its lifespan, from construction and operation until decommissioning.

In certain sectors, for instance **transport, energy and urban development**, it is mainly at planning level that effective action must be taken to reduce greenhouse gas emissions. In fact, it is at this stage that the choice between modes to serve certain destinations or corridors is made (e.g. public transport versus private car), which is often an important factor affecting both energy consumption and greenhouse gas emissions. Similarly, an important role is played by policy and 'softer' measures, for instance incentives to use public transport, biking and walking.

Carbon footprint methodologies can be extended, for example to transport network planning, to give an immediate assessment of the extent to which the plan is producing the expected positive impacts on GHG emissions. This could be one of the main *key performance indications* for such plans. The calculations are typically based on a traffic model that reproduces the status of traffic on the network (e.g. flows, capacity, and level of congestion).

A similar approach can be taken for urban development, in particular considering the impact of the location decision of certain activities on mobility and energy use, for instance urban planning options on the form of development (e.g. in terms of density, location, land-use mix, connectivity and permeability, and accessibility). Evidence shows that different urban forms and housing patterns affect greenhouse gas emissions, energy demand, resource depletion, etc.

Particular caution is needed in any infrastructure project fuelled by or carrying fossil fuel, even if it includes energy efficiency measures. In all cases, a specific assessment should be made to assess compatibility with and to avoid significant harm to climate change mitigation objectives.

For instance, in cities, the bulk of GHG emissions are generated by transport, energy use in buildings, electricity supply, and waste. Therefore, projects in these sectors should aim to achieve climate neutrality by 2050, which in practical terms implies net zero GHG emissions. In other words, carbon-free technologies are needed to achieve carbon neutrality.

Within the EU, all building projects – whether renovation or new build projects – must meet the requirements of the EU Energy Performance of Buildings Directive ([63]), which has been transposed by the Member States into national building codes. For renovations, this requires meeting cost-optimum refurbishment levels. For new buildings, this means nearly zero-energy buildings (NZEBs).

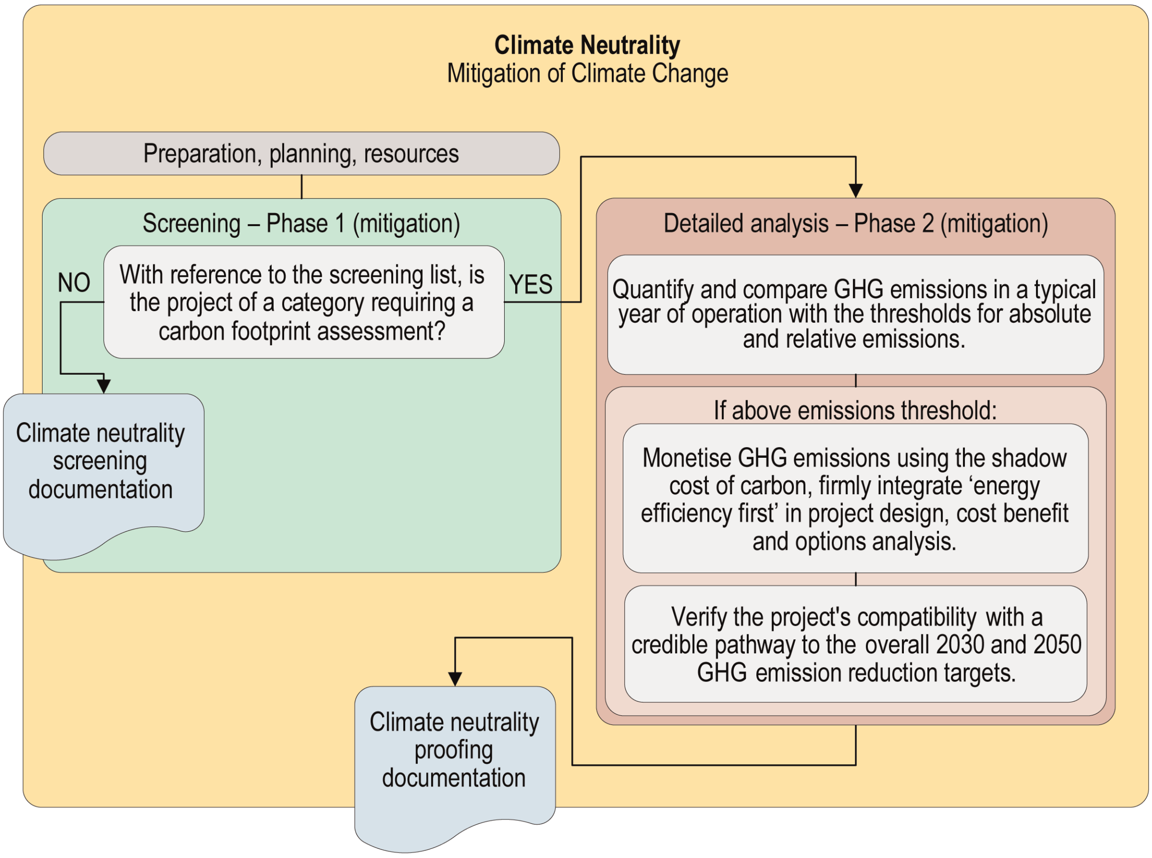
([61]) Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 (OJ L 115, 25.4.2013, p. 39), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R0347

([62]) Guide to Cost-Benefit Analysis of Investment Projects – Economic appraisal tool for Cohesion Policy 2014-2020, ISBN 978-92-79-34796-2, European Commission, https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

([63]) https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

Figure 4

Overview of the climate mitigation related process for climate proofing



3.2.1. *Screening – Phase 1 (Mitigation)*

Table 2 guides the process of screening infrastructure projects in terms of their GHG emissions, which divides projects into two groups based on the project category.

Table 2

Screening list – carbon footprint – examples of project categories [64]

Screening	Categories of infrastructure projects
In general, depending on the scale of the project, a carbon footprint assessment WILL NOT be required in these project categories. With reference to the climate-proofing process for climate change mitigation in Figure 7, the process concludes with phase 1 (screening).	— Telecommunications services — Drinking water supply networks — Rainwater and wastewater collection networks — Small-scale industrial waste water treatment and municipal waste water treatment — Property developments [1]

[64] This table is amended from the EIB Project Carbon Footprint Methodologies, July 2020, Table 1: Illustrative examples of project categories for which a GHG assessment is required, https://www.eib.org/attachments/strategies/eib_project_carbon_footprint_methodologies_en.pdf

Screening	Categories of infrastructure projects
	— Mechanical/biological waste treatment plants — R&D activities — Pharmaceuticals and biotechnology
In general, a carbon footprint assessment WILL ([2]) be required for these project categories. With reference to the climate-proofing process for climate change mitigation in Figure 7, the process for this type of project categories will include phase 1 (screening) and phase 2 with a detailed analysis.	— Municipal solid waste landfills — Municipal waste incineration plants — Large wastewater treatment plants — Manufacturing industry — Chemicals and refining — Mining and basic metals — Pulp and paper — Rolling stock, ship, transport fleet purchases — Road and rail infrastructure ([3]), urban transport — Ports and logistic platforms — Power transmission lines — Renewable sources of energy — Fuel production, processing, storage and transport — Cement and lime production — Glass production — Heat and power generating plants — District heating networks — Natural gas liquefaction and re-gasification facilities — Gas transmission infrastructure — Any other infrastructure project category or scale of project for which the absolute and/or relative emissions could exceed 20 000 tonnes CO_2e/year (positive or negative) (see Table 7)

([1]) Including among other safe and secure parking and external border checks.
([2]) Any infrastructure that is not eligible for funding should be excluded.
([3]) Measures addressing road safety and reduction of rail freight noise may be exempted.

3.2.2. *Detailed analysis – Phase 2 (Mitigation)*

The detailed analysis includes quantifying and monetising GHG emissions (and reductions) as well as assessing consistency with the climate targets for 2030 and 2050.

3.2.2.1. Carbon footprint methodology for infrastructure projects

This guidance recommends the Carbon Footprint Methodologies ([65]) of the European Investment Bank (EIB) for calculating the carbon footprints of infrastructure projects. The methodology includes the default emissions calculation approach for e.g.:

— Waste water and sludge treatment

([65]) EIB Project Carbon Footprint Methodologies for the Assessment of Project GHG Emissions and Emission Variations, July 2020, https://www.eib.org/en/about/cr/footprint-methodologies.htm and https://www.eib.org/attachments/strategies/eib_project_carbon_footprint_methodologies_en.pdf and https://www.eib.org/en/about/documents/footprint-methodologies.htm

— Waste treatment management facilities

— Municipal solid waste landfill

— Road transport

— Rail transport

— Urban transport

— Building refurbishment

— Ports

— Airports

To monetise greenhouse gas emissions, the EIB carbon footprint methodology can be used and complemented by the separate publication *The Economic Appraisal of Investment Projects at the EIB (2013)* (66) and the *Shadow Cost of Carbon* (see Section 3.2.2.4).

The EIB methodology is in line with the International Financial Institution Framework for a Harmonised Approach to Greenhouse Gas Accounting, published in November 2015.

Many infrastructure projects result in emission reductions or increases when compared to the scenario if the project were not carried out, referred to as baseline emissions. In addition, many projects emit greenhouse gases into the atmosphere either directly (e.g. fuel combustion or production process emissions) or indirectly through purchased electricity and/or heat.

The greenhouse gases included in the *EIB carbon footprint methodology* include the seven gases listed in the UNFCCC Kyoto Protocol (67), namely: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF_6); and nitrogen trifluoride (NF_3). The greenhouse gas emission quantification process converts all emissions into tonnes of carbon dioxide called CO_2e (equivalent) using Global Warming Potentials (GWP) (68).

The carbon assessment should be included throughout the project development cycle with a view to promoting low-carbon choices and options, and be used as a tool to rank and select options (including in EIA and SEA).

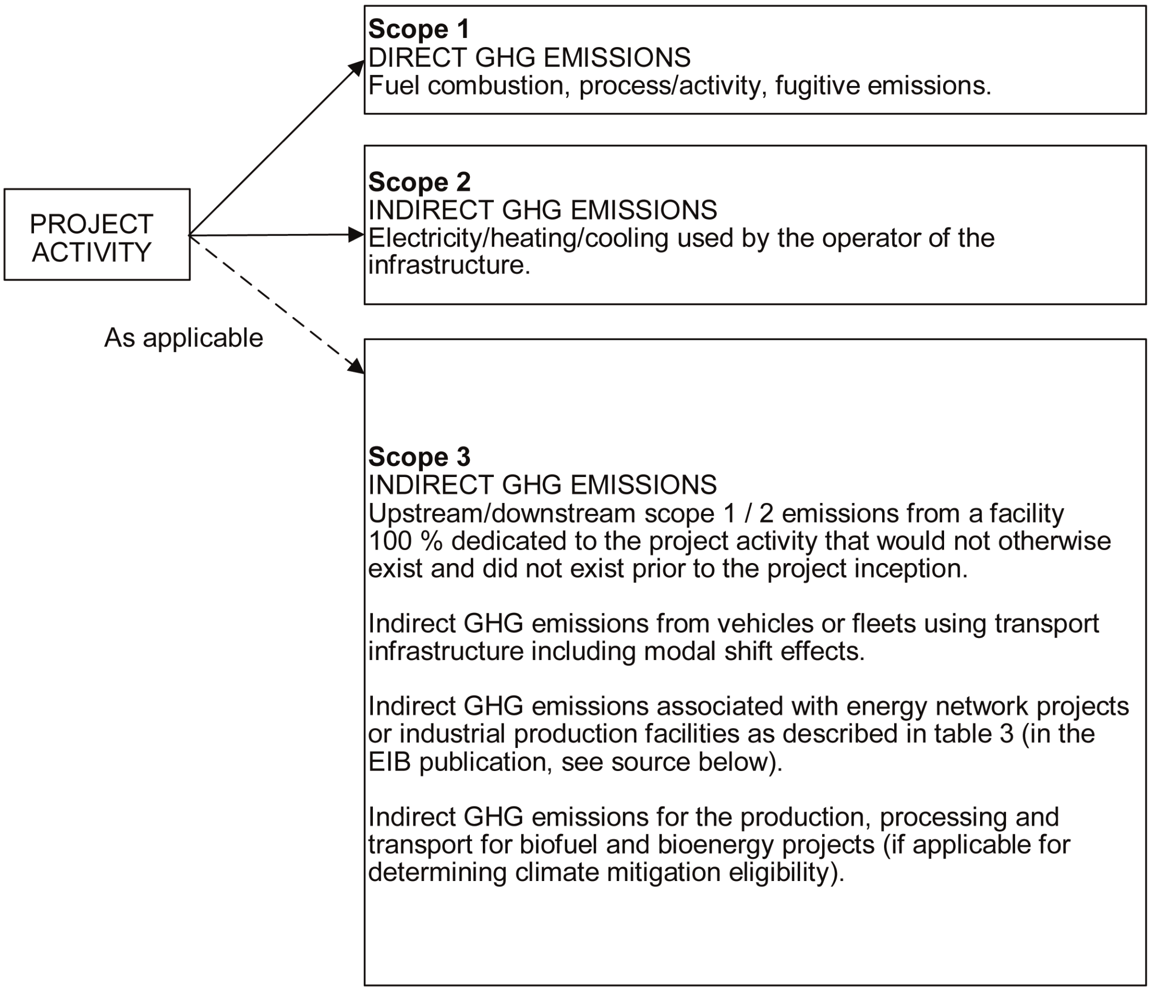
It is recommended to adopt the same approach in the planning stage, for instance in the transport sector, where the main options to reduce greenhouse gas emissions focus on the options related to the operational setup of the network and to the selection of transport modes and policies.

The carbon footprint methodology uses the concept of '**scope**' defined by the Greenhouse Gas Protocol (69).

(66) The Economic Appraisal of Investment Projects at the EIB: https://www.eib.org/en/publications/economic-appraisal-of-investment-projects
(67) UNFCCC Kyoto Protocol: https://unfccc.int/kyoto_protocol
(68) Global Warming Potentials/Factors/Values (used for carbon footprinting):
— Table A1.9 in the EIB Carbon Footprint Methodology;
— Greenhouse Gas Protocol: http://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf
— 'GWP 100-year' in Appendix 8.A: Lifetimes, Radiative Efficiencies and Metric Values of the IPCC fifth Assessment Report, WG I, the Physical Science Basis, https://www.ipcc.ch/assessment-report/ar5/
(69) Greenhouse Gas Protocol: https://ghgprotocol.org/

Figure 5

The concept of 'scope' under the carbon footprint methodology ([70])



Source: Figure 1 from the publication 'EIB Project Carbon Footprint Methodologies'.

Table 3

Overview of the three scopes that form part of the carbon footprint methodology and the assessment of indirect emissions for road, rail, and urban public transport infrastructure

Scope	Road, rail and urban public transport infrastructure	All other projects
Scope 1: Direct greenhouse gas emissions physically occur 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.	If applicable: Fuel combustion, process / activity, fugitive emissions	Yes: Fuel combustion, process / activity, fugitive emissions

([70]) Figure 1 from the publication 'EIB Project Carbon Footprint Methodologies', https://www.eib.org/en/about/documents/footprint-methodologies.htm

Scope	Road, rail and urban public transport infrastructure	All other projects
Scope 2: Indirect greenhouse gas emissions associated with energy consumption (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 with energy efficiency measures or switching to consume electricity from renewable sources.	If applicable: Transport (mainly electric rail) infra-structure projects that are operated by the owner of the infrastructure	Yes: Electricity, heating, cooling
Scope 3: Other indirect greenhouse gas emissions that can be considered a consequence of the activities of the project (e.g. emissions from the production or extraction of raw material or feedstock and vehicle emissions from the use of road infrastructure, including emissions from the electricity consumption of trains and electric vehicles).	Yes: Indirect greenhouse gas emissions from vehicles using transport infrastructure including modal shift effects	If applicable: Direct and exclusive upstream or down-stream scope 1 and 2 emissions

The carbon footprint methodology includes the following main steps:

(1) Define project boundary

(2) Define the assessment period

(3) Emission scopes to include

(4) Quantify absolute project emissions (A_b)

(5) Identify and quantify baseline emissions (B_e)

(6) Calculate relative emissions ($R_e = A_b - B_e$)

The project boundary describes what to include in calculating the absolute and relative emissions:

— **Absolute emissions** are based on a project boundary that includes all significant scope 1, scope 2 and scope 3 emissions (as applicable) that occur within the project. For example, the boundary for a stretch of motorway would be the length of motorway set out in the finance contract as the project and the calculation of absolute emissions would cover the greenhouse gas emissions of vehicles using that particular stretch of motorway in a typical year.

— **Relative emissions** are based on a project boundary that adequately covers the 'with project' and 'without project' scenarios. It includes all significant scope 1, scope 2 and scope 3 emissions (as applicable), but may also require a boundary outside the physical limits of the project to represent the baseline. For example, without the motorway, traffic would increase on secondary roads outside the physical limits of the project. The relative emissions calculation will use a boundary that covers the entire region affected by the project.

The absolute (A_b) greenhouse gas emissions are the annual emissions estimated for an average year of operation for the project.

The baseline (B_e) greenhouse gas emissions are the emissions that would be generated under the expected alternative scenario that reasonably represents the emissions that would be generated if the project is not carried out.

The relative (R_e) greenhouse gas emissions represent the difference between the absolute emissions and the baseline emissions.

The absolute and relative emissions should be quantified for a typical year of operation.

The carbon assessment should be included throughout the project development cycle and be used as a tool to rank and select options with a view to promoting low-carbon choices and options as well as the energy efficiency first principle.

The carbon assessment presented in this guidance is therefore a more elaborate tool in support of the low-carbon transition, which goes well beyond the one-off assessment usually accompanying applications to a financial institution for funding.

The project boundary describes what to include in calculating absolute, baseline, and relative emissions.

All relevant information should be included when quantifying a project's greenhouse gas emissions.

Carbon foot printing involves many forms of uncertainty, including uncertainty about the identification of secondary effects, about the baseline scenarios and baseline emission estimates. Therefore, greenhouse gas estimates are by definition approximate.

Uncertainties inherent in greenhouse gas estimates or calculations should be reduced as far as is practical, and estimation methods should avoid bias. Where the level of accuracy is low, the data and assumptions used to quantify greenhouse gas emissions should be conservative.

Therefore, the carbon footprint methodology should be based on conservative assumptions, values and procedures. Conservative values and assumptions are those that are more likely to overestimate absolute emissions and 'positive' relative emissions (net increases), and underestimate 'negative' relative emissions (net reductions). If there are differences in the level of uncertainty or bias between the 'with project' and 'without project' scenarios, particular care may be needed.

3.2.2.2. Greenhouse gas (GHG) emissions assessment

Greenhouse gas emissions should be assessed against this guidance for individual investment projects with significant emissions ([71]). In addition, users are encouraged to check the legislation applicable to his/her investment.

The following table sets out the thresholds as set out for the EIB carbon footprint methodology.

Table 4

Thresholds for the EIB carbon footprint methodology ([72])

— Absolute emissions greater than 20 000 tonnes CO_2e/year (positive or negative)
— Relative emissions greater than 20 000 tonnes CO_2e/year (positive or negative)

Infrastructure projects ([73]) with absolute and/or relative emissions above 20 000 tonnes CO_2e/year (positive or negative) must be subject to both phase 1 (screening) and phase 2 (detailed analysis) of the climate-proofing process for climate change mitigation, as shown in Figure 7.

Research ([74]) (on the project portfolio of the EIB) indicates that the thresholds in Table 4 capture approximately 95 % of the absolute and relative greenhouse gas emissions from projects.

([71]) Due to cumulative effects, some small GHG emissions may exceed the tipping point taking a non-significant impact into the category of significant impact, and would then have to be accounted for.

([72]) EIB Project Carbon Footprint Methodologies for the Assessment of Project GHG Emissions and Emission Variations, July 2020, https://www.eib.org/en/about/cr/footprint-methodologies.htm and https://www.eib.org/attachments/strategies/eib_project_carbon_footprint_methodologies_en.pdf and https://www.eib.org/en/about/documents/footprint-methodologies.htm

([73]) Projects in certain sectors – e.g. in urban transport – are often set within an integrated planning document (e.g. a Sustainable Urban Mobility Plan) aiming at defining a coherent investment programme. Although each individual investment/project included in such investment programmes may not exceed the thresholds, it may be relevant to assess GHG emissions for the whole programme, with the goal to capture the extent of its overall contribution towards GHG mitigation.

([74]) EIB Project Carbon Footprint Methodologies – Methodologies for the Assessment of Project GHG Emissions and Emission Variations, 8 July 2020: https://www.eib.org/en/about/documents/footprint-methodologies.htm

3.2.2.3. Baselines (carbon footprint, cost-benefit analysis)

The baseline for the carbon footprint methodology is often referred to as the 'likely alternative' to the plan/project, and for the cost-benefit analysis as the 'counterfactual baseline scenario'. For certain projects, there may be a difference between these baselines. In such cases, it is important to ensure consistency between the quantification of greenhouse gas emissions and the cost-benefit analysis. This should be adequately described in the cost-benefit analysis (where applicable) and summarised in the climate-proofing documentation.

CBA typically takes the form of a comparison between the 'with project' and 'without project' scenarios. From a climate-proofing (mitigation) perspective, it is important that the baseline project scenario is a credible representation of EU climate policy. This would exclude, for instance, a baseline in which highly-carbon intensive fuels are still in use in 2050. By contrast, it should be compatible with a credible greenhouse gas (GHG) emission reduction pathway in line with the EU's new climate targets for 2030 and climate neutrality by 2050.

3.2.2.4. Shadow cost of carbon

This guidance uses the shadow cost of carbon published by the EIB as the best available evidence ([75]) on the cost of meeting the temperature goal of the Paris Agreement (i.e. the 1,5 °C target). The shadow cost of carbon is measured in real terms and indicated in 2016 prices.

The shadow cost of carbon to be used for infrastructure projects for the period 2021-2027 is given in the table below (see also Table 6 with annual values for the shadow cost of carbon).

Table 5

Shadow cost of carbon for GHG emissions and reductions in EUR/tCO_2e, 2016 prices

Year	2020	2025	2030	2035	2040	2045	2050
EUR/tCO_2e	80	165	250	390	525	660	800

Source: EIB Group Climate Bank Roadmap 2021-2025.

To give an example, consider a project being assessed for financing today. It will take four years to construct, and then operate from 2025 for 20 years – i.e. to 2045. The project plan forecasts emissions for each year of operation. For the first year of operation, emissions are valued at EUR 165 per tonne. The value of emissions estimated to occur in 2030 is EUR 250 per tonne. If the project is estimated to emit in 2045, the emissions are valued at EUR 660 per tonne.

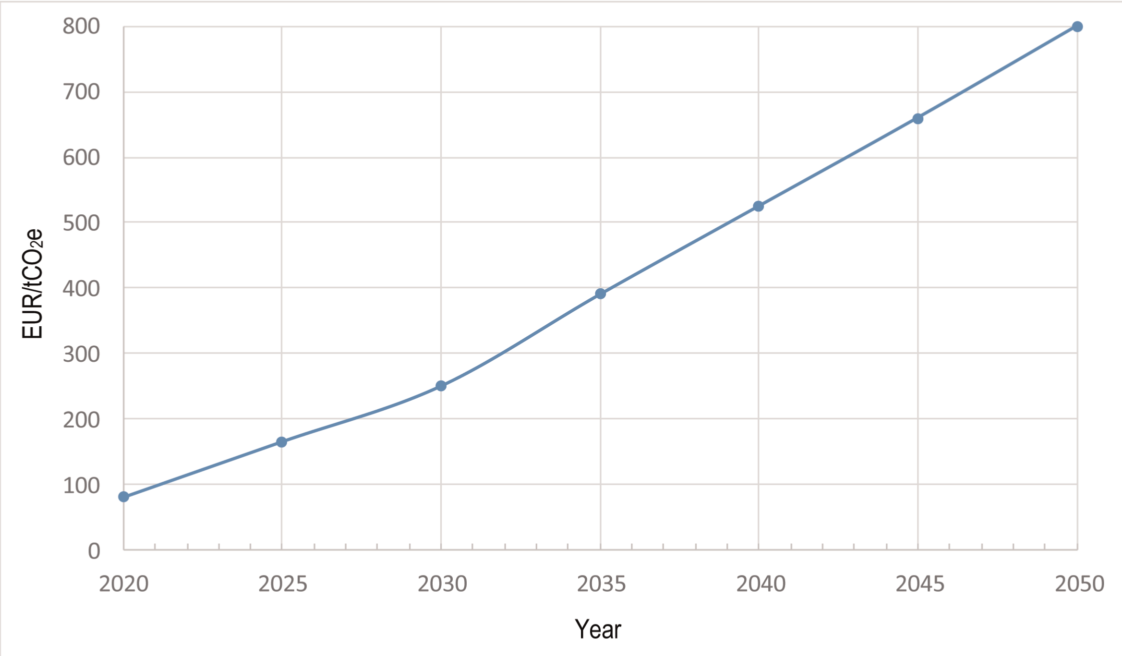
For the avoidance of doubt, these figures are only used to estimate the value of net carbon savings or emissions in a cost-benefit analyses representing society's point of view. Demand forecasts and other related aspects of economic analysis or economic viability of projects are driven by current market price signals, which are influenced by the full range of support policies.

([75]) Further information is available in the EIB Group Climate Bank Roadmap 2021-2025, 14 December 2020, https://www.eib.org/en/publications/the-eib-group-climate-bank-roadmap.htm

The figure below illustrates the shadow cost of carbon for the period 2020-2050:

Figure 6

Shadow cost of carbon for GHG emissions and reductions in EUR/tCO_2e, 2016-prices



Source: EIB Group Climate Bank Roadmap 2021-2025.

Table 6 below provides the shadow cost of carbon for each year over the period 2020-2050. The values in Table 6 are calculated on the basis of the values in Table 5.

Table 6

Shadow cost of carbon per year in EUR/tCO_2e, 2016-prices

Year	EUR/tCO_2e	Year	EUR/tCO_2e	Year	EUR/tCO_2e	Year	EUR/tCO_2e
2020	80	2030	250	2040	525	2050	800
2021	97	2031	278	2041	552		
2022	114	2032	306	2042	579		
2023	131	2033	334	2043	606		
2024	148	2034	362	2044	633		
2025	165	2035	390	2045	660		
2026	182	2036	417	2046	688		
2027	199	2037	444	2047	716		
2028	216	2038	471	2048	744		
2029	233	2039	498	2049	772		

The shadow cost of carbon is a minimum value to be used to monetise greenhouse gas emissions and reductions. Higher values for the shadow cost of carbon can be used for the purpose of climate proofing and cost-benefit analysis, for instance when higher values are used in the Member State or by the lending institution concerned or where there are other requirements. The shadow cost of carbon may also be adjusted when more information becomes available.

The CBA will usually include discounting of monetised GHG emissions. Reference is made to the Commission Guide ([76]), which explains the **social discount rate**. The guide recommends that for the social discount rate 5 % is used for major projects in Cohesion countries and 3 % for the other Member States ([77]). Whereas the guide refers to the period 2014-2020, it remains a useful reference for the period 2021-2027. The climate-proofing documentation should describe the social discount rate used.

3.2.2.5. Verify compatibility with a credible GHG pathway to 2030 and 2050

The project promoter should verify the project's compatibility with a credible pathway in line with ([78]) the EU's 2030 and 2050 GHG emission reduction targets and with the goals of the Paris Agreement and the European Climate Law (see chapter 3.1). As part of this process, for infrastructure with a lifespan beyond 2050, the project promoter should also verify the project's compatibility with for instance operation, maintenance and final decommissioning under conditions of climate neutrality. This may entail factoring in circular economy considerations early in the project development cycle and the transition to renewable energy sources.

In addition, Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (Governance Regulation) provides a **governance mechanism** based on long-term strategies, integrated national energy and climate plans (NECPs) covering ten-year periods starting from 2021 to 2030, corresponding integrated national energy and climate progress reports by the Member States and integrated monitoring by the Commission.

The NECPs set out the national objectives, targets and contributions for the five dimensions of the Energy Union, including the dimension 'decarbonisation', which refers to the 'long-term Union greenhouse gas emissions commitments consistent with the Paris Agreement, other objectives and targets, including sector targets and adaptation goals'.

The NECPs are an additional and relevant reference for verifying compatibility with a credible GHG pathway (when the NECPs are amended and assessed in 2023 to include the EU's new targets for 2030 and climate neutrality by 2050 as per the European Climate Law).

The project promoter should demonstrate that the project's greenhouse gas emissions will be limited in a way that is consistent with the EU's overall objectives for 2030 and 2050, and any more ambitious targets for the sector to which the project belongs.

3.3. Adaptation to climate change (climate resilience)

Infrastructure ([79]) is usually long-lasting and may be exposed for many years to a changing climate with increasingly adverse and frequent extreme weather and climate impacts.

Under the supervision and control of the concerned public authorities, the climate vulnerability and risk assessment helps identify the significant climate risks. It is the basis for identifying, appraising and implementing targeted adaptation measures. This will help reduce the **residual risk** to an acceptable level.

The project promoter should provide to the public authorities all required information to verify that the acceptable level of residual climate risks has been set with due regard to all legal, technical or other requirements.

([76]) Guide to Cost-Benefit Analysis of Investment Projects – Economic appraisal tool for Cohesion Policy 2014-2020, ISBN 978-92-79-34796-2, European Commission, https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

([77]) For the 2014-2020 period, Commission Implementing Regulation (EU) 2015/207 stipulates the applicable *social discount rates*, which remain a useful reference for the period 2021-2027.

([78]) See e.g. the EIB Group Climate Bank Roadmap and the Institut Louis Bachelier 'The Alignment Cookbook, A technical review of methodologies assessing a portfolio's alignment with low-carbon trajectories or temperature goal'.

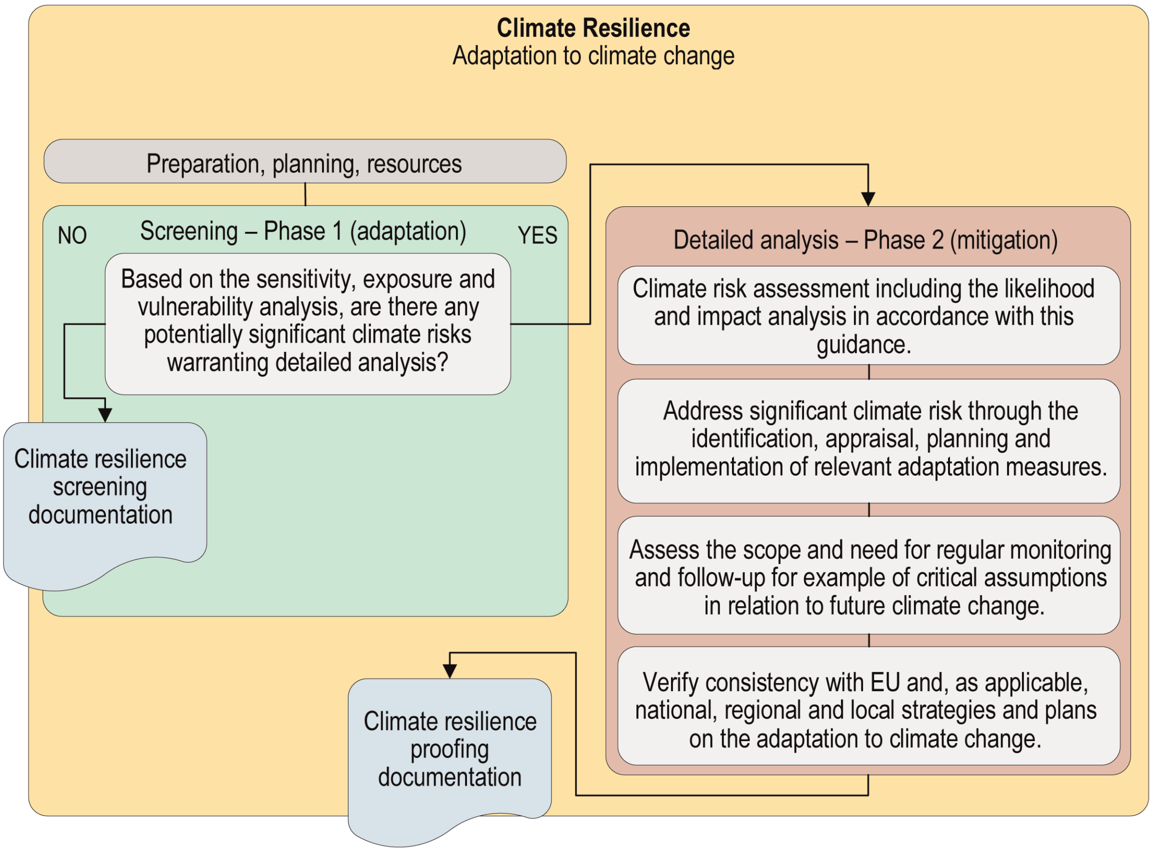
([79]) Infrastructure includes, in addition to traditional 'grey' infrastructure, also 'green' infrastructure and mixed forms of 'grey/green infrastructure'. Commission Communication COM/2013/249 defines green infrastructure as 'a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, green infrastructure is present in rural and urban settings'.

As explained in chapter 4 and Annex C, it is recommended to integrate the climate vulnerability and risk assessment from the beginning of the project development process ([80]), including EIA, because this will generally provide the broadest range of possibilities for selecting the optimal adaptation options.

For example, the project location, which is often decided at an early stage, can be decisive for the climate change vulnerability and risks assessment. There will usually be more constraints when the climate vulnerability and risk assessment is initiated later in the project development, which could lead to suboptimal solutions being chosen.

Figure 7

Overview of the climate adaptation-related process for climate proofing



Climate change adaptation measures for infrastructure projects centre around ensuring a suitable level of resilience to the impacts of climate change, which includes acute events such as more intense floods, cloudbursts, droughts, heatwaves, wildfires, storms and landslides and hurricanes, as well as chronic events such as projected sea-level rise and changes in average precipitation, soil moisture and air humidity.

In addition to factoring in the climate resilience of the project, there must be measures to ensure that the project does not increase the vulnerability of neighbouring economic and social structures. This could happen, for instance, if a project includes an embankment that could increase flood risk in the vicinity.

([80]) See e.g. the EUFIWACC note 'Integrating Climate Change Information and Adaptation in Project Development' Guidance for project managers on making infrastructure climate resilient: https://ec.europa.eu/clima/sites/clima/files/docs/integrating_climate_change_en.pdf

Figure 8

Indicative overview of the climate vulnerability and risk assessment, and the identification, appraisal and planning/integration of relevant adaptation measures

Phase 1 (screening)

SENSITIVITY ANALYSIS

Indicative sensitivity table: *(example)*		Flood	Heat	…	Drought
		Climate variables and hazards			
Themes	On-site assets, …	High	Low	…	Low
	Inputs (water, …)	Medium	Medium	…	Low
	Outputs (products, …)	High	Low	…	Low
	Transport links	Medium	Low	…	Low
	Highest score 4 themes	High	Medium	…	Low

The output of the sensitivity analysis may be summarised in a table with the sensitivity ranking of the relevant climate variables and hazards for a given project type, irrespective of the location, including critical parameters, and divided in e.g. the four themes.

EXPOSURE ANALYSIS

Indicative exposure table: *(example)*	Flood	Heat	…	Drought
	Climate variables and hazards			
Current climate	Medium	Low	…	Low
Future climate	High	Medium	…	Low
Highest score, current+future	High	Medium	…	Low

The output of the exposure analysis may be summarised in a table with the exposure ranking of the relevant climate variables and hazards for the selected location, irrespective of the project type, and divided in current and future climate. For both the sensitivity and exposure analysis, the scoring system should be carefully defined and explained, and the given scores should be justified.

VULNERABILITY ANALYSIS

Indicative vulnerability table: *(example)*		Exposure (current + future climate): High	Medium	Low
Sensitivity (highest across the four themes)	High	Flood		
	Medium		Heat	
	Low			Drought

Legend: Vulnerability level
High
Medium
Low

The vulnerability analysis may be summarised in a table for the given specific project type at the selected location. It combines the sensitivity and the exposure analysis. The most relevant climate variables and hazards are those with a high or medium vulnerability level, which are then taken forward to the steps below. The vulnerability levels should be carefully defined and explained, and the given scores justified.

Phase 2 (subject to the outcome of phase 1)

LIKELIHOOD ANALYSIS

Indicative scale for assessing the likelihood of a climate hazard (example):

Term	Qualitative	Quantitative (*)
Rare	Highly unlikely to occur	5 %
Unlikely	Unlikely to occur	20 %
Moderate	As likely to occur as not	50 %
Likely	Likely to occur	80 %
Almost certain	Very likely to occur	95 %

The output of the likelihood analysis may be summarised in a qualitative or quantitative estimation of the likelihood for each of the essential climate variables and hazards. (*) Defining the scales requires careful analysis for various reasons including e.g. that the likelihood and impacts of the essential climate hazards may change significantly during the lifespan of the infrastructure project among other due to climate change. Various scales are referred to in the literature.

IMPACT ANALYSIS

Indicative scale for assessing the potential impact of a climate hazard (example) — *Impacts:* / *Risk areas:*	Insignificant	Minor	Moderate	Major	Catastrophic
Asset damage, engineering, operational					
Safety and health					
Environment, cultural heritage					
Social					
Financial					
Reputation					
Any other relevant risk area(s)					
Overall for the above-listed risk areas					

The impact analysis provides an expert assessment of the potential impact for each of the essential climate variables and hazards.

RISK ASSESSMENT

Indicative risk table: *(example)*		Overall impact of the essential climate variables and hazards (example): Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood	Rare					
	Unlikely		Drought			
	Moderate		Heat	Flood		
	Likely					
	Almost certain					

Legend: Risk level
Low
Medium
High
Extreme

The output of the risk analysis may be summarised in a table combining likelihood and impact of the essential climate variables and hazards. Detailed explanations are required to qualify and substantiate the assessment conclusions. The risk levels should be explained and justified.

IDENTIFYING ADAPTATION OPTIONS

Option identification process:

— Identify options responding to the risks (use e.g. expert workshops, meetings, evaluations, …)

— Adaptation may involve a mix of responses, e.g.:

— training, capacity building, monitoring, …

— use of best practices, standards, …

— nature-based solutions, ...

— engineering solutions, technical design, …

— risk management, insurance, ...

APPRAISING ADAPTATION OPTIONS

The appraisal of adaptation options should give due regard to the specific circumstances and availability of data. In some cases a quick expert judgement may suffice whereas other cases may warrant a detailed cost-benefit analysis. It may be relevant to consider the robustness of various adaptation options vis-à-vis climate change uncertainties.

ADAPTATION PLANNING

Integrate relevant climate resilience measures into the technical project design and management options. Develop implementation plan, finance plan, plan for monitoring and response, plan for regular review of the assumptions and the climate vulnerability and risk assessment, and so on. The vulnerability and risk assessment and adaptation planning is aiming to reduce the remaining climate risks to an acceptable level.

This guidance permits the use of alternative approaches to the described climate vulnerability and risk assessment that are recent and internationally recognised approaches and methodological frameworks, for instance the approach applied by the IPCC in the context of the 6th Assessment Report (AR6) ([81]). The aim remains to identify significant climate risks as the basis for identifying, appraising and implementing targeted adaptation measures.

3.3.1. *Screening – Phase 1 (adaptation)*

Analysing the vulnerability of a project to climate change is an important step in identifying the right adaptation measures to take. The analysis is broken down into three steps, comprising of a sensitivity analysis, an assessment of current and future exposure, and then a combination of the two for the vulnerability assessment.

Technical specialists typically specify clearly the level and resolution of data required to analyse the issues sufficiently.

The aim of the **vulnerability analysis** ([82]) is to identify the relevant climate hazards ([83]) for the given specific project type at the planned location. The vulnerability of a project is a combination of two aspects: how sensitive the project's components are to climate hazards in general (sensitivity) and the probability of these hazards occurring at the project location now and in the future (exposure). These two aspects can be assessed separately (as described below) or together.

Figure 9

Overview of the screening phase with the vulnerability analysis

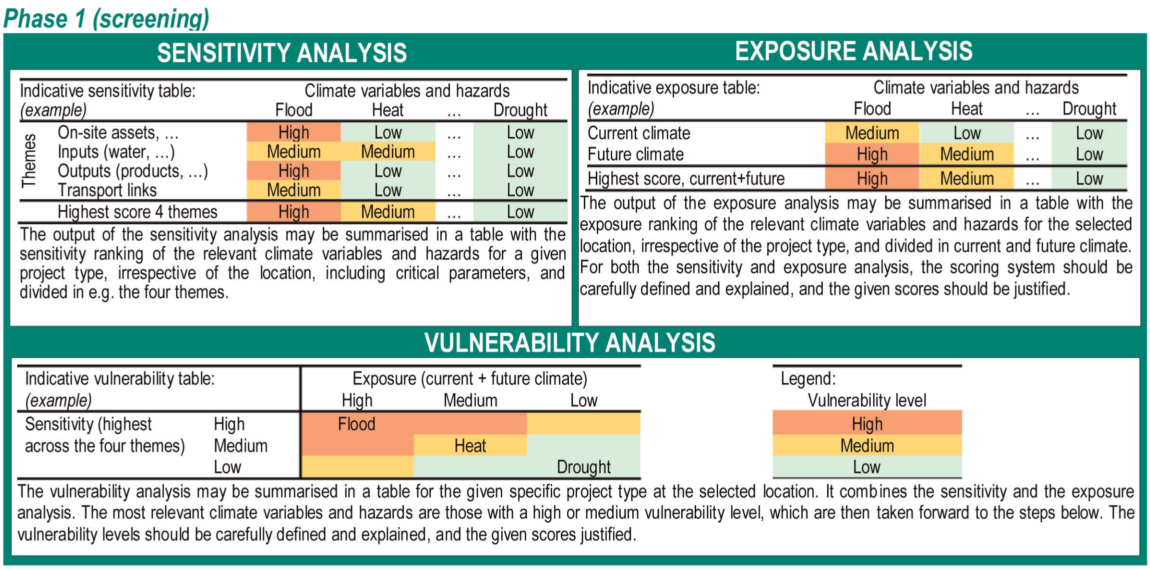


Figure 9 provides an overview of the sensitivity, exposure and vulnerability analysis, which constitute phase 1 (screening) of the full process illustrated in Figure 8.

An initial **screening** may focus on climate hazards ranked as 'high' in the sensitivity analysis and/or the exposure analysis, as the input to the vulnerability assessment.

([81]) IPCC AR6: https://www.ipcc.ch/assessment-report/ar6/

([82]) There are multiple definitions of vulnerability and risk. For example, see IPCC AR4 (2007) on vulnerability and IPCC SREX (2012) and IPCC AR5 (2014) on risk (as a function of likelihood and the consequences of the hazard), http://ipcc.ch/

([83]) For a structured overview of climate change indicators and climate change impact indicators (hazards) see e.g. EEA Report 'Climate change, impacts and vulnerability in Europe 2016' (https://www.eea.europa.eu/publications/climate-change-impacts-and-vulnerability-2016) and EEA Report 'Climate change adaptation and disaster risk reduction in Europe' (https://www.eea.europa.eu/publications/climate-change-adaptation-and-disaster) and ETC CCA Technical Paper 'Extreme weather and climate in Europe' (2015) (https://www.eionet.europa.eu/etcs/etc-cca/products/etc-cca-reports/extreme-20weather-20and-20climate-20in-20europe) as well as EEA Report 'State of the European Environment' (2020) (https://www.eea.europa.eu/soer).

3.3.1.1. Sensitivity

The aim of the **sensitivity analysis** is to identify which climate hazards are relevant to the specific type of project, irrespective of its location. For example, sea-level rise is likely to be a significant hazard for most seaport projects, irrespective of their location.

The sensitivity analysis should cover the project in a comprehensive manner, looking at the various components of the project and how it operates within the wider network or system, for example by distinguishing between the **four themes**:

— on-site assets and processes,

— inputs such as water and energy,

— outputs such as products and services,

— access and transport links, even if outside the direct control of the project.

Assigning **sensitivity scores** to project types is best carried out by technical experts, i.e. engineers and other specialists with good knowledge of the project.

In addition, the project design may critically depend on specific (engineering or other) parameters. For example, the design of a bridge could be critically dependent on the water level in the river it crosses; or the uninterrupted operation of a thermal power plant could be critically dependent on sufficient cooling water and the minimum water level and maximum water temperature in the adjacent river. It may be important to include such **critical design parameters** in the climate sensitivity analysis.

Figure 10 provides an overview of the sensitivity analysis, which is part of phase 1 (screening) as illustrated in Figure 7.

Figure 10

Overview of the sensitivity analysis

SENSITIVITY ANALYSIS

Indicative sensitivity table: *(example)*		Climate variables and hazards Flood	Heat	…	Drought
Themes	On-site assets, …	High	Low	…	Low
	Inputs (water, …)	Medium	Medium	…	Low
	Outputs (products, …)	High	Low	…	Low
	Transport links	Medium	Low	…	Low
	Highest score 4 themes	High	Medium	…	Low

The output of the sensitivity analysis may be summarised in a table with the sensitivity ranking of the relevant climate variables and hazards for a given project type, irrespective of the location, including critical parameters, and divided in e.g. the four themes.

A score of 'high', 'medium' or 'low' should be given for each theme and climate hazard:

— **high sensitivity**: the climate hazard may have a significant impact on assets and processes, inputs, outputs and transport links;

— **medium sensitivity**: the climate hazard may have a slight impact on assets and processes, inputs, outputs and transport links;

— **low sensitivity**: the climate hazard has no (or an insignificant) impact.

3.3.1.2. Exposure

The aim of the **exposure analysis** is to identify which hazards are relevant to the planned project location, irrespective of the project type. For example, flooding could be a significant climate hazard for a location next to a river in a floodplain.

The exposure analysis therefore focuses on the location whereas the sensitivity analysis focuses on the type of project.

The exposure analysis can be split in two parts: exposure to the *current climate* and exposure to the *future climate*. Available historic and current data for the project location (or project alternative locations) should be used to assess current and past climate exposure. Climate model projections can be used to understand how the level of exposure may change in the future. Particular attention should be given to changes in the frequency and intensity of extreme weather events.

Figure 11 provides an overview of the exposure analysis, which is part of the phase 1 (screening) as illustrated in Figure 7.

Figure 11

Overview of the exposure analysis

EXPOSURE ANALYSIS

Indicative exposure table: *(example)*	Climate variables and hazards			
	Flood	Heat	…	Drought
Current climate	Medium	Low	…	Low
Future climate	High	Medium	…	Low
Highest score, current+future	High	Medium	…	Low

The output of the exposure analysis may be summarised in a table with the exposure ranking of the relevant climate variables and hazards for the selected location, irrespective of the project type, and divided in current and future climate. For both the sensitivity and exposure analysis, the scoring system should be carefully defined and explained, and the given scores should be justified.

Different geographical locations can be exposed to different climate hazards. It is useful to understand how the exposure of different geographic areas in Europe will change as a result of changing climate hazards, as illustrated in the list below.

For instance:

— areas where people depend on natural resources for income/livelihood

— coastal areas, islands and offshore locations are particularly exposed to increasing storm surge heights, wave heights, coastal flooding and erosion;

— areas with low and falling seasonal precipitation are often more exposed to increasing risks of drought, subsidence and wildfire;

— areas with high and increasing temperature are often more at risk of heatwaves;

— areas with increased seasonal precipitation (possibly combined with more rapid snowmelt and cloudbursts) are often more exposed to flash floods and erosion;

— areas containing both tangible and intangible cultural heritage.

It is important to understand what the exposed areas are, and how they and the people living there will be affected, as often these locations will see the greatest benefits from proactive adaptation.

The more local and specific the data is, the more accurate and relevant the assessment will be (see e.g. the list of data sources for the future climate in section 3.1).

Some hazards might require site-specific data and studies, for instance flash floods.

3.3.1.3. Vulnerability

The **vulnerability analysis** combines the outcome of the analysis of sensitivity and the analysis of exposure (when separately assessed).

Figure 12 provides an overview of the vulnerability analysis, which brings together the findings from the sensitivity and exposure analyses (see Figure 7).

Figure 12

Overview of the vulnerability analysis

VULNERABILITY ANALYSIS

Indicative vulnerability table: *(example)*		Exposure (current + future climate) High	Medium	Low
Sensitivity	High	Flood		
(highest across	Medium		Heat	
the four themes)	Low			Drought

Legend: Vulnerability level
High
Medium
Low

The vulnerability analysis may be summarised in a table for the given specific project type at the selected location. It combines the sensitivity and the exposure analysis. The most relevant climate variables and hazards are those with a high or medium vulnerability level, which are then taken forward to the steps below. The vulnerability levels should be carefully defined and explained, and the given scores justified.

The **vulnerability assessment** aims to identify potential significant hazards and related risk and it forms the basis for the decision to continue to the risk assessment phase. Typically it unveils the most relevant hazards for the risk assessment (these can be considered as the vulnerabilities ranked as 'high' and possibly 'medium', depending on the scale). If the vulnerability assessment concludes that all vulnerabilities are ranked as low or insignificant in a justified manner, no further (climate) risk assessment might be needed (this concludes the screening and phase 1). Nonetheless, the decision on vulnerabilities to take forward to a detailed risk analysis will depend on the justified assessment of the project promoter and the climate assessment team.

The location of an infrastructure, together with the adaptive capacity of local businesses, governments and communities, may influence an asset's climate sensitivity and vulnerability. Vulnerability to multiple climate hazards can also be strongly sector specific and closely linked to the technology used for construction and operation.

3.3.2. *Detailed analysis – Phase 2 (adaptation)*

3.3.2.1. Impacts, likelihood, and climate risks

The risk assessment provides a structured method of analysing climate hazards and their impacts to provide information for decision making.

This process works by assessing the likelihoods and severities of the impacts associated with the hazards identified in the vulnerability assessment (or initial screening of relevant hazards), and assessing the significance of the risk to the success of the project.

This should be part of the overall project risk assessment logic that permeates the whole project development process, so that risk can be addressed holistically and not as a stand-alone assessment.

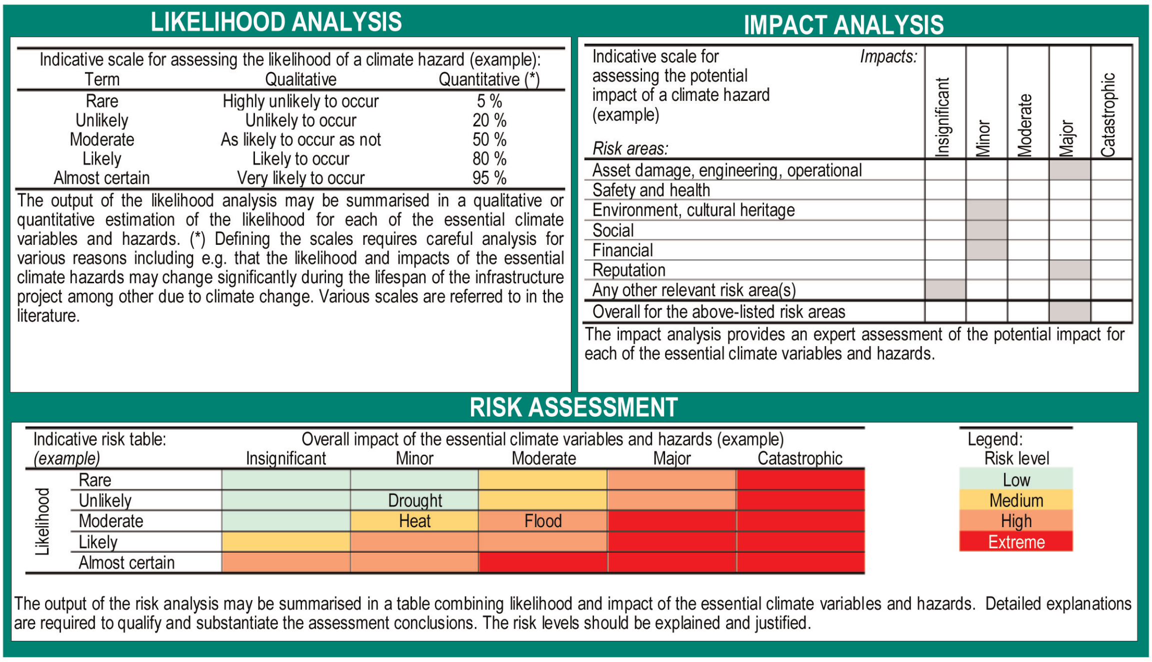
It is recommended to start the risk assessment process at the earliest opportunity in project planning, because risks identified early can usually be managed and/or avoided more easily and cost effectively.

The aim is to quantify the significance of the risks to the project in the current and future climate conditions.

Figure 13 provides an overview of the likelihood analysis, impact analysis, and risk assessment, which form the basis for identifying, appraising, selecting and implementing adaptation measures. The complete process is illustrated in Figure 8.

Figure 13

Overview of the climate risk assessment in phase 2



Compared to the vulnerability analysis, the risk assessment more readily facilitates identification of longer *cause-effect* chains linking climate hazards to how the project performs across several dimensions (technical, environmental, social/inclusion/accessibility and financial, etc.) and looks at interactions between factors. Hence, a risk assessment may identify issues that are not picked up by the vulnerability assessment.

ISO 14091 ([84]) uses the concept of 'impact chains', which is an effective tool that helps to better understand, visualise, systemise and prioritise the factors that drive risk in the system. Impact chains serve as an analytical starting point for the overall risk assessment. They specify which hazards potentially cause direct and indirect climate change impacts and therefore form the basic structure for the risk assessment. They serve as important communication tools to discuss what is to be analysed and which climate and socioeconomic, biophysical or other parameters should be taken into account. In this way, they are useful to identify the targeted adaptation actions to take.

The *risk assessment may include* expert judgement by the assessment team and a review of related literature/historical data. It often involves running a *risk identification workshop* ([85]) to identify hazards, consequences and key climate-related risks, and to agree on the extra analysis needed to gauge the significance of risks.

The *detailed risk assessment* typically takes the form of quantitative or semi-quantitative assessments, often involving numerical modelling. These are best performed during smaller meetings or expert analyses.

3.3.2.2. Likelihood

This part of the risk assessment looks at how likely the identified climate hazards are to occur within a given timescale, e.g. the lifetime of the project.

Figure 14 provides an illustrative overview of the likelihood analysis, part of phase 2 as illustrated in Figure 13. Alternative scales could also be used to assess likelihood, for instance the scale used by IPCC ([86]).

([84]) ISO 14091 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment, https://www.iso.org/standard/68508.html

([85]) Risk Identification Workshop: for more details, see e.g. Section 2.3.4 of the *Non-paper – Guidelines for Project Managers: Making vulnerable investments climate resilient* (https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/non_paper_guidelines_project_managers_en.pdf).

([86]) IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, Chapter 1, p. 75, https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/05_SROCC_Ch01_FINAL.pdf

Figure 14

Overview of the likelihood analysis

LIKELIHOOD ANALYSIS

Indicative scale for assessing the likelihood of a climate hazard (example):

Term	Qualitative	Quantitative (*)
Rare	Highly unlikely to occur	5 %
Unlikely	Unlikely to occur	20 %
Moderate	As likely to occur as not	50 %
Likely	Likely to occur	80 %
Almost certain	Very likely to occur	95 %

The output of the likelihood analysis may be summarised in a qualitative or quantitative estimation of the likelihood for each of the essential climate variables and hazards. (*) Defining the scales requires careful analysis for various reasons including that the likelihood and impacts of the essential climate hazards may change significantly during the lifespan of the infrastructure project among other due to climate change. Various scales are referred to in the literature.

For some climate risks there can be considerable uncertainty about the likelihood of occurrence. It may require using expert judgement, based on currently best available information and data from registers, statistics, simulations, and current/past knowledge drawn from consultations with stakeholders. This should also include references to national, regional and/or local climate data and projections. Additional consideration should be given to how the likelihood of the climate risks may evolve over time. For instance, climate change-driven increases in the average temperature may significantly raise the likelihood of certain climate risks over the lifespan of a project.

3.3.2.3. Impact

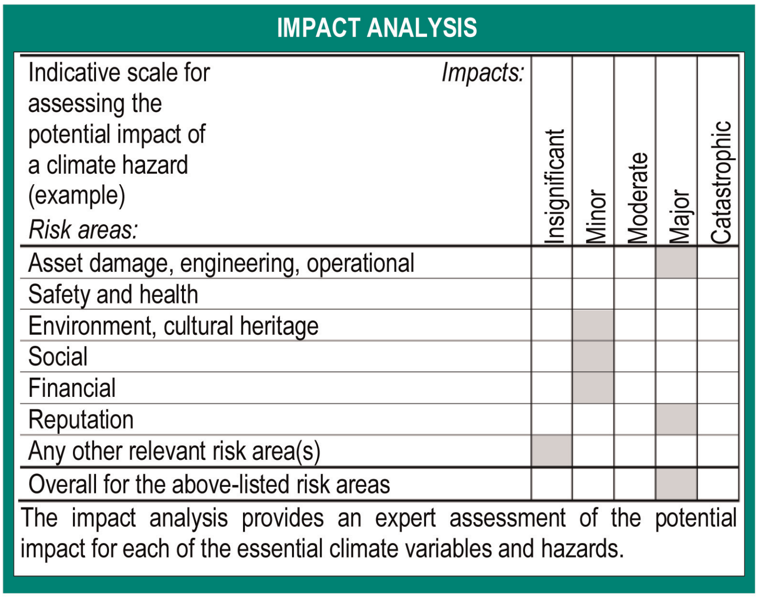
This part of the risk assessment looks at the consequences if the climate hazard identified occurs. This should be assessed on a scale of impact per hazard. This is also referred to as severity or magnitude.

The consequences generally relate to physical assets and operations, health and safety, environmental impacts, social impacts, impact on accessibility for persons with disabilities, financial implications, and reputational risk. The assessment may need to cover the adaptive capacity of the system in which the project operates. It may also be relevant to consider how fundamental this infrastructure is to the wider network or system (i.e. criticality) and whether it may lead to additional wider impacts and cascading effects.

Figure 15 provides an overview of the impact analysis, part of phase 2 as illustrated in Figure 13.

Figure 15

Overview of the impact analysis



Typically, infrastructure projects have long lifespans, often in the range of 30 to 80 years. Temporary and emergency works, for example, can have shorter lifespans however. Not all components of an infrastructure project need to be assessed for the same (long) lifespan. For example, railway tracks will be replaced (as part of regular maintenance) more often than the railway embankment. Infrastructure projects with a lifespan of under five years will often not require the use of climate projections, but should still be resilient to the current climate.

For a range of climate hazards it can be expected ([87]) that the likelihood and impacts will change during the lifespan of the project, as global warming and climate change unfolds. The projected changes in likelihood and impacts should be integrated in the risk assessment. For this purpose, it can be useful to divide the lifespan into a sequence of shorter periods (e.g. 10-20 years). Particular attention should be given to weather extremes and cascade effects.

As illustrated below, the risk assessment should cover the risk areas relevant to each climate change scenario, and several levels of consequences:

Table 7

Magnitude of consequence across various risk areas (*) ([88])

Risk areas	Magnitude of consequence				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophe
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

([87]) IPCC 5th Assessment Report, WG I, WG II: https://www.ipcc.ch/report/ar5/

([88]) Table 10 from the Non-paper: Guidelines for Project Managers – Making vulnerable investments climate resilient (https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/non_paper_guidelines_project_managers_en.pdf).

Risk areas	Magnitude of consequence				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophe
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 (1). 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

(1) 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.

(*) The ratings and values suggested here are illustrative. The project promoter and climate-proofing manager may choose to modify them.

(**) 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).

3.3.2.4. Risks

Having assessed the likelihood and the impact of each hazard, the significance level of each potential risk can be estimated by combining the two factors. The risks can be plotted on a risk matrix (as part of the overall project risk assessment) to identify the most significant potential risks and those where adaptation measures need to be taken.

Figure 16

Overview of the risk assessment

RISK ASSESSMENT

Indicative risk table: *(example)*

Overall impact of the essential climate variables and hazards (example)

Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Rare					
Unlikely		Drought			
Moderate		Heat	Flood		
Likely					
Almost certain					

Legend:

Risk level
Low
Medium
High
Extreme

The output of the risk analysis may be summarised in a table combining likelihood and impact of the essential climate variables and hazards. Detailed explanations are required to qualify and substantiate the assessment conclusions. The risk levels should be explained and justified.

Figure 16 provides an overview of the risk assessment, which brings together the findings of the likelihood and impact analysis (see Figure 13).

Judging what is an acceptable level of risk, what is significant and what not is the responsibility of the project promoter and expert team that carries out the assessment, specific to the circumstances of the project.

Whatever categorisation is used must be defendable, clearly specified and described in a clear and logical manner, and coherently integrated into the overall project risk assessment. For example, it may be considered that a catastrophic event, even if it is rare or unlikely, still represents an extreme risk to the project as the consequences are so severe.

3.3.2.5. Adaptation measures

If the risk assessment concludes that there are significant climate risks to the project, the risks must be managed and reduced to an acceptable level.

For each significant risk identified, targeted adaptation measures should be assessed. The preferred measures should then be integrated into the project design and/or its operation to improve climate resilience ([89]).

Figure 17 provides an overview of the process to identify, appraise/select, and implement/integrate/plan adaptation options, building on the preceding steps shown in Figure 8.

([89]) For further details on the approach to adaptation options, appraisal and integration of adaptation measures into the project, see e.g. Sections 2.3.5 to 2.3.7 of the *Non-paper – Guidelines for Project Managers: Making vulnerable investments climate resilient* (https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/non_paper_guidelines_project_managers_en.pdf).

Figure 17

Overview of the process to identify, appraise and plan/integrate adaptation options

IDENTIFYING ADAPTATION OPTIONS	APPRAISING ADAPTATION OPTIONS	ADAPTATION PLANNING
Option identification process: — Identify options responding to the risks (use e.g. expert workshops, meetings, and evaluations) Adaptation may involve a mix of responses, e.g.: — training, capacity building, monitoring — use of best practices, standards — nature-based solutions — engineering solutions, technical design — risk management, insurance	The appraisal of adaptation options should give due regard to the specific circumstances and availability of data. In some cases a quick expert judgement may suffice whereas other cases may warrant a detailed cost-benefit analysis. It may be relevant to consider the robustness of various adaptation options vis-à-vis climate change uncertainties.	Integrate relevant climate resilience measures into the technical project design and management options. Develop implementation plan, finance plan, plan for monitoring and response, plan for regular review of the assumptions and the climate vulnerability and risk assessment, and so on. The vulnerability and risk assessment and adaptation planning is aiming to reduce the remaining climate risks to an acceptable level.

There is an increasing volume of literature and experience on adaptation options, appraisal and planning ([90]), as well as related resources ([91]) in the Member States.

More information on adaptation planning in the Member States is available on Climate-ADAPT ([92]).

Adaptation will often involve adopting a mix of structural and non-structural measures. Structural measures include modifying the design or specification of physical assets and infrastructure, or adopting alternative or improved solutions. Non-structural measures include land-use planning, improved monitoring or emergency response programmes, staff training and skills transfer activities, development of strategic or corporate climate risk assessment frameworks, financial solutions such as insurance against supply chain failure or alternative services.

Different adaptation options should be assessed to find the right measure or mix of measures that can be implemented to reduce the risk to an acceptable level.

Settling on the 'acceptable level' of risk depends on the expert team carrying out the assessment and the risk that the project promoter is prepared to accept. For example, there may be aspects of the project considered to be non-essential infrastructure where the costs of adaptation measures outweigh the benefits of avoiding the risks and the best option could be to allow the non-essential infrastructure to fail under certain circumstances.

Given the considerable uncertainty in future predictions for climate change hazards, the key is often to identify adaptation solutions (where possible) that will perform well in the current situation and in all future scenarios. Such measures are often termed low or no-regret options.

([90]) See e.g. Climate-ADAPT (http://climate-adapt.eea.europa.eu/) concerning adaptation:
— options: http://climate-adapt.eea.europa.eu/adaptation-measures;
— case study search tool: https://climate-adapt.eea.europa.eu/knowledge/tools/case-studies-climate-adapt;
and e.g.
— EEA Report 8/2014 'Adaptation of transport to climate change in Europe' (http://www.eea.europa.eu/publications/adaptation-of-transport-to-climate)
— EEA Report 1/2019 'Adaptation challenges and opportunities for the European energy system – Building a climate-resilient low-carbon energy system': (https://www.eea.europa.eu/publications/adaptation-in-energy-system).

([91]) 2018 Study on 'Climate change adaptation of major infrastructure projects' undertaken for DG REGIO: https://ec.europa.eu/regional_policy/en/information/publications/studies/2018/climate-change-adaptation-of-major-infrastructure-projects

([92]) Climate-ADAPT, Country Profiles: https://climate-adapt.eea.europa.eu/countries-regions/countries

It may also be appropriate to consider flexible/adaptive measures such as monitoring the situation and only implementing physical measures when the situation reaches a critical threshold (or considering adaptation pathways ([93])). This option may be particularly useful when climate predictions show high levels of uncertainty. It is appropriate as long as the thresholds or trigger points are clearly set out and the future proposed measures can be proven to address the risks sufficiently. Monitoring should be integrated in the infrastructure management processes.

Assessing the adaptation options can be quantitative or qualitative, depending on the availability of information and other factors. In some circumstances, such as relatively low-value infrastructure with limited climate risks, it may be sufficient with a rapid expert assessment. In other circumstances, in particular for options with significant socioeconomic impact, it will be important to use more comprehensive information, for example on the climate hazard's probability distribution, the economic value of the associated (avoided) damages and the residual risks.

The next step is to integrate the appraised adaptation options into the project, at the right development stage, including investment and finance planning, monitoring and response planning, defining roles and responsibilities, organisational arrangements, training, engineering design and to ensure that the options comply with national guidelines and applicable law.

In addition, as good management practice, ongoing monitoring should be carried out throughout the operational lifetime of the project in order to: (i) check the accuracy of the assessment and feed into future assessments and projects; and (ii) identify whether specific trigger points or thresholds are likely to be reached, indicating the need for additional adaptation measures (i.e. staged adaptation).

The adaptation pillar of climate proofing should include:

— verifying the infrastructure project's consistency with EU and, as applicable, national, regional and local strategies and plans on adaptation to climate change, and other relevant strategic and planning documents; and

— assessing the scope and need for regular monitoring and follow-up, for example of critical assumptions in relation to future climate change.

Both aspects should be properly integrated into the project development cycle.

4. CLIMATE PROOFING AND PROJECT CYCLE MANAGEMENT (PCM)

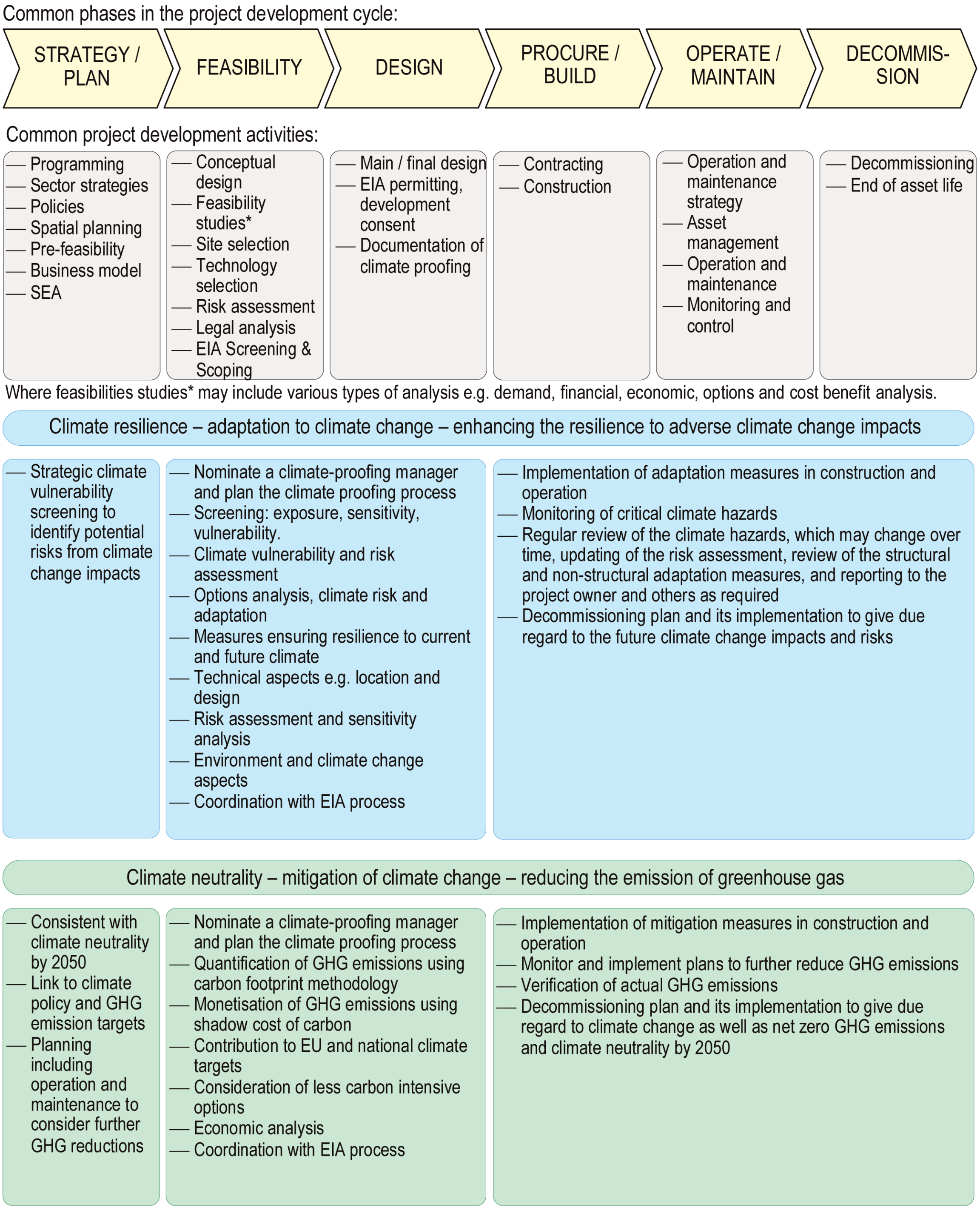
Project cycle management (PCM) is the process of planning, organising, coordinating, and verifying a project effectively and efficiently throughout its phases, from planning, implementation, operation to decommissioning.

Climate proofing should be integrated into the project cycle management from the outset, as illustrated in Figure 18 and explained in detail in Annex C.

([93]) An approach designed to schedule adaptation decision-making: it identifies the decisions that need to be taken now and those that may be taken in future, and to avoid potential maladaptation.

Figure 18

Overview of climate proofing and project cycle management (PCM)

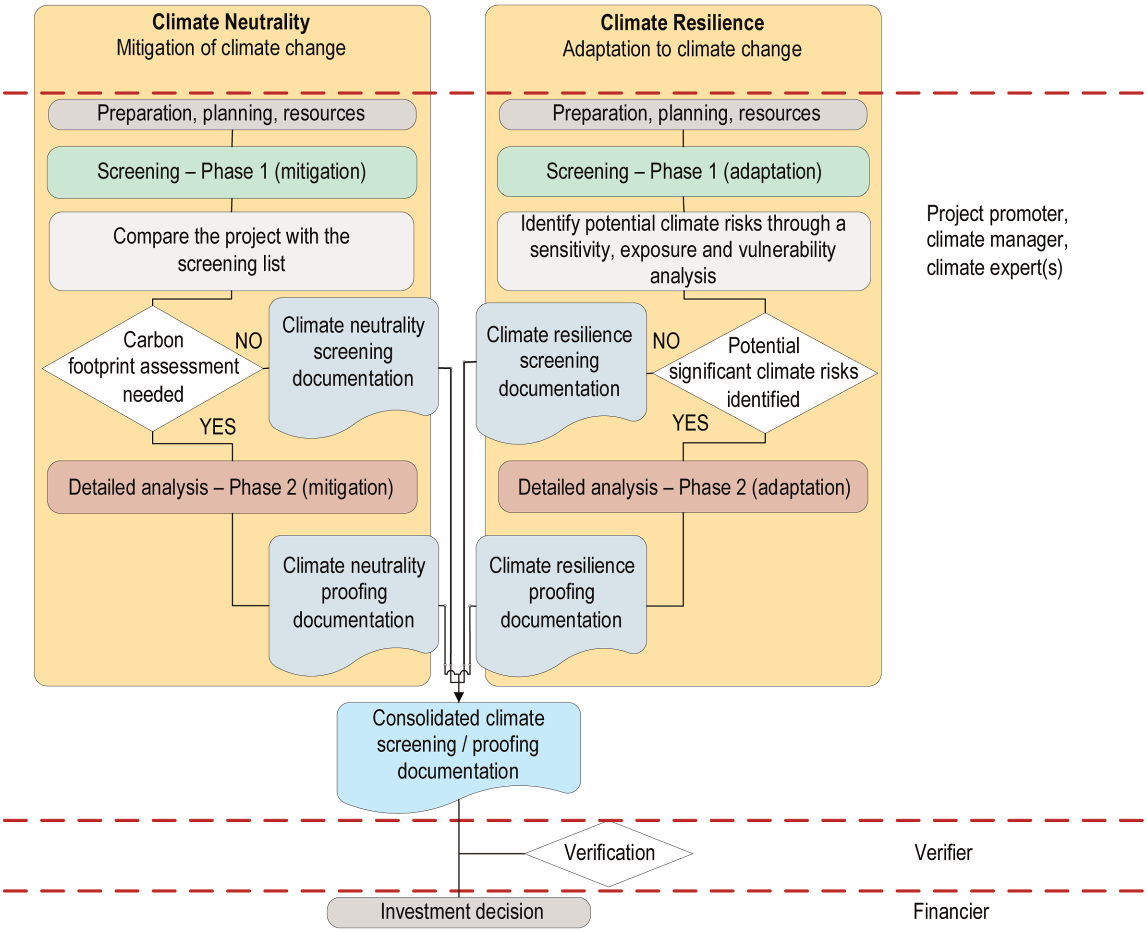


The climate-proofing process may involve different bodies taking the lead in different stages of the project development cycle. For instance, public authorities may lead the strategy/plan stage, the project promoter during the feasibility/design stage, and asset owners and managers later on.

The climate-proofing documentation is often verified before the project promoter submits the project application for approval to the financier, as illustrated in Figure 19. In this case, the verification should be carried out by an independent verifier. However, the documentation could also be verified by the financier as an initial step in the process leading to the investment decision.

Figure 19

Bodies leading the different stages of project development



5. CLIMATE PROOFING AND ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Climate change considerations may form an important part of the Environmental Impact Assessment (EIA) of a project. This applies to both pillars of climate proofing, i.e. climate change mitigation and adaptation.

The **Environmental Impact Assessment (EIA)** is defined by Directive 2011/92/EU of the European Parliament and of the Council ([94]) as amended by Directive 2014/52/EU of the European Parliament and of the Council ([95]) (hereafter referred to as the EIA Directive).

Directive 2014/52/EU (the **2014 EIA Directive)** applies, in accordance with Article 3, to projects for which screening is initiated (for Annex II projects), or the scoping was initiated or the EIA report was submitted by the developer (for Annexes I and II projects subject to an EIA procedure) on/after 16 May 2017.

Directive 2011/92/EU (the **2011 EIA Directive)** applies to projects for which the screening was initiated (for Annex II projects), or the scoping was initiated or the EIA report was submitted by the developer (for Annexes I and II projects subject to an EIA procedure) before 16 May 2017.

([94]) Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (OJ L 26, 28.1.2012, p. 1), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011L0092

([95]) Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (OJ L 124, 25.4.2014, p. 1), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0052

The amended EIA Directive includes provisions on climate change. For projects under the 2014 EIA Directive, there is an overlap between the EIA process and the climate-proofing process. The two processes should be planned together to take advantage of the overlap.

The EIA applies to public and private projects listed in Annex I and II to the EIA Directive. All projects listed in Annex I are considered as having significant effects on the environment and are therefore subject to an EIA. For projects listed in Annex II, the national authorities must decide whether an EIA is needed. This is carried out through a screening procedure, by which the competent authority assesses whether a project would have significant effects on the basis of thresholds/criteria or a case-by-case examination, while taking into account the criteria laid down in Annex III to the EIA Directive.

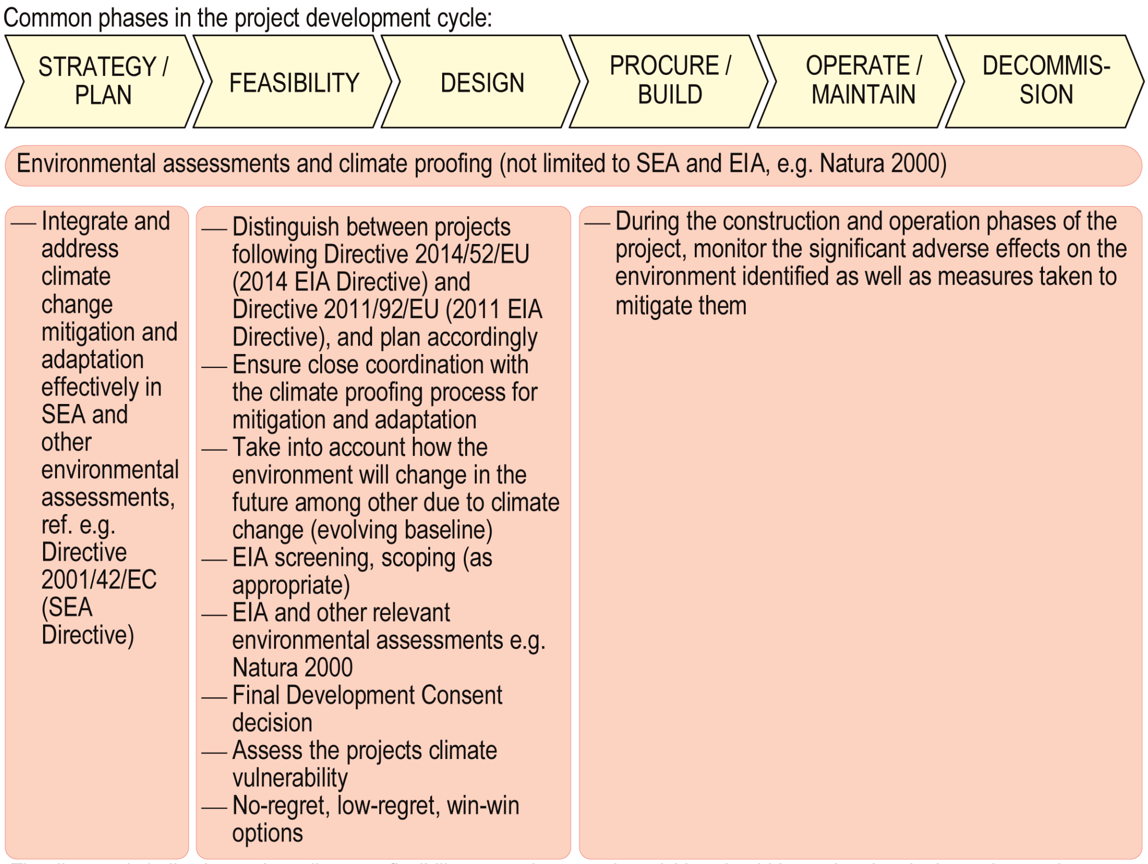
This section focuses on the projects subject to an EIA, i.e. Annex I projects and Annex II projects '*screened in*' by the competent authorities.

The projects listed in Annex I and II to the EIA Directive (incl. any changes or extensions to projects, which by virtue of, inter alia, its nature or scale, present risks that are similar, in terms of their effects on the environment, to those posed by the project itself) will, based on the indicated project types, usually warrant climate proofing (mitigation and/or adaptation).

For Annex II projects '*screened out*' by the competent authorities under the 2011 EIA Directive, i.e. when an EIA is not required, it may nonetheless be relevant to carry out climate proofing in line with this guidance, for instance to comply with the legal basis for the targeted EU funding.

Figure 20

Environmental Assessments (EAs) and Project Cycle Management (PCM)



The diagram is indicative and entails some flexibility as to when certain activities should be undertaken in the project cycle.
Acronyms: SEA = Strategic Environmental Assessment; EIA = Environmental Impact Assessment.

See Annex D for further guidance on climate change considerations in the EIA.

Lastly, climate change considerations may be an important component of the **strategic environmental assessment (SEA)** of a plan or programme, setting the framework for developing certain projects. This applies to both pillars of climate proofing, i.e. climate change mitigation and adaptation. See Annex E for guidance on climate proofing and SEA. However, with reference to Figure 23, this may be outside the scope of the project promoter.

ANNEX A

EU funding for infrastructure 2021-2027

A.1. INTRODUCTION

With regard to EU funding for infrastructure in the programming period 2021-2027, the main instruments which may be employed include the InvestEU Programme ([1]), Connecting Europe Facility (CEF) ([2]), and – under the Common Provisions Regulation (CPR) ([3]) – the European Regional Development Fund (ERDF), the Cohesion Fund (CF) ([4]) and the Just Transition Fund (JTF) ([5]), as well as the Recovery and Resilience Facility (RRF) ([6]), ([7]).

A.2. INVESTEU

The **InvestEU Regulation** reflects in **recital 10** on the importance of tackling climate change in line with the Union's commitment to implement the Paris Agreement, and refers to the objective of EU climate neutrality by 2050 and the Union's new 2030 climate targets.

Recital 13 refers to the *screening* and *proofing* of investment projects, in particular in the area of infrastructure, with regard to environmental, climate and social impacts. The Commission should develop the accompanying guidance in close cooperation with potential implementing partners under the InvestEU Programme. The guidance should be consistent with the guidance developed for other programmes of the Union. The guidance should appropriately use the criteria of the Taxonomy Regulation, including the principle of 'do no significant harm'. Furthermore, operations that are inconsistent with the achievement of the climate objectives should not be eligible for support under this Regulation.

Article 8(5) of the InvestEU Regulation stipulates that financing and investment operations shall be *screened* to determine whether they have an environmental, climate or social impact. If those operations have such an impact they shall be subject to *climate, environmental and social* ([8]) *sustainability proofing* with a view to minimising detrimental impacts and to maximising benefits to the climate, environment and social dimensions. Projects below a certain size specified in the guidance on sustainability proofing shall be excluded from the proofing. *Projects that are inconsistent with the climate objectives shall not be eligible for support* under the InvestEU Regulation.

Article 8(6) and Article 8(6) a) stipulate that the sustainability guidance, while *taking appropriate account of the principle of 'do no significant harm'*, shall allow for, *as regards adaptation*, ensuring resilience to the potential adverse impacts of climate change through a climate vulnerability and risk assessment, including through relevant adaptation measures, and, *as regards mitigation*, integrating the cost of greenhouse gas emissions and the positive effects of climate mitigation measures in the cost-benefit analysis.

Article 8(6) e) refers to the screening guidance.

Article 8(6) d) stipulates that the sustainability guidance shall allow for identifying projects that are *inconsistent with the achievement of climate objectives*.

Annex II of the InvestEU Regulation defines the *areas eligible for financing and investment operations*. For instance, the development of the energy sector refers to commitments taken under the Paris Agreement.

([1]) InvestEU: Regulation (EU) 2021/523.
([2]) CEF: Regulation (EU) 2021/1153.
([3]) CPR: Regulation (EU) 2021/1060.
([4]) ERDF/CF: Regulation (EU) 2021/1058.
([5]) JTF: Regulation (EU) 2021/1056.
([6]) RRF: Regulation (EU) 2021/241.
([7]) Commission staff working document 'Guidance to Member States – Recovery and resilience plans', SWD(2021) 12 final, encourages, as regards investments in infrastructure, to apply the guidance on climate proofing established under the InvestEU Regulation. Technical guidance on the application of 'do no significant harm' is available in Commission Notice 2021/C 58/01 under the Recovery and Resilience Facility (RRF), which refers to this guidance on climate proofing of infrastructure 2021-2027.
([8]) Social sustainability includes e.g. accessibility for persons with disabilities.

Article 8(1) defines the *four policy windows*, which includes sustainable infrastructure; research, innovation and digitisation; SMEs; and social investment and skills.

It is possible that there may be infrastructure investments requiring climate proofing under all policy windows.

Article 8(1) a) includes a comprehensive list of what is comprised under the *sustainable infrastructure policy window*, i.e. in the areas of transport, including multimodal transport, road safety, including in accordance with the Union objective of eliminating fatal road accidents and serious injuries by 2050, the renewal and maintenance of rail and road infrastructure, energy, in particular renewable energy, energy efficiency in accordance with the 2030 energy framework, buildings renovation projects focused on energy savings and the integration of buildings into a connected energy, storage, digital and transport systems, improving interconnection levels, digital connectivity and access, including in rural areas, supply and processing of raw materials, space, oceans, water, including inland waterways, waste management in accordance with the waste hierarchy and the circular economy, nature and other environment infrastructure, cultural heritage, tourism, equipment, mobile assets and the deployment of innovative technologies that contribute to the environmental or climate resilience or social sustainability objectives of the Union and that meet the environmental or social sustainability standards of the Union;.

The sustainability guidance for InvestEU specifies a threshold of EUR 10 million exclusive of VAT below which projects are required to undertake sustainability proofing in accordance with **Article 8(5)**. However, for some projects below the threshold there may still be a legal requirement to undertake an Environmental Impact Assessment (EIA), which then may include climate proofing considerations as per the amended EIA Directive (see chapter 5 and Annex D).

A.3. CONNECTING EUROPE FACILITY (CEF)

The **CEF Regulation** reflects in **recital 5** on the importance of tackling climate change in line with the Union's commitments to implement the Paris Agreement and refers to climate proofing. According to that recital, in order to prevent infrastructure from being vulnerable to potential long term climate change effects, and to ensure that the cost of greenhouse gas emissions arising from the project is included in the project's economic evaluation, projects supported by the CEF should be subject to *climate proofing*, where relevant, in accordance with *guidance that should be developed by the Commission* coherently with the guidance developed for other programmes of the Union.

The CEF Regulation sets out in **Article 14** the award criteria. As regards the *mitigation* of climate change, Article 14(1) l) requires 'consistency with Union and national energy and climate plans, including the energy efficiency first principle'. As regards the *adaptation* to climate change, Article 14(2) requires that 'the assessment of proposals against the award criteria shall take into account, where relevant, the resilience to the adverse impacts of climate change through a climate vulnerability and risk assessment including the relevant adaptation measures'.

As regards *energy efficiency first*, the definition in Article 2(l) of the CEF Regulation refers to Article 2(18) of Regulation (EU) 2018/1999.

Article 2(18) of Regulation (EU) 2018/1999 includes this definition: '(18) "**energy efficiency first**" means taking utmost account in energy planning, and in policy and investment decisions, of alternative cost-efficient energy efficiency measures to make energy demand and energy supply more efficient, in particular by means of cost-effective end-use energy savings, demand response initiatives and more efficient conversion, transmission and distribution of energy, whilst still achieving the objectives of those decisions;'.

A.4. COMMON PROVISIONS REGULATION (CPR)

The **Common Provisions Regulation (CPR)** states in **recital 6** on Horizontal principles that the objectives of the Funds should be pursued in the framework of sustainable development and the Union's promotion of the aim of preserving, protecting and improving the quality of the environment as set out in Article 11 and Article 191(1) of the Treaty on the Functioning of the European Union (TFEU), taking into account among other the Paris Agreement.

Recital 10 reflects on the importance of tackling climate change in line with the Union's commitments to implement among other the Paris Agreement. According to that recital, the Funds should support activities that would respect the climate and environmental standards and priorities of the Union and would *do no significant harm* to environmental objectives within the meaning of Article 17 of Regulation (EU) No 2020/852, i.e. the Taxonomy Regulation. Adequate mechanisms to ensure the *climate proofing* of supported investment in infrastructure should be an integral part of programming and implementation of the Funds.

Recital 60 refers to the responsibility of managing authorities and states 'with a view to pursuing the objective of achieving a climate neutral Union by 2050, Member States should ensure the **climate proofing of investments in infrastructure** and should prioritise operations that respect the "energy efficiency first" principle when selecting such investments'.

Article 2(42) defines **climate proofing** as 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.

Article 9(4) on Horizontal principles stipulates that the objectives of the Funds shall be pursued in line with the objective of promoting sustainable development as set out in Article 11 TFEU, taking into account the UN Sustainable Development Goals, the *Paris Climate Agreement* and the '*do no significant harm*' principle.

Article 73(2) j) stipulates that the managing authority in selecting operations shall ensure the *climate proofing* of investments in infrastructure with an expected *lifespan of at least five years*.

Major Projects 2014-2020 with phased implementation 2021-2027

This guidance on the climate proofing of infrastructure in the period 2021-2027 builds on best practice, lessons-learned and available guidance ([9]) from applying a similar approach – albeit within a specific legal basis – for major projects funded by the European Regional Development Fund and the Cohesion Fund in the period 2014-2020.

This guidance does not concern major projects for the period 2014-2020. With few exceptions, the major projects are already well advanced in the project development cycle and obliged to adhere to the legal requirements for 2014-2020, e.g. as embedded in the application form for major projects ([10]).

Article 118 sets out the conditions for operations subject to phased implementation but does not address the climate-proofing requirement.

The Commission considers that major projects approved by the Commission for the period 2014-2020 which are continued with additional funding in the period 2021-2027 as phased implementation should not be subject to climate proofing according to these guidelines provided that both phases of these major projects already underwent such assessment in accordance with the applicable provisions before their approval in the 2014-2020 period.

In the period 2021-2027, the climate proofing obligation applies more generally and is no longer linked to the concept of 'major project'.

([9]) Selected guidance on the climate proofing of major projects in the period 2014-2020:
— https://ec.europa.eu/clima/sites/clima/files/docs/major_projects_en.pdf
— http://www.eib.org/en/about/documents/footprint-methodologies.htm
— http://www.jaspersnetwork.org/plugins/servlet/documentRepository/displayDocumentDetails?documentId=422
— http://www.jaspersnetwork.org/plugins/servlet/documentRepository/displayDocumentDetails?documentId=381
— http://www.jaspersnetwork.org/plugins/servlet/documentRepository/displayDocumentDetails?documentId=421
— http://www.jaspersnetwork.org/plugins/servlet/documentRepository
— http://www.jaspersnetwork.org/display/EVE/Workshop+on+climate+change+adaptation%2C+risk+prevention+and+management+in+the+Water+Sector
— http://www.jaspersnetwork.org/display/EVE/Climate+change+requirements+for+major+projects+in+the+2014-2020+programming+period
— http://www.jaspersnetwork.org/display/EVE/Knowledge+sharing+event+on+climate+adaptation+in+projects
— http://www.jaspersnetwork.org/display/EVE/Follow-up+on+Climate+Change+Related+Requirements+for+Major+Projects+in+the+2014-2020+Programming+Period
— http://www.jaspersnetwork.org/display/EVE/Climate+Change+Adaption+in+Transport+Sector

([10]) Application Form Major Projects: Commission Implementing Regulation (EU) 2015/207 (OJ L 38, 13.2.2015, p. 1), Annex II 'Format for submission of the information on a major project', https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R0207

ANNEX B

Climate-proofing documentation and verification

B.1. INTRODUCTION

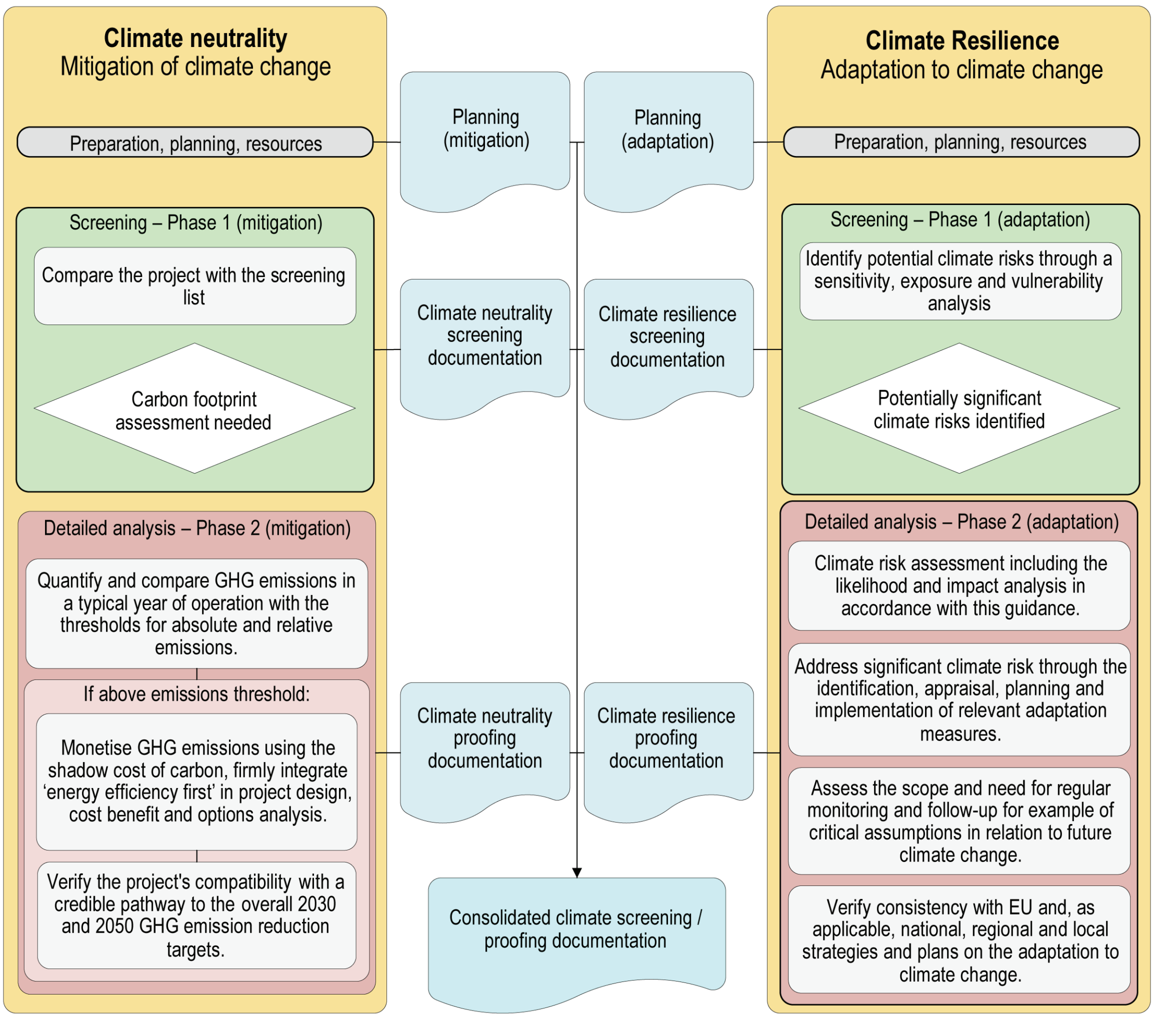
The climate-proofing process and related decisions should be documented. It serves among other to inform relevant authorities, investors, interlocutors, stakeholders and others in a consistent and transparent manner. It will usually be an essential component of the documentation presented for the investment decision.

This annex presents a generic set of requirements to the documentation. In addition, the project promoter should give due consideration to applicable legal and other requirements.

Figure 21 illustrates the components of the climate-proofing documentation in the case where both phases (screening, detailed analysis) are carried out for both pillars (mitigation, adaptation).

Figure 21

Overview of the components of the climate-proofing documentation



The climate-proofing documentation should provide a concise summary of the various steps in the climate proofing process.

The planning should foresee when the documentation will be compiled along the related activities and stages of the project development cycle, and how the climate proofing will be coordinated with other activities such as the EIA process. A particular concern is to ensure that the climate proofing does not arrive at a moment where design modifications will be challenging.

The climate-proofing documentation is intended as a relatively short summarising document in the range of 10-20 pages albeit depending on e.g. the size and complexity of the project and the complementarity with the EIA. However, it should be possible for the verifier and stakeholders (e.g. InvestEU Implementing Partners) to query the documentation and obtain further insights into the underlying documentation.

B.2. **DOCUMENTATION OF CLIMATE PROOFING**

Indicatively, the documentation should include:

— **Introduction**:

  — Describe the infrastructure project and outline how it addresses climate change, including financial information (total investment costs, EU contribution).

  — Contact details (e.g. the organisation of the project promoter)

— **Climate-proofing process**:

  — Describe the climate-proofing process from initial planning to completion, including the integration into the project development cycle and coordination with environmental assessment processes (e.g. EIA).

— **Mitigation of climate change (climate neutrality)**:

  — Describe the screening and its outcome.

  — Where phase 2 (detailed analysis) is undertaken:

    — Describe the GHG emissions and compare with the thresholds for absolute and relative emissions. As applicable, describe the economic analysis and the use of the shadow cost of carbon as well as the options analysis and the integration of the principle of 'energy efficiency first'.

    — Describe the project's consistency with relevant EU and National Energy and Climate Plans, the EU target for emission reductions by 2030 and climate neutrality by 2050. How is the project contributing to the objectives of these plans and targets.

    — For projects with an intended lifespan beyond 2050, describe the compatibility with operation, maintenance and eventual decommissioning under circumstances of climate neutrality.

    — Provide other relevant information, for instance about the baseline for the carbon footprint (see section 3.2.2.3).

— **Adaptation to climate change (climate resilience)**:

  — Describe the screening and its outcome, including adequate details of the sensitivity, exposure and vulnerability analysis.

— Where phase 2 (detailed analysis) is undertaken:

  — Describe the climate risk assessment including the likelihood and impact analysis, and identified climate risks.

  — Describe how the identified climate risks are addressed by relevant adaptation measures, including the identification, appraisal, planning and implementation of these measures.

  — Describe the assessment and outcome with regard to regular monitoring and follow-up for example of critical assumptions in relation to future climate change.

  — Describe the project's consistency with EU and, as applicable, national, regional and local strategies and plans on the adaptation to climate change, and national or regional disaster risk management plans.

— **Information about the verification (where applicable)**:

  — Describe how the verification has been undertaken.

  — Describe the main findings.

— **Any additional relevant information**:

  — Any other pertinent issues required by this guidance and other applicable references.

  — Describe any tasks related to climate proofing, which are deferred to a subsequent stage of the project development, for instance to be carried out by the contractor during the construction or by the asset manager during the operation.

  — List of published documents (e.g. related to the EIA and other environmental assessments).

  — List of key documents available with the project promoter.

B.3. **VERIFICATION OF CLIMATE PROOFING**

An independent expert verification of the concerned documentation may be required to provide assurance that the climate proofing adheres to the applicable guidance and other requirements. It could be essential for instance for the project promoter, asset owner, financial institutions, operators, other stakeholders, and the public in general.

In principle, the cost of the independent verification is part of the project development and covered by the project promoter.

It is common with a clear and well-established definition of competences, tasks, responsibilities and deliverables for the expert(s) undertaking the independent verification.

The verification should be documented in a report to the project promoter and other relevant recipients.

The above-mentioned verification is not pre-empting the financier (e.g. InvestEU Implementing Partners), as part of the project appraisal and preparation of the investment decision, to request clarification from the project promoter or undertake their own assessment of the climate proofing.

ANNEX C

Climate proofing and project cycle management (PCM)

C.1. COMMON PROJECT CYCLE PHASES AND PROJECT DEVELOPMENT ACTIVITIES

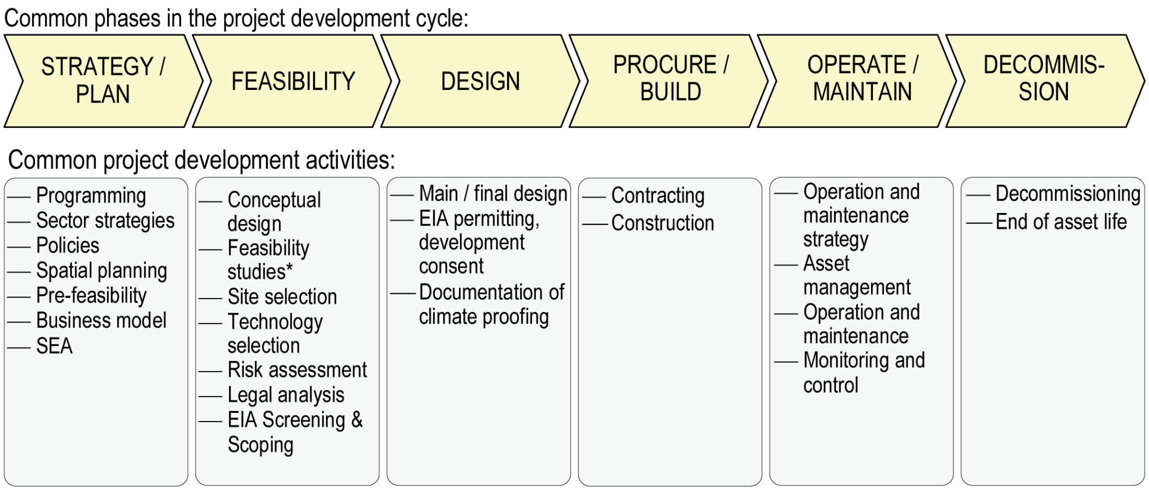
Project cycle management (PCM) is the process of planning, organizing, coordinating, and controlling a project effectively and efficiently throughout its phases, from planning through implementation and operation to decommissioning.

Experience shows that climate proofing should be integrated in the project development cycle from the outset.

The following diagram provides a simplified and illustrative overview of the project cycle phases and common project development activities.

Figure 22

Overview of the project cycle phases and project development activities



Where feasibilities studies* may include various types of analysis e.g. demand, financial, economic, options and cost benefit analysis.
The diagram is indicative and entails some flexibility as to when certain activities should be undertaken in the project cycle.
Acronyms: SEA = Strategic Environmental Assessment; EIA = Environmental Impact Assessment.

The following table provides an indicative overview of the links between the project cycle phases, developer aims, and processes relating to climate proofing.

Table 8

Stages, developer aims, and typical processes and analyses in the project cycle

Project cycle phase	Developer aims	Processes and analyses, which relate to one or more of the components of climate proofing
Strategy / plan	Establish business strategy/framework & projects pipeline (compliant with climate change targets on GHG emissions and climate neutrality, as well as preliminary climate change risk assessment e.g. at area/corridor level and/or type/group of projects).	☒ System analysis and planning ☒ Identification of system developments (e.g. infrastructure, organisation/institution, and operation/maintenance) ☒ Business model development ☒ Preparation of pipeline of measures/projects ☒ Strategic Environment Assessment (SEA) ☒ Pre-feasibility study

Project cycle phase	Developer aims	Processes and analyses, which relate to one or more of the components of climate proofing
Feasibility / design	Establish development options & execution plan (identification of project option that maximises the climate change mitigation effects & project's detailed climate vulnerability and risk assessment – including recommendations for O&M)	☒ Feasibility study ☒ Options analysis ☒ Contract planning ☒ Technology selection ☒ Front-end engineering design (FEED) ☒ Cost estimating, financial / economic modelling ☒ Full Environmental and Social Impact Assessment (EIA, ESIA) and Environmental and Social Action Plan (ESAP) ☒ Climate proofing, e.g. (1) project's compatibility with the climate targets for 2030 and 2050; (2) pursue low carbon options and solutions among other by integrating the cost of GHG emissions in the cost-benefit analysis and in the comparison of alternatives, and the principle 'energy efficiency first'; and (3) climate vulnerability and risk screening / assessment, including the identification, appraisal and implementation of adaptation measures.
Procure / build	Detail & construct asset	☒ Detailed engineering ☒ Engineering, Procurement & Construction Management (EPCM) ☒ Climate proofing (see above) with due regard to the contract format (e.g. FIDIC Red Book versus FIDIC Yellow Book) to ensure planned GHG emission and climate resilience levels
Operate / maintain	Operate, maintain, monitor & improve asset (and its operation)	☒ Asset management, Operations & maintenance e.g. O&M Plan aiming at ensuring sustainability of infrastructure and level of service with due regard to climate risks and including an efficient and effective monitoring of the infrastructure and operations, integrating climate events (e.g. incident register), together with user warning and response systems) ☒ Climate proofing (see above), including monitoring (with contingency plans) of GHG emissions and climate change impacts/risks (for instance where updated flood risk data would trigger raising the height of flood defences)
Decom-mission	Decommission & manage liabilities	☒ Decommission plan (including that it in most cases will take place in a context of net zero GHG emissions and climate neutrality, the principle 'do no significant harm' to environmental objects, and a changing climate with impacts and risks that may have evolved significantly (e.g. increased flood risk)

Furthermore, at the end of the SEA and EIA procedures, it is likely that there will be environmental mitigation measures. These should be integrated either in the decision for adopting the respective plan/programme (as a result of a SEA procedure) and/or the development consent of a project (as a result of a screening or EIA procedures) and in tender documents for works, including as regards climate change mitigation and adaptation.

Particular attention is needed to integrate the *climate mitigation and adaptation measures* resulting from the climate proofing alongside the *environmental mitigation measures* resulting from the SEA and EIA procedures into the tender documents, taking into consideration the differences between, for instance, FIDIC (1) Red Book and FIDIC Yellow Book.

The integration of climate proofing in the project cycle management alongside e.g. environmental assessments will allow for synergies and potential time and cost efficiency gains.

C.2. **THE STRATEGY/PLAN PHASE AND THE PROJECT PROMOTER**

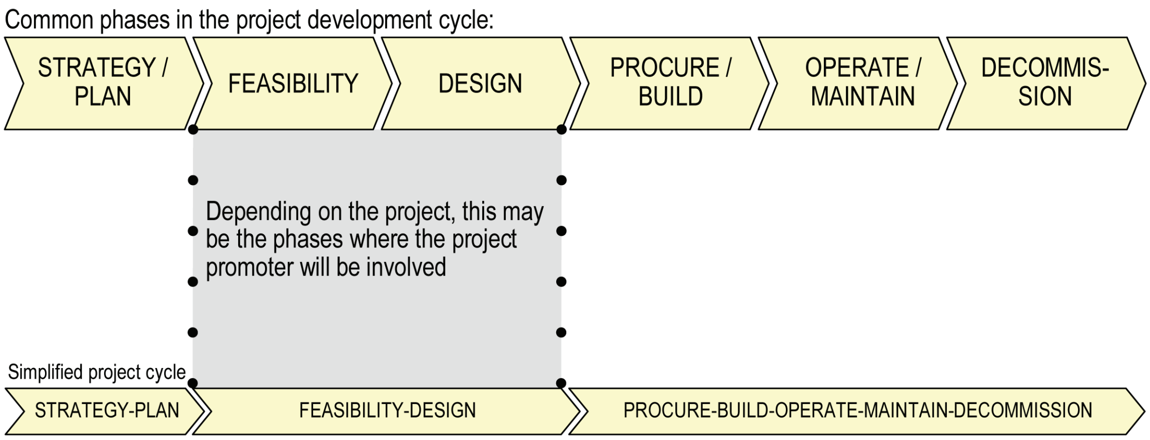
The organisational entity assuming the role of project promoter or project leader for a given infrastructure project is not necessarily taking part in initial decisions during the strategy/plans phase.

There may be different lead actors on climate proofing at various project cycle stages, for instance the project promoter during the feasibility/design phase, public authorities during the strategy/plan phase, and asset owners and managers later on.

The following diagram illustrates this aspect:

Figure 23

Involvement of the project promoter in the different project cycle phases



The project promoter should integrate climate proofing into the project development cycle from as early as possible. This includes understanding how climate change has been addressed in any earlier phases of the project development cycle.

C.3. **EXAMPLES OF CLIMATE PROOFING ISSUES IN THE PROJECT CYCLE PHASES**

Climate proofing is a continuous process to be integrated in all relevant phases and related processes and analyses. This ensures that the project can integrate the corresponding climate resilience measures (2) (3) and mitigation options in an optimal manner.

While the project development process is usually depicted as a linear process, the reality is not so straightforward. Projects do not necessarily transition smoothly from phase to phase, and may become stalled at a certain phase, or may be sent back to earlier stages. The same applies to climate proofing.

(1) FIDIC: http://fidic.org/bookshop/about-bookshop/which-fidic-contract-should-i-use
(2) Non-paper – Guidelines for Project Managers: Making vulnerable investments climate resilient, https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/non_paper_guidelines_project_managers_en.pdf and https://publications.europa.eu/en/publication-detail/-/publication/514e385a-ef68-46ea-95a0-e91365a69782/language-en
(3) Commission Staff Working Paper, SWD(2013) 137 final, 16.4.2012, Adapting infrastructure to climate change, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013SC0137&from=EN

The integration of climate proofing at all project phases can trigger some of the following questions/analyses, which should not be treated in isolation of all other aspects that are usually part of a good project preparation process:

STRATEGY / PLAN

At the '**STRATEGY/PLAN**' phase, decisions should among other include considerations on low-emission actions including the project's compatibility with a place in the transition to net zero GHG emissions and climate neutrality by 2050, the principle of '*do no significant harm*' to environmental objectives, and a first round of climate vulnerability assessment. The Strategy/Plan scenarios should elaborate on the main climate change issues.

The first stage of analysis and preparation for an efficient and effective *Operation and Maintenance strategy* for the project starts with the strategy/plan phase, including the financing strategy, and it will usually be relevant to include climate change mitigation and adaptation considerations.

For **climate change mitigation**, the strategy/plans phase is often the effective stage to take decisions, notably because its scope goes beyond infrastructure development concerns, covering also all the necessary changes to the system operation and organisation/institutional setup.

Decisions taken at this level are in most cases (the most) critical and are the main drivers to reduce GHG emissions, enabling to achieve the full climate change mitigation potential of the project.

For some sectors, once a project is selected, its overall impact depends largely on the fact that it is part of a strategy, i.e. its full benefits will be achieved only when the set of complementary actions and factors foreseen in the strategy are also implemented. This is particularly true/relevant firstly for the transport sector but also for other sectors such as urban development.

The key performance indicator(s), KPI(s), for CO_2e and related targets for the strategy/plans phase will usually be among the main indicators driving the strategy/planning.

For **climate change adaptation**, the strategy/plan phase should usually include a (strategic) vulnerability assessment to identify potential climate impacts and risks and support the planning of the detailed climate change vulnerability and risk assessment.

FEASIBILITY / DESIGN

The technical aspects of the project will usually be specified during the '**FEASIBILITY/DESIGN**' phase. The final choice of technology may for instance be different when climate change mitigation and climate neutrality by 2050 are among the main objectives. This may also generate an additional environmental contribution and climate change benefits.

The bulk of the detailed climate-proofing process will often take place during the feasibility/design phase. See chapter 3 of this guidance for details on climate proofing and chapter 5 for the links to the EIA.

The climate vulnerability and risk assessment would usually include aspects such as site selection and design options and other aspects of feasibility such as project inputs, financial, economic, operations and management, legal, environmental, social inclusion and accessibility.

PROCURE / BUILD

The aim is to ensure that the risks from climate change impacts will be reduced to an acceptable level after integrating relevant adaptation measures. The level of acceptable residual risks will usually be specified beforehand for instance as part of the planning of the climate proofing. The '**PROCURE/BUILD**' phase will among other need to ensure that the project fully reflects the climate proofing developed during the preceding stages, for instance when the contractor is able to propose alternative technical solutions without reducing the level of ambition (including ensuring planned resilience level). Considerations should also be given to minimising GHG emissions during construction.

OPERATE / MAINTAIN

The '**OPERATE/MAINTAIN**' phase will implement the corresponding mitigation and adaptation measures, monitor the effectiveness of these measures including impacts of the project on the environment (e.g. GHG emissions) and climate change impacts on the project. An efficient and effective Operation and Maintenance strategy for the system should be developed, ensuring the sustainability of the infrastructure and standard of services while adequately addressing climate risks.

As mentioned above, this type of analysis starts with at the strategy/plans phase. The efficient and effective monitoring of the infrastructure and operations needs to be included, integrating climate events (e.g. incident register), together with user warning and response systems. This should include also monitoring and procedures to minimise impacts on particularly hazardous events, accepting a degraded level of operations or the complete stop (depending on the location and on the type of area/users served – e.g. residences vs hospitals…) and recovering/fully protecting people and assets (e.g. escape and recovery areas for passengers and vehicles of a metro system).

DECOMMISSION

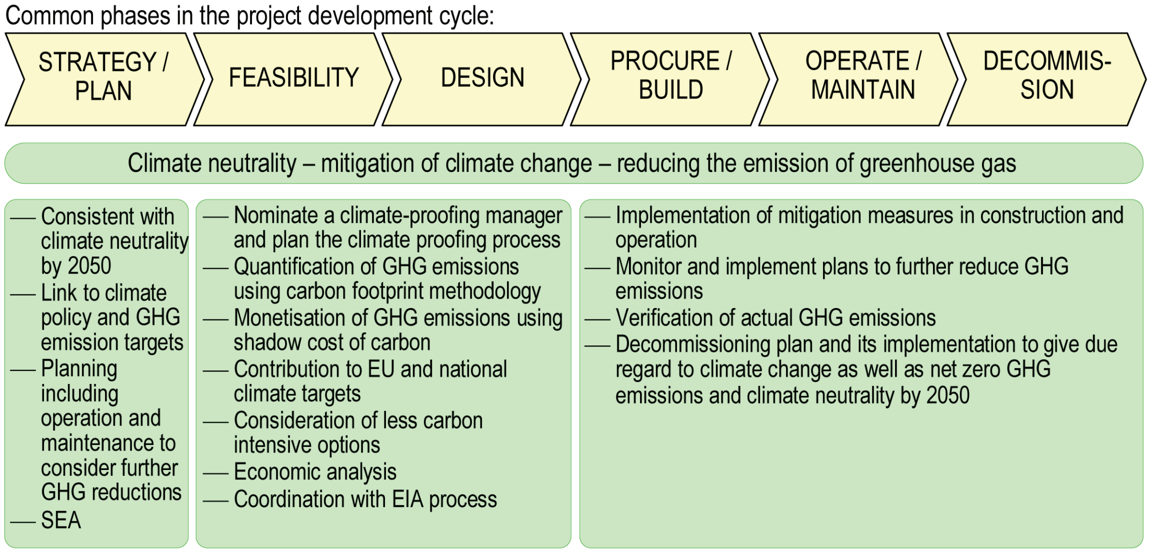
The '**DECOMMISSION**' phase will – for most of the infrastructure projects that will be funded in the period 2021-2027 – take place after 2050 in the context of net zero GHG emissions and climate neutrality as well as the principle of '*do no significant harm*' to environmental objectives. Over the same period, climate change will lead to changes in various climate hazards. This may have implications for analysis and decisions during the earlier stages of the project development cycle.

C.4. **PCM AND THE MITIGATION OF CLIMATE CHANGE**

The following figure provides an overview of the links between PCM and the mitigation of climate change.

Figure 24

Overview of the links between PCM and mitigation of climate change



The diagram is indicative and entails some flexibility as to when certain activities should be undertaken in the project cycle.
Acronyms: SEA = Strategic Environmental Assessment; EIA = Environmental Impact Assessment; GHG = Greenhouse gas.

The following table provides an indicative overview of links between PCM and the mitigation of climate change for the various project cycle stages.

Table 9

Overview of PCM and the mitigation of climate change

Project cycle phases	Developer aims	Processes and analyses	Project compatible with net zero GHG emissions and climate neutrality by 2050 (or credible pathways to 2050 if shorter lifespan)
Strategy / plan	Establish preliminary scope & business strategy Establish development options & execution strategy	— Business model development — Strategic Environmental Assessment (SEA) — Conceptual design — Site selection — Contract planning — Technology selection — Cost estimating, financial / economic modelling — Pre-feasibility study — Scoping & baseline for the Environmental and Social Impact Assessment (ESIA)	☒ Detail the analysis for the project vis-à-vis climate neutrality by 2050, circular economy, and the use of life cycle assessment for GHG emissions, including relevant alternatives ☒ Pursue low carbon options ☒ Where relevant, undertake in-depth analysis of GHG emissions according to the EIB Carbon Footprint Methodology ☒ Nominate a climate-proofing manager and plan the climate-proofing process

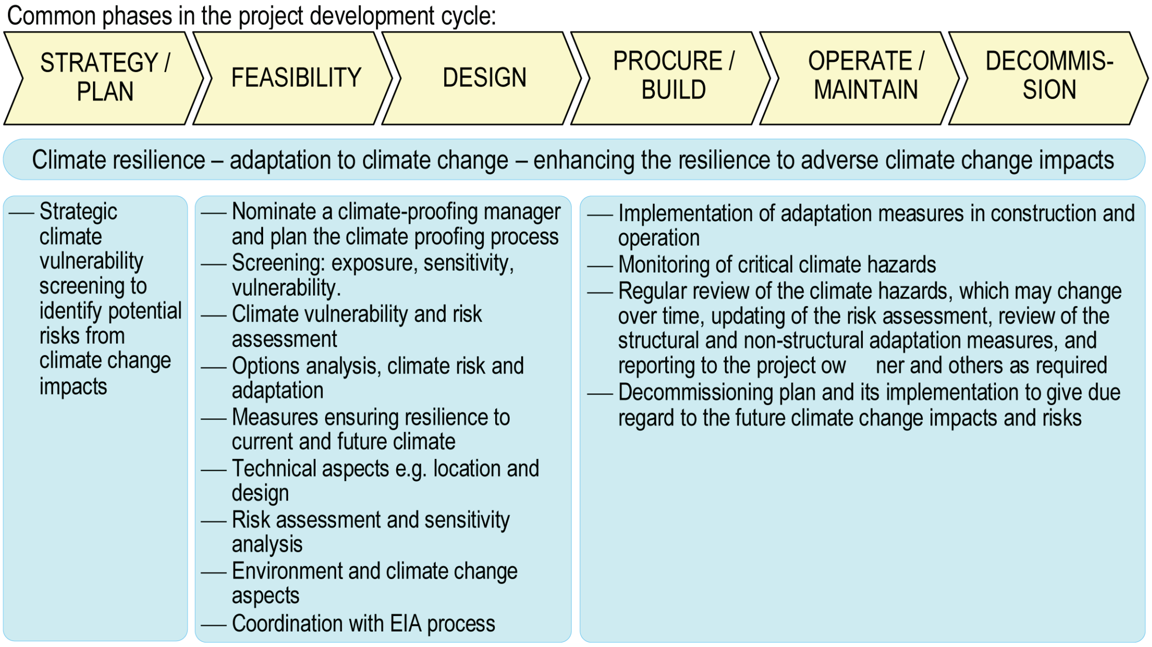
Project cycle phases	Developer aims	Processes and analyses	Project compatible with net zero GHG emissions and climate neutrality by 2050 (or credible pathways to 2050 if shorter lifespan)
Feasibility / design	Finalise scope & execution plan	— Front end engineering design (FEED) — Cost estimating, financial / economic modelling — Full Environmental and Social Impact Assessment (ESIA) and Environmental and Social Action Plan (ESAP) — Accessibility for persons with disabilities ensured	☒ Nominate a climate-proofing manager and plan the climate-proofing process (if not done earlier) ☒ Climate proofing, e.g. (1) project's compatibility with the transition to net zero GHG emissions by 2050 and climate neutrality and the principles of 'energy efficiency first' and 'do no significant harm' to environmental objectives; (2) pursue low carbon options and solutions among other by integrating the cost of GHG emissions in the cost-benefit analysis and in the comparison of alternatives
Procure / build	Detail & construct asset	— Detailed engineering — Engineering, Procurement & Construction Management (EPCM)	☒ Climate proofing: integrate climate change mitigation objectives (derived as part of the climate proofing) into detailed engineering and procurement
Operate / maintain	Operate, maintain & improve asset	— Asset management — Operations & maintenance	☒ Monitor the emission of GHG and the planned reductions towards climate neutrality
Decommission	Decommission & manage liabilities	— Decommissioning plan	☒ the decommissioning plan and its implementation should give due regard to climate change as well as net zero GHG emissions by 2050 and climate neutrality, and the principles of '*energy efficiency first*' and '*do no significant harm*'

C.5. **PCM AND ADAPTATION TO CLIMATE CHANGE**

The following figure provides an illustrative overview of links between PCM and the adaptation to climate change.

Figure 25

Overview of links between PCM and adaptation to climate change



The diagram is indicative and entails some flexibility as to when certain activities should be undertaken in the project cycle.
Acronyms: EIA = Environmental Impact Assessment.

The following table provides an indicative overview of links between PCM and the adaptation to climate change for the various project cycle stages.

Table 10

Overview of PCM and the adaptation to climate change

Project cycle phases	Developer aims	Processes and analyses	Vulnerability assessment	Risk assessment	Adaptation options
Strategy / plan	Establish preliminary scope & business strategy Establish development options & execution strategy	— Business model development — Strategic Environment Assessment (SEA) — Conceptual design — Site selection — Contract planning — Technology selection — Cost estimate — Scoping & baseline for the Environmental and Social Impact Assessment (EIA, ESIA) — Pre-feasibility study	☒ For the asset lifetime, consider how current and future climate could affect the project's success ☒ Consider climate risks associated with the design options ☒ Integrate climate vulnerability into the site selection ☒ Sensitivity analysis to include technologies and design thresholds ☒ Risk assessment ☒ Identify adaptation options and benefits (reduced risks/damages) ☒ Provide cost estimates, appraise adaptation options ☒ Specify an acceptable level of residual risk to adverse impacts of climate change		

Project cycle phases	Developer aims	Processes and analyses	Vulnerability assessment	Risk assessment	Adaptation options
			☒ Identify and assess risks (higher level) and adaptation measures – based on an identification and analysis of environmental and social changes driven by climate change, which may impact on the project (e.g. increase demand for irrigation leading to water resource conflict), and of ways that changing climate conditions could affect the environmental and social performance of the project (e.g. increase existing social and/or gender inequalities) ☒ Nominate a climate-proofing manager and plan the climate-proofing process		
Feasibility / design	Finalise scope & execution plan	— Front end engineering design (FEED) — Cost estimating, financial / economic modelling — Full Environmental and Social Impact Assessment (ESIA) and Environmental and Social Action Plan (ESAP) — Feasibility study	☒ Nominate a climate-proofing manager and plan the climate-proofing process (if not done earlier) ☒ Further analysis of critical design thresholds most sensitive to climate change ☒ Analyse climate risks and test robustness of critical design in the current and future climate ☒ Identify adaptation options and benefits (reduced risks/damages) ☒ Provide cost estimates, appraise adaptation options ☒ Identify and assess risks and adaptation measures – based on a detailed analysis of environmental and social changes driven by climate change, which may impact the project, and of ways changing climate conditions could affect the environmental and social performance of the project. Incorporate measures to manage risks to the environment and society. Address accessibility for persons with disabilities. ☒ In the feasibility study, consider and articulate the climate vulnerabilities and risks associated with the project covering all areas of feasibility, e.g. project inputs, project location and site, financial, economic, operations and management, legal, environmental and social, as well as relevant adaptation options.		

Project cycle phases	Developer aims	Processes and analyses	Vulnerability assessment	Risk assessment	Adaptation options
Procure / build	Detail & construct asset	— Detailed engineering — Engineering, Procurement & Construction Management (EPCM)	☒ Refine climate resilience measures from the above *front end engineering design (FEED)* and embed final agreed measures within detailed engineering designs. ☒ Update of earlier sensitivity analysis, vulnerability and risk assessments, and identification and integration of adaptation options into the project ☒ EPCM to ensure that the project demonstrates that current and future climate risks have been assessed, and resilience measures incorporated where necessary – and integrated in e.g. an 'climate resilience action plan'		
Operate / maintain	Operate, maintain & improve asset	— Asset management — Operations & maintenance	☒ To ensure the asset remains climate resilient and continues to perform as intended over its lifetime, regular monitoring should be undertaken as climate change unfolds. The monitoring should include underlying design assumptions (such as future levels of global warming) as well as adaptation and environment and other measures, to check they are providing the expected level of risk reduction. The project's 'climate resilience action plan' should be regularly reviewed and updated; it should be flexible and open-ended, particularly for long-lived assets. Regular monitoring will alert the asset owner / operator to the any emerging need to modify the adaptation actions.		
Decommission	Decommission & manage liabilities	— Decommissioning plan	☒ The decommissioning plan and its implementation should give due regard to the future climate change impacts and risks (and it may be relevant to give consideration to these aspects earlier in the PCM)		

C.6. **PCM AND ENVIRONMENTAL ASSESSMENTS (EIA, SEA)**

For an overview of the links between PCM and environmental assessments (e.g. EIA, SEA), see Figure 20.

The following table provides an indicative overview of the steps in the EIA and SEA for the project cycle stages.

Table 11

Overview of PCM and environmental assessments (EIA, SEA)

Project cycle phases	Developer aims	Environmental assessments	Explanation
Strategic Environmental Assessment (SEA)			
Strategy / plan	Establish preliminary scope & business strategy	Strategic Environmental Assessment (SEA)	Specify headline climate change issues including net zero greenhouse emissions and climate neutrality by 2050, the environmental protection objectives, established at international, EU or Member State level, which are relevant to the plan and the way those objectives and any environmental considerations have been taken into account during its preparation as well as climate resilience. Assess critical challenges for addressing climate change in SEA. Identify climate issues and effects. Address climate change effectively in SEA (and other environmental assessments) as appropriate.
Environmental Impact Assessment (EIA)			
Feasibility / design	Establish development options & execution strategy Finalise scope & execution plan	Screening (as appropriate)	The Competent Authority makes a decision about whether EIA is required. At the end of this stage, a Screening Decision must be issued and made public. NB. EIA Directive Annex II projects that are 'screened out', i.e. an EIA is not required, may nonetheless require climate proofing.
		Scoping (as appropriate)	The Directive provides that Developers may request a Scoping Opinion from the Competent Authority, which identifies the content and the extent of the assessment and specifies the information to be included in the EIA Report.
		EIA Report	The Developer, or the expert(s) on his/her behalf, carries out the assessment. The results of the assessment are presented in the EIA Report which contains: information regarding the project, the Baseline scenario, the likely significant effect of the project, the proposed Alternatives, the features and Measures to mitigate adverse significant effects as well as a Non-Technical Summary and any additional information specified in Annex IV of the EIA Directive.
		Information and Consultation	The EIA Report is made available to authorities with environmental responsibilities, local and regional authorities and the public for review. They are given the opportunity to comment on the project and its environmental effects.

Project cycle phases	Developer aims	Environmental assessments	Explanation
		Decision Making and Development Consent	The Competent Authority examines the EIA report including the comments received during consultation, assesses the project's effects in the light of each individual case and issues a Reasoned Conclusion on whether the project entails significant effects on the environment. This must be incorporated into the final Development Consent decision.
		Information on Development Consent	The public is informed about the Development Consent decision and has the right to a review procedure.
Procure / build	Detail & construct asset	Monitoring (as appropriate)	During construction and operation phase of the project, the Developer must monitor the significant adverse effects on the environment identified as well as measures taken to mitigate them.
Operate / maintain	Operate, maintain & improve asset		
Decommission	Decommission & manage liabilities		

ANNEX D

Climate proofing and environmental impact assessment (EIA)

In this guidance on climate proofing, chapter 5 provides a brief introduction to the links and overlaps between climate proofing and environmental impact assessment, which is elaborated in this annex.

D.1. INTRODUCTION

The EIA Directive requires Member States to ensure that projects likely to have significant effects on the environment because of inter alia their nature, size or location are subject to an assessment of their environmental effects.

This assessment should take place before development consent is given, i.e. before the authority/ies decide(s) that the developer can go ahead with the project.

The Directive harmonises EIA principles by introducing minimum requirements, in particular for the types of projects that should be assessed, the main obligations of developers, the assessment's content and provisions on the participation of competent authorities and the public.

In 2014, the EIA Directive was amended with a view to adjusting it to developments in the policy, legal and technical context over the past 25 years, including to new environmental challenges. The co-legislators agreed that environmental issues, such as climate change and risks of accidents and disasters, have become more important in policy making and they should therefore also constitute important elements in assessment and decision-making processes in project approval.

Directive 2014/52/EU, i.e. the **2014 EIA Directive** applies to projects for which the screening was initiated (for Annex II projects), or the scoping was initiated or the EIA report was submitted by the developer (for Annexes I and II projects subject to an EIA procedure) on/after 16 May 2017.

Directive 2011/92/EU, i.e. the **2011 EIA Directive** applies to projects for which the screening was initiated (for Annex II projects), or the scoping was initiated or the EIA report was submitted by the developer (for Annexes I and II projects subject to an EIA procedure) before 16 May 2017.

The amended Directive includes provisions on climate change. For projects following the 2014 EIA Directive there is an overlap between the EIA-process and the climate-proofing process. The planning of the two processes should take this into account to benefit from the advantages.

In accordance with the amended EIA Directive, the impact of projects on climate and their vulnerability to climate change should be considered at the screening stage (selection criteria) and described when an EIA is necessary.

Projects listed in Annex I to the EIA Directive are automatically subjected to an EIA because their environmental effects are presumed to be significant.

Projects listed in Annex II to the Directive require a determination to be made about their likely significant environmental effects i.e. the project is '**Screened**' to determine whether an EIA is necessary. The Member State's competent authority make that determination through either a (i) case-by-case examination or (ii) set thresholds or criteria. In any case, the competent authorities must always take into account the criteria laid down in Annex III, i.e. characteristics of the projects (e.g. size, cumulation with other projects, etc.), location of the projects and characteristics of the potential impact.

The '**Scoping stage**' provides the opportunity for developers to ask competent authorities about the extent of the information required to make an informed decision about the project and its effects. This step involves the assessment and determination, or 'scoping', of the amount of information and analysis that authorities will need.

The information relating to a project's significant effects on the environment is gathered during the third stage: the **preparation of the EIA report**.

The environmental authorities as well as local and regional authorities and the public (and affected Member States) must be informed and consulted on the EIA report. Following these consultations, a competent authority decides, taken into consideration the results of consultations whether to authorise the project.

This authorisation should be made available to the public and can be challenged before national courts. If projects do entail significant adverse effects on the environment, developers will be obliged to do the necessary to avoid, prevent or reduce such effects. These projects will need to be **monitored** using procedures determined by the Member States.

The website of the European Commission Directorate-General for Environment ([1]) provides a comprehensive introduction and overview of EU environmental policies, legislation and legal compliance, and the *greening* of other EU policy areas.

The following guidance document on the specific stages of the EIA process have been issued:

— EIA Guidance Document on Screening (2017) ([2]);

— EIA Guidance Document on Scoping (2017) ([3]);

— EIA Guidance Document on the preparation of the EIA Report (2017) ([4]).

The three guidance documents contain useful references inter alia to address impacts related to climate change. They supplement the guidance ([5]) issued in 2013 on integrating climate change (and biodiversity) into EIA.

It should be noted that these guidance documents have been designed to be used throughout the EU and cannot, therefore, reflect all of the specific legal requirements and practices of EIA in the different EU Member States. As such, any existing national, regional or local guidance on EIAs should always be taken into consideration alongside the Guidance Documents. The same remark applies to this guidance on climate proofing.

Furthermore, the Guidance Documents should always be read in conjunction with the Directive and with national or local EIA legislation. Interpretation of the Directive remains the prerogative of the Court of Justice of the European Union (CJEU) solely and, therefore, case-law from the CJEU should also be considered.

The EIB Handbook on Environmental and Social ([6]) Standards ([7]) may also be a useful reference for project developers – in relation to the integration of climate change in environmental assessments.

D.2. OVERVIEW OF THE MAIN STAGES OF THE EIA PROCESS

Climate change mitigation and adaptation issues can be integrated in the main stages of the EIA process as illustrated in the table below:

Table 12

Overview of the integration of climate change in the main stages of the EIA process

EIA process	Key considerations
Screening (not formally part of EIA, applicable to Annex II projects)	Would implementing the project be likely to have significant effects on, or be significantly affected by, climate change issues? Is an EIA required?

([1]) Overview of EU environmental policies and legislation: http://ec.europa.eu/environment/index_en.htm
([2]) Screening: https://ec.europa.eu/environment/eia/pdf/EIA_guidance_Screening_final.pdf
([3]) Scoping: https://ec.europa.eu/environment/eia/pdf/EIA_guidance_Scoping_final.pdf
([4]) EIA report: https://ec.europa.eu/environment/eia/pdf/EIA_guidance_EIA_report_final.pdf
([5]) EIA guidance 2013: https://ec.europa.eu/environment/eia/pdf/EIA%20Guidance.pdf
([6]) EN 17210 can serve as a useful reference for addressing accessibility for persons with disabilities
([7]) EIB Handbook on Environmental and Social Standards: https://www.eib.org/attachments/strategies/environmental_and_social_practices_handbook_en.pdf

EIA process	Key considerations
Scoping (as appropriate)	What are the key climate change issues likely to be? Who are the key stakeholders and environmental authorities with an interest in climate change and how will they be involved in the EIA? What do they think are the key issues? What is the current situation relating to climate change and how is it likely to change in the future? What is the climate change policy context, what are the objectives and targets?
EIA report/Information and consultation	What methods, tools and approaches will be most helpful in understanding and assessing key climate change issues? What alternatives are there to tackle key climate change issues? How would implementing them affect climate change objectives? How can we avoid adverse effects on climate change? If we cannot, how can they be reduced or offset? How can the positive effects be maximised? How could climate change be integrated into the project (e.g. undertake climate proofing)? Have the ways of identifying climate change, managing uncertainty, etc. been clearly explained?
Decision making/ Development consent	How can climate change issues be integrated into development consent and the final project?
Monitoring	How will the effects on climate change be monitored? How will the EIA-mitigation measures be monitored? How will adaptive management be evaluated?

Identifying key climate change issues early on, with input from relevant authorities and stakeholders, ensures that they are recognised by all involved and followed-up throughout the EIA process.

Involving relevant authorities and stakeholders at an early stage (at the latest at the scoping stage for Annex I projects or prior to the issuing of a screening decision for Annex II projects) will improve compliance with the EIA Directive. It will also make it possible to capture the most important issues and establish a consistent approach to assessing impact and looking for solutions.

Making use of the knowledge and opinions of environmental, local and regional authorities and stakeholders can help to:

— highlight potential areas of contention and areas of improvement in a timely and effective way;

— provide information on relevant forthcoming projects, policies and legislative or regulatory reforms, other types of environmental assessments that should be considered when analysing evolving baseline trends (see section below);

— collect suggestions for building climate change mitigation and adaptation measures into the proposed project from the outset.

Both the impact of the project on climate and climate change (i.e. climate mitigation aspects) and the impact of climate change on the project and its implementation (i.e. climate adaptation aspects) should be considered early on in the EIA process.

Infrastructure investments should be aligned with the goals of the Paris Agreement and a credible pathway of GHG emission reduction consistent with the EU 2030 climate targets and climate neutrality by 2050, and climate resilient development.

Furthermore, investments in infrastructure projects should do no significant harm to other EU environmental objectives such as the sustainable use and protection of water and marine resources, the transition to a circular economy, waste prevention and recycling, pollution prevention and control and the protection of healthy ecosystems. This is to ensure that progress against the climate objectives are not made at the expense of others and also recognises the reinforcing relationships between different environmental objectives.

Note that this list is not comprehensive and should be adapted depending on the project assessed.

The issues and impacts relevant to a particular EIA should be specified by the specific context of each project and by the concerns of the authorities and stakeholders involved. Flexibility is therefore needed.

D.3. **UNDERSTANDING KEY CLIMATE CHANGE ADAPTATION CONCERNS**

Both a project's impact on climate change (i.e. mitigation aspects) and the impact of climate change on the project and its implementation (i.e. adaptation aspects) should be considered early on in the EIA process. How might implementing the project be affected by climate change? How might the project need to adapt to a changing climate and possible extreme events? Will the project influence the climate vulnerability of people and assets in its vicinity?

When addressing climate change adaptation concerns as part of EIA, one should not only consider the historical data on climate, but also clearly identify and present the climate change scenario that should be considered in the assessment process.

A clear description of the climate change scenario facilitates discussion on whether the expected climatic factors should be considered in the project design and how they may affect the project's environmental context.

EIA practitioners, in particular, should outline extreme climate situations to be considered as part of the environmental baseline analysis. One should also review any existing adaptation strategies, risk management plans and other national or sub-regional studies on the effects of climate variability and climate change, as well as proposed responses and available information on expected climate-related effects relevant to the project.

This guidance includes examples of basic questions that to be asked when identifying major climate change adaptation concerns.

Analysing the evolving baseline trends

The evolution of the baseline – how the current state of the environment is expected to change in the future – is critical to understanding how the proposed project might impact that changing environment.

The baseline environment is a moving baseline. This is especially true for large-scale projects, which might only become fully operational after many years. During this time, the environmental factors in the project's area may change and the area may be subject to different climatic conditions, such as storms, increased flooding, etc. For long-term projects or those with long-lasting effects (timescales exceeding 20 years), climate scenarios based on climate model results should be ideally used. Such projects may need to be designed to withstand very different environmental conditions from current ones. For short-term projects, scenarios need to represent only 'near future' or 'present-day' climates.

Environmental outlooks and scenario studies that analyse trends and their likely future directions can provide useful information. If data are unavailable, it may be useful to use proxy indicators. For example, if air quality monitoring data are not readily available for an urban area, perhaps there are data outlining trends in traffic flow/volumes over time, or trends in emissions from stationary sources.

Spatially explicit data and assessments, potentially using Geographical Information Systems (GIS), are likely to be important for analysing the evolving baseline trends and also to understand distributional effects. There are several such European sources of data, including data repositories and online digital datasets.

When looking at the evolving baseline, the following should be considered:

— **Trends in key indicators over time**, for example GHG emissions, indices of vulnerability, frequency of extreme weather events, disaster risk. Are these trends continuing, changing, or levelling out? Are there environmental outlooks or scenario studies available that have looked at their likely future direction? If data are unavailable for certain indicators are there useful proxy indicators?

— **Drivers of change** (both direct and indirect), which may cause a particular trend. Identifying drivers facilitates future projections, especially if some existing drivers are expected to change or new drivers are about to come into play and will significantly affect a given trend (e.g. already approved developments that have not been implemented yet; changes in economic incentives and market forces; changes in the regulatory or policy frameworks). Identifying drivers should not become a complex academic exercise – it is only important to recognise drivers that will significantly change the trend and take them into account when outlining the expected future state of the environment.

— **Thresholds/limits**, e.g. have thresholds already been breached or are limits expected to be reached? The EIA may determine whether the given trend is already approaching an established threshold or if it is coming close to certain tipping points that can trigger significant changes in the state or stability of the local ecosystem.

— **Key areas that may be particularly adversely affected by the worsening environmental trends** including, for example, protected areas, such as areas designated pursuant to the Birds Directive and the Habitats Directive ([8]).

— **Critical interdependencies**, for example water supply and sewage treatment systems, flood defences, energy/electricity supply, and communication networks.

— **Benefits and losses brought by these trends and their distribution** may determine who benefits and who does not. Benefits and impacts are often not proportionally distributed within society – changes in ecosystems affect some population groups and economic sectors more seriously than others.

— **Climate change vulnerability assessment** needs to be built into any effective assessment of the evolution of the baseline environment, as well as of alternatives. Large infrastructure projects, in particular, are likely to be vulnerable.

Identifying alternatives and EIA-mitigation ([9]) ***measures***

In the early stages of the project development, alternatives are essentially different ways in which the developer can feasibly meet the project's objectives, for example by carrying out a different type of action, choosing a different location or adopting a different technology or design for the project. The zero option should also be considered, either as a specific alternative or to define the baseline. At the more detailed level of the process, alternatives may also merge into mitigating measures, where specific changes are made to the project design or to methods of construction or operation to 'prevent, reduce and where possible offset any significant adverse effects on the environment'.

Note that many alternatives and EIA-mitigation measures important from the point of view of climate change should be addressed at strategic level, in a SEA. For example, as regards adaptation to avoid problems associated with flood risk, planners should prevent projects from being developed on flood plains or areas of flood risk, or promote land management to increase water retention capacity, and, as regards mitigation, alternative models of transport and energy

Mitigation of climate change

For climate change mitigation, it is important to investigate and use options to eliminate GHG emissions as a precautionary approach in the first place, rather than having to deal with mitigating their effects after they have been released. Climate mitigation measures identified and introduced because of an EIA, e.g. construction and operational activities that use energy and resources more efficiently, may contribute to climate change mitigation as well. However, this does not always mean that the project will have overall positive impacts as regards GHG emissions. Impact may be less negative in terms of the quantity of emissions, but still have overall negative impact, unless the carbon used in development and transport is unequivocally equal to zero.

Bear in mind that some EIA-mitigation measures that address climate change can themselves have significant environmental impact and may need to be taken into account (e.g. renewable energy generation or tree planting may have impacts on biodiversity).

([8]) Habitats Directive: https://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

([9]) In relation to EIA and SEA, the word 'mitigation' is used to ensure that the adverse environmental impacts of a developmental project are minimized or completely avoided. In relation to climate action, the word 'mitigation' is used in relation to the reduction or elimination of GHG emissions. This annex seeks to distinguish between the two uses of 'mitigation' by referring to EIA-mitigation (or environmental mitigation) and climate change mitigation.

The impact of the project on climate change (GHG emissions)

Most projects will have an impact on GHG emissions, compared to the Baseline, through their construction, operation, and eventual decommissioning and through indirect activities that occur because of the project.

This should be seen in the context of the project not as an isolated event but as a set of different and complementary interventions – in particular stemming from a plan. This might mean that a certain specific project does not have an individual net GHG reduction effect but is integral part of an overall plan that reduces emissions.

The EIA should include an assessment of the direct and indirect GHG emissions of the Project, where these impacts have been deemed significant:

— direct GHG emissions generated through the Project's construction and the operation of the Project over its lifetime (e.g. from on-site combustion of fossil fuels or energy use);

— GHG emissions generated or avoided as a result of other activities encouraged by the Project (indirect impacts) e.g.

  — Transport infrastructure: increased or avoided carbon emissions associated with energy use for the operation of the Project;

  — Commercial development: carbon emissions due to consumer trips to the commercial zone where the Project is located.

The assessment should take relevant GHG reduction targets at the national, regional, and local levels into account, where available. For certain sectors, in particular transport and urban development this should also make reference to the most relevant stage which is the overall plan to which the project belongs to (or should belong).

The EIA may also assess the extent to which Projects contribute to these targets through reductions, as well as identify opportunities to reduce emissions through alternative measures

Adaptation to climate change

In terms of climate change adaptation, different types of alternatives measures are available for decision-makers to use in planning the adaptation of projects to climate change. The most appropriate mix of alternatives and/or mitigation measures will depend on the nature of the decision being made and the sensitivity of that decision to specific climate impacts and the level of tolerated risk as determined according to the methodology in section 3.2 of the main text. Key considerations include:

— 'no-regret' or 'low-regret' options that yield benefits under different scenarios;

— 'win-win-win' options that have the desired impacts on climate change, biodiversity and ecosystem services, but also have other social, environmental or economic benefits;

— favouring reversible and flexible options that can be modified if significant impacts start to occur;

— adding 'safety margins' to new investments to ensure responses are resilient to a range of future climate impacts;

— promoting soft adaptation strategies, which could include building adaptive capacity to ensure a project is better able to cope with a range of possible impacts (e.g. through more effective forward planning);

— shortening project times;

— delaying projects that are risky or likely to cause significant effects.

If, based on an assessment of specific risks and constraints, alternatives and mitigation measures are considered impossible or too expensive, the project may have to be abandoned.

There are EIA-mitigation measures for climate change adaptation and risk management, for instance to strengthen the project's capacity to adapt to increasing climate variability and climate change (e.g. building in early warning or emergency/disaster preparedness):

— Risk reduction mechanisms (e.g. insurance);

— Measures that control or manage certain identified risks (e.g. choice of project location to reduce exposure to natural disasters);

— Measures that improve the project's ability to operate under identified constraints (e.g. choice of most water efficient or energy-efficient options);

— Measures that better exploit certain opportunities offered by the natural environment.

Assessing significant effects

Many assessment approaches used in the EIA process have the capacity to address climate change. There are, however, three fundamental issues that one should consider when addressing climate change: the long-term and cumulative nature of effects, complexity of the issues and cause-effect relationships, and uncertainty of projections.

Long-term and cumulative nature of effect

Climate change is a complex issue with long-term impacts and consequences. EIAs that aim to properly address it should consider this and assess the combined impact of any number of different effects. This requires an understanding of evolving baseline trends and an assessment of the cumulative effects of the project on the changing baseline.

There are a number of tips and approaches to be considered when assessing the cumulative effects of climate change in EIA:

— Recognise **cumulative effects** early on in the EIA process, in the scoping stage if possible. Talking to the right stakeholders as early as possible can give the wide overview needed to better understand how seemingly insignificant individual effects can have greater consequences when considered together.

— Pay attention to the **evolving baseline** when assessing the cumulative effects of climate change impacts. The current state of the environment will not necessarily be the future state of the environment, even if the proposed project does not go ahead. A changing climate may mean that the design and operational management of a project meant for a certain climate scenario will no longer be relevant in 20 years' time. For instance, warmer summers may increase the susceptibility of materials to heat deformation or increase the risk of wildfires to a project. Considering potential impacts such as these is a unique challenge of climate change within EIA.

— Where possible, use causal chains or network analysis to understand the **interactions and associated cumulative effects** between specific elements of the project and aspects of the environment. The point is not to be comprehensive, but to understand which cumulative effects might be most significant. These can often be identified with stakeholders who can help work through potential pathways in causal chains.

Complexity of the issues and cause-effect relationships

Many of the recommendations regarding assessing a project's long-term and cumulative effects addressed in the previous section will also help address the complexity of climate change and understand the cause-effect relationship it has with other issues assessed within an EIA.

The complexity of climate change should not deter one from analysing direct and indirect impacts the proposed project could have on trends in key issues. At times, this will require simplified models that give best estimates of emissions and impacts, e.g. using best-case and worst-case scenarios to illustrate different future states under various assumptions.

Judging an impact's magnitude and significance must be context-specific. For an individual project – e.g. a road project – the contribution to GHG emissions may be insignificant on the global scale, but may well be significant on the local/regional scale, in terms of its contribution to set GHG-reduction targets. As described above, using casual chains or network analysis should help to understand the complexity of the issues and cause-effect relationships.

The impact of climate change on the project (adaptation)

The Directive also requires that Environmental Impact Assessments consider the impacts that climate change may have on the project itself – and the extent to which the project will be able to adapt to possible changes in the climate over the course of its lifetime.

This aspect of the issue of climate change can be particularly challenging as it:

— requires those carrying out the assessment to consider the impacts of the environment (the climate in this case) on the project, rather than vice-versa;

— often involves a considerable degree of uncertainty, given that the actual climate change impacts, especially at local levels, are challenging to predict. To this end, the EIA analysis should take trends and risk assessment into consideration, while following the methodology described in section 3.2 of the main text.

Uncertainty

One of the tasks of describing expected impacts is to help audiences understand what is known with a high degree of confidence and what is relatively poorly understood. Decision-makers and stakeholders are used to dealing with uncertainty all the time (e.g. economic growth, technological change) and they will be able to use such information. It will be important to reassure them that considering a range of possible uncertain futures and understanding the uncertainties is part of good EIA practice and permits better and more flexible decisions. The key principle in communicating uncertainty is avoiding complex or obscure language. Those undertaking EIA should describe the sources of uncertainty, characterise its nature and explain the meaning of phrases used. Using everyday language to describe uncertainty can makes the concept more accessible, but there is a risk of misunderstanding, as people may have personal and differing interpretations of terms like 'high confidence'.

The European Climate Adaptation Platform, Climate-ADAPT ([10]), for instance, offers uncertainty guidance, which aims to help decision-makers to understand the sources of uncertainty in climate information that are most relevant for adaptation planning. It also provides further suggestions for dealing with uncertainty in adaptation planning and for communicating uncertainty.

Monitoring and adaptive management

Monitoring of projects with significant adverse effects is now mandatory under the EIA Directive. It can also be identified and implemented as an EIA-mitigation measure. For example, such monitoring measures could be linked to the environmental conditions set in the development consent as a result of the EIA procedure.

This guidance emphasises the importance of analysing long-term trends related to climate change, assessing direct and indirect impacts of proposed projects on these trends, acknowledging assumptions and uncertainty in the assessment process and ideally choosing a project design and implementation that allows for changes in light of lessons learnt. If project implementation does allow for changes to be made, EIA practitioners may find it useful to consider the principles of adaptive management.

([10]) https://climate-adapt.eea.europa.eu/knowledge/tools/uncertainty-guidance

A key feature of adaptive management is that decision-makers seek development strategies that can be modified once new insights are gained from experience and research. Learning, experimenting and evaluation are key elements of this approach. Adaptive management requires the flexibility to change decisions as new information becomes available. While this may not always be possible, project development designs and permits should increasingly allow for changes in project structure and operation, if changes in the environmental context make them necessary (e.g. increasing severity of flooding, droughts, and heatwaves).

EIA may facilitate adaptive management by clearly acknowledging assumptions and uncertainty and proposing practical monitoring arrangements to verify the correctness of the predictions made and bring any new information to the attention of decision-makers. When designing such systems, EIA practitioners will need to expand project-owners' and stakeholders' knowledge and awareness, ensure their commitment, and propose approaches to project implementation that provide for flexibility.

D.4. **INTEGRATION OF CLIMATE CHANGE INTO EIA, CRITICAL CHALLENGES**

The main ways of incorporating climate change into EIA can be summarised as follows:

— The project manager may nominate a climate-proofing manager early in the project development;

— Build climate change into the assessment process at an early stage of the screening and scoping as well as into the project cycle management from the outset;

— Tailor how to incorporate climate change to the specific context of the project;

— Bring together all stakeholders who need to be part of climate change related decision-making;

— Understand how climate change may interact with other issues to be assessed in the EIA (e.g. biodiversity).

Critical challenges to be looked at for addressing climate change in EIA include e.g.:

— Consider the impact that predicted changes in climate will have on the proposed project, potentially over a long timescale, and the project's resilience and capacity to cope;

— Consider long-term trends, with and without the proposed project, and avoid 'snapshot' analyses;

— Manage complexity;

— Consider the complex nature of climate change and the potential of projects to cause cumulative effects;

— Be comfortable with uncertainty, because you can never be sure of the future (e.g. use tools such as scenarios);

— Base your recommendations on the precautionary principle and acknowledge assumptions and the limitations of current knowledge;

— Be practical and use your common sense! When consulting stakeholders, avoid drawing out the EIA procedure and leave enough time to properly assess complex information.

How to assess effects related to climate change in EIA:

— Consider climate change scenarios from the outset and include extreme climate situations and 'big surprises';

— Analyse the evolving climate and environmental baseline trends;

— Seek to avoid climate change effects from the start, before considering mitigation;

— Assess alternatives that make a difference in terms of climate change mitigation and adaptation;

— Use ecosystem-based approaches and green infrastructure as part of project design and/or mitigation measures;

— Assess climate change and e.g. biodiversity synergies and cumulative effects, which can be significant.

D.5. EXAMPLES OF KEY QUESTIONS ON CLIMATE MITIGATION FOR THE EIA

Table 13 provides examples of key questions for the EIA as regards the mitigation of climate change. The **optimal timing** of these questions (and those in Table 14 on adaptation) should be determined vis-à-vis the climate-proofing process, the EIA process, options analysis, and more generally the project cycle management.

Table 13

Examples of key questions on climate mitigation for the EIA

Main concerns related to:	Some key questions for identifying climate mitigation issues	Examples of alternatives and measures related to climate mitigation
Paris alignment and 'do no significant harm'	Infrastructure investments should be aligned with the goals of the Paris Agreement and compatible with a credible pathway to net zero GHG emissions scenario and climate neutrality by 2050. Furthermore, investments in infrastructure projects should do no significant harm to other EU environmental objectives such as the sustainable use and protection of water and marine resources, the transition to a circular economy, waste prevention and recycling, pollution prevention and control and the protection of healthy ecosystems.	
Direct GHG emissions	Will the proposed project emit carbon dioxide (CO_2), nitrous oxide (N_2O) or methane (CH_4) or any other GHG part of the UNFCCC? Does the proposed project entail any land use, land-use change or forestry activities (e.g. deforestation) that may lead to increased emissions? Does it entail other activities (e.g. afforestation) that may act as emission sinks?	Consider different technologies, materials, supply modes, etc. to avoid or reduce emissions; Take into account the need to protect natural carbon sinks that could be endangered by the project, such as local peat soils, woodlands, wetland areas, forests; Plan possible carbon offset measures, available through existing offset schemes or incorporated into the project (e.g. planting trees).
Indirect GHG emissions due to an increased demand for energy	Will the proposed project significantly influence demand for energy? Is it possible to use renewable energy sources?	Use recycled / reclaimed and low-carbon construction materials; Build energy efficiency into the design of a project (e.g. include insulation, south facing windows for solar energy, passive ventilation and low-energy light bulbs); Use energy-efficient machinery; Make use of renewable energy sources
Indirect GHG emissions caused by any supporting activities or infrastructure that is directly linked to the implementation of the proposed project (e.g. transport)	Will the proposed project significantly increase or decrease personal travel? Will the proposed project significantly increase or decrease freight transport?	Choose a site that is linked to a public transport system or put in place transport arrangements; Provide low-emission infrastructure for transport (e.g. electric charging bays, cycling facilities).

D.6. **EXAMPLES OF KEY QUESTIONS ON CLIMATE ADAPTATION FOR THE EIA**

The following table provides examples of key questions for the EIA as regards the adaptation of climate change:

Table 14

Examples of key questions on climate adaptation for the EIA

Main concerns related to:	Some key questions for identifying climate adaptation issues	Examples of alternatives and measures related to climate adaptation
Climate resilience	Infrastructure investments should have an adequate level of resilience to acute and chronic climate extremes, be aligned with the goals of the Paris Agreement (i.e. global goal on adaptation), and contribute to the Sustainable Development Goals and the objectives of the Sendai Framework for Disaster Risk Reduction	
Heatwaves	Will the proposed project restrain air circulation or reduce open spaces? Will it absorb or generate heat? Will it emit volatile organic compounds (VOCs) and nitrogen oxides (NOx) and contribute to tropospheric ozone formation during sunny and warm days? Can it be affected by heatwaves? Will it increase energy and water demand for cooling? Can the materials used during construction withstand higher temperatures (or will they experience, for example, material fatigue or surface degradation)?	Ensure that the proposed project is protected from heat exhaustion; Encourage design optimal for environmental performance and reduce the need for cooling; Reduce thermal storage in a proposed project (e.g. by using different materials and colouring)
Drought	Will the proposed project increase water demand? Will it adversely affect the aquifers? Is the proposed project vulnerable to low river flows or higher water temperatures? Will it worsen water pollution – especially during periods of drought with reduced dilution rates, increased temperatures and turbidity? Will it change the vulnerability of landscapes or woodlands to wild fires? Is the proposed project located in an area vulnerable to wild-fires? Can the materials used during construction withstand higher temperatures?	Ensure that the proposed project is protected from the effects of droughts (e.g. use water-efficient processes and materials that can withstand high temperatures); Install livestock watering ponds within animal-rearing systems; Introduce technologies and methods for capturing storm water; Put in place state-of-the-art wastewater treatment systems that make reusing water possible.

Main concerns related to:	Some key questions for identifying climate adaptation issues	Examples of alternatives and measures related to climate adaptation
Wildfires, forest fires	Is the proposed project area exposed to fire risks Are the materials used during construction resistant to fire? Does the proposed project increase fire risk (e.g. by means of vegetation in the project area?)	Use fire-resistant construction materials; Create a fire-adapted space in and around the project area
Flood regimes and extreme rainfall events	Will the proposed project be at risk because it is located in a riverine flooding zone? Will it change the capacity of existing flood plains for natural flood management? Will it alter the water retention capacity in the watershed? Are embankments stable enough to withstand flooding? Will the project be a risk from raising levels of near-surface ground water?	Consider changes in construction design that allow for rising water levels and ground water levels (e.g. build on pillars, surround any flood-vulnerable or flood-critical infrastructure with flood barriers that use the lifting power of approaching floodwater to automatically rise, set up backwater valves in drainage-related systems to protect interiors from flooding caused by backflow of wastewater). Improve the project's drainage.
Storms and wind gusts	Will the proposed project be at risk because of storms and strong winds? Can the project and its operation be affected by falling objects (e.g. trees) close to its location? Is the project's connectivity to energy, water, transport and ICT networks ensured during high storms?	Ensure a design that can withstand increased high winds and storms
Landslides	Is the project located in an area that could be affected by extreme precipitation and land-slides?	Protect surfaces and control surface erosion (e.g. by quickly establishing vegetation – hydroseeding, turfing, trees); Put in place designs that control erosion (e.g. appropriate drainage channels and culverts).
Sea-level rise, storms, surge, coastal erosion, hydrological regimes, and saline intrusion	Is the proposed project located in areas that may be affected by rising sea levels? Can seawater surges caused by storms affect the project? Is the proposed project located in an area at risk of coastal erosion? Will it reduce or enhance the risk of coastal erosion? Is it located in areas that may be affected by saline intrusion? Can seawater intrusion lead to leakage of polluting substances (e.g. waste)?	Consider changes in construction design to allow for rising sea levels, e.g. building on pillars.

Main concerns related to:	Some key questions for identifying climate adaptation issues	Examples of alternatives and measures related to climate adaptation
Cold spells	Can the proposed project be affected by short periods of unusually cold weather, blizzards or frost? Can the materials used during construction withstand lower temperatures? Can ice affect the functioning/operation of the project? Is the project's connectivity to energy, water, transport and ICT networks ensured during cold spells? Can high snow loads have an impact on the construction's stability?	Ensure that the project is protected from cold spells and snow (e.g. use construction materials that can withstand low temperatures and make sure the design can resist snow build-up)
Freeze-thaw damage	Is the proposed project at risk of freeze-thaw damage (e.g. key infrastructure projects)? Can the project be affected by thawing permafrost?	Ensure that the project (e.g. key infrastructure) is able to resist winds and prevent moisture from entering the structure (e.g. by using different materials or engineering practices)

ANNEX E

Climate proofing and strategic environmental assessment (SEA)

The Strategic Environmental Assessment (SEA) will usually provide important framework conditions for subsequent infrastructure projects, including as regards climate change.

As illustrated in Figure 23, the project promoter is not necessarily involved in the SEA and the 'STRATEGY/PLAN' phase at the beginning of the project cycle. Therefore, this annex is primarily intended for the public authorities, policymakers, planners, SEA practitioners and experts, and other stakeholders involved in SEA processes.

The aim is to support the integration of climate change mitigation and adaptation considerations into the SEA and the framework conditions that may steer the climate proofing of subsequent infrastructure projects.

In turn, this may support the achievement of the EU Climate Objectives and the goals of the Paris Agreement.

E.1. **INTRODUCTION**

The Strategic Environmental Assessment (SEA) is defined by Directive 2001/42/EC of the European Parliament and of the Council [1] (hereafter referred to as the SEA Directive).

The SEA Directive applies to a wide range of public plans and programmes. These plans and programmes must be prepared or adopted by an authority (at national, regional or local level) and be required by legislative, regulatory or administrative provisions.

Climate change may be an important component of the Strategic Environmental Assessment (SEA) of a plan or programme. This applies to both pillars of climate proofing, i.e. climate change mitigation and adaptation.

Lessons-learned from the climate proofing of major projects in the 2014-2020 period indicate that decisions taken at the SEA stage and/or early in the project development cycle may have significant influence on the climate proofing of infrastructure projects.

A SEA is mandatory for **public plans and programmes** that (1) are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste / water management, telecommunications, tourism, town & country planning or land use and which set the framework for future development consent of projects listed in the EIA Directive; or (2) have been determined to require an assessment under the Habitats Directive.

The legal requirements for environmental assessments stemming from the Strategic Environmental Assessment (SEA), Habitats, and Water Framework Directives fully apply to the preparation of, for instance, EU co-financed programmes drawn up for the 2021-2027 period under the Common Provisions Regulation (CPR).

EU co-financed programmes developed in sectors not covered by the SEA Directive (for instance, social action, migration, security or border management) may not necessarily require such assessment. Experience has shown that the interventions supported by such programmes in many cases do not involve works or infrastructure laid down in the annexes of the EIA Directive and does not therefore set the framework for projects in the sense of the SEA Directive. However, if such programmes set the framework for the development consent of projects listed in the annexes of the EIA Directive (such as the construction of schools, hospitals, accommodation facilities for migrants, transnational or cross-border infrastructure), it is necessary to determine if they are likely to have significant environmental effects. If the screening concludes that no assessment is necessary, the reasons for this should be made public.

(1) Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (OJ L 197, 21.7.2001, p. 30), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32001L0042

To be effective, the environmental assessments have to be carried out as early as possible in the preparatory phase of the programmes. This will strengthen the environmental integration, contribute to their social acceptance, and ensure that any likely significant negative impacts on the environment are duly addressed.

Broadly speaking, for the plans/programmes not included above, the Member States have to carry out a screening procedure to determine whether the plans/programmes are likely to have significant environmental effects. If there are significant effects, an SEA is needed. The screening procedure is based on criteria set out in Annex II of the SEA Directive.

The SEA procedure can be summarized as follows: an environmental report is prepared in which the likely significant effects on the environment and the reasonable alternatives of the proposed plan or programme are identified. The public and the environmental authorities are informed and consulted on the draft plan or programme and the environmental report prepared. As regards plans and programmes that are likely to have significant effects on the environment in another Member State, the Member State in whose territory the plan or programme is being prepared must consult the other Member State(s).

The environmental report and the results of the consultations are taken into account before adoption. Once the plan or programme is adopted, the environmental authorities and the public are informed and relevant information is made available to them. In order to identify unforeseen adverse effects at an early stage, significant environmental effects of the plan or programme are to be monitored.

As mentioned in the European Commission *Guidance on Integrating Climate change and Biodiversity into SEA* ([2]), the strategic environmental assessments provide an opportunity to integrate systematically climate change in a standardised approach into plans and programmes across the EU.

There are considerable benefits, not to mention cost-effectiveness, of considering climate change mitigation and adaptation, biodiversity, and other environmental issues together.

The SEA Directive, Annex I(f), requires an environmental report to consider the effects on 'climate factors' as well as the 'interrelationship' between all the listed factors.

The consideration of climate change will feed into the planning stage, which is the most relevant in particular for sectors like transport, where the main decisions especially for climate change mitigation are taken at this stage (e.g. favouring certain lower impact transport modes, policies, mobility patterns/habits). This is also true then for any projects that result from the implementation of a particular public plan/programme, as well as any associated EIAs or Article 6(3) appropriate assessments under the Habitats Directive.

As regards long-term risks, the potential impacts of climate change on infrastructure warrants a shift in thinking from the traditional assessment of the effects of a public plan/programme on the environment alone, to one where the likely long-term risks associated with climate change are also taken into account.

Building climate resilience into public plans/programmes can often be seen as instrumental in creating an adaptive management response to climate change.

The Commission has provided guidance ([3]) on integrating climate change into the SEA.

([2]) Guidance on Integrating Climate Change and Biodiversity into Strategic Environmental Assessment (SEA), ISBN 978-92-79-29016-9, https://ec.europa.eu/environment/eia/pdf/SEA%20Guidance.pdf

([3]) Guidance on Integrating Climate Change and Biodiversity into Strategic Environmental Assessment (SEA), ISBN 978-92-79-29016-9, https://ec.europa.eu/environment/eia/pdf/SEA%20Guidance.pdf

Key issues include:

— How will the public plan/programme influence climate change (e.g. reducing or increasing the atmospheric concentration of GHG) or be influenced by climate change (e.g. increasing the risks of weather and climate extremes)?

— What is it about climate change that poses a challenge to the assessment process?

— How will climate change affect the information needs – what type of information, what sources and what stakeholders will hold information and specific knowledge in these areas?

— What are the key climate change aspects to cover in the detailed assessment and how important will those issues be in decision-making?

Table 15

Examples of climate change issues to consider as part of SEA

Mitigation of climate change	Adaptation to climate change
— Energy demand in industry and related GHG emissions — Energy demand in housing and construction and related GHG emissions — GHG emissions in agriculture — GHG emissions in waste management — Travel patterns and GHG emissions from transport — GHG emissions from energy production — Land use, land-use change, forestry and biodiversity	— Heatwaves (including impact on human, animal, and plant health, damage to crops, and forest fires) — Droughts(including decreased water availability and quality and increased water demand) — Flood management and extreme rainfall events — Storms and high wind (including damage to infrastructure, buildings, crops and forests), landslides — Sea-level rise, extreme storms, coastal erosion and saline intrusion — Cold spells, freeze-thaw damage

How to address climate change effectively in SEA:

— Build climate change into the SEA process and the public plans and programmes from the earliest stages and follow them throughout – start at the screening and scoping stages to build these issues into the mind-set of all the key parties, i.e. competent authorities and policymakers, planners, SEA practitioners and other stakeholders. Being an upstream process the SEA can be used as a creative process to support learning amongst all these parties;

— The consideration of climate change issues must be tailored to the specific context of the public plan/programme. It is not simply a checklist of issues to tick off. Each SEA can potentially be different;

— Be practical and use common sense! When consulting stakeholders, avoid drawing out the SEA procedure and leave enough time to properly assess information (i.e. the respective plan/programme and the environmental report);

— Use the SEA as an opportunity to address key issues regarding different or specific types of projects. At this time, many options (e.g. consideration of alternatives) are still open which can be used to avoid potentially problematic situations at the EIA/project level.

Among the critical challenges for addressing climate change in SEA are (examples):

— Assess the public plan/programme and how it is:

  — aligned with the goals of the Paris Agreement and EU climate objectives,

  - — compatible with having a place in the transition to net zero GHG emissions and climate neutrality by 2050, including the GHG reduction targets for 2030,
  - — ensuring/facilitating investments that ‘do no significant harm’ on the concerned environmental objectives, and
  - — ensuring an adequate level of resilience to acute and chronic impacts of climate change;

- — Consider long-term trends both with and without the proposed public plan/programme and avoid ‘snapshot’ analyses;
- — Assess the public plan/programme against the future baseline and key trends and their drivers taking into account other public plans/programmes.
- — Consider the impact that predicted changes in the climate will have on the proposed public plan/programme, potentially over a long timescale, and its resilience and capacity to cope;
- — Manage complexity, consider whether implementation of part of a public plan/programme e.g. climate change mitigation, that might otherwise be positive in its impact, could have a negative impact on climate change adaptation and/or biodiversity;
- — Consider what existing climate change objectives and targets need to be integrated into the public plan/programme;
- — Consider the long-term and cumulative effects on climate change and other environmental and social issues such as biodiversity of public plan/programme or accessibility for persons with disabilities as these will be potentially significant given the complex nature of these topics;
- — Be comfortable with uncertainty. Use tools such as scenarios to help deal with the uncertainty inherent within complex systems and imperfect data. Think about risks when impacts are too uncertain and factor this into monitoring to manage adverse effects;
- — Develop more resilient alternatives and solutions based on ‘win-win’ or ‘no regret’/‘low regret’ approaches to public plan/programme development, given the uncertainty inherent in climate change and predicting impacts on biodiversity as well as society in particular for men and women that depend on natural resources for their income/livelihoods or due to certain socio-economic characteristics have lower adaptive capacity to climate change;
- — Develop more resilient alternatives and solutions to safeguarding both tangible and intangible cultural heritage;
- — Prepare for adaptive management and monitor to improve adaptive capacity;
- — Base your recommendations on the precautionary principle and acknowledge assumptions and limitations of current knowledge.

How to identify climate issues in SEA (examples):

- — Identify key climate change issues early in the process, but be flexible and review them as new issues emerge along the plan/programme preparation;
- — Identify and bring together all the stakeholders and environmental authorities to help identify the key issues;
- — Investigate how climate change interact with other environmental issues such as biodiversity;
- — Use ecosystem services to provide a framework for assessing the interactions between biodiversity and climate change.
- — Remember to consider both the impacts of the public plan/programme on climate and climate change and the impact of a changing climate and natural environment on the public plan/programme;

— Investigate how climate change mitigation and adaptation interact with each other (e.g. remember that a positive effect on climate change mitigation may lead to negative effects on climate resilience and adaptation, and vice-versa);

— Consider the national, regional and local context as appropriate, depending on the scale of the public plan/programme. You may also need to consider the European and global context;

— Consider the objectives, commitments and targets set in policy and how to integrate them into the public plan/programme. Consider the climate effects from alternative selection. For example, to what extent is it possible to prefer implementing brownfield plan/programmes instead of more climate damaging greenfield ones. Consider the re-use of existing resources. Consider the network structures that ensure highest resilience and generated the least GHG emissions. A similar approach can be used for urban planning/development.

How to assess the effects related to climate change in SEAs (examples):

— Consider climate change scenarios at the outset. Include extreme weather and climate situations and 'big surprises' that may either adversely affect implementation of the public plan/programme or may worsen its impacts on e.g. biodiversity and other environmental factors and social factors in particular on men and women that depend on natural resources for their income/livelihoods and the safeguarding of cultural heritage, or due to certain socio-economic characteristics have lower adaptive capacity to climate change;

— Analyse the evolving environmental baseline trends. Include trends in key issues over time, drivers for change, thresholds and limits, areas that may be particularly adversely affected and the key distributional effects. Use vulnerability assessments to help assess changes to the baseline environment and identify the most resilient alternative(s);

— Where relevant, take an integrated, 'ecosystems' approach to planning and examine the thresholds and limits;

— Look for opportunities for enhancement. Ensure that the public plans/programmes are consistent with other relevant policy objectives including climate policy objectives, and priority actions for climate change and e.g. biodiversity;

— Assess alternatives that make a difference in terms of climate change effects – review the need, the process for its implementation, locations, timings, procedures, and alternatives that enhance ecosystem services including for carbon sequestration and climate resilience;

— First, seek to avoid climate change effects and then mitigate;

— Assess climate change and biodiversity synergistic/cumulative effects. Causal chains/network analysis may be helpful to understand interactions;

— Monitor the effectiveness that adaptive management has been built into the public plan/programme and whether it is being delivered.

> In light of the above, the project promoter should verify – as early as possible in the project cycle – whether the project falls under one or more plans and/or programmes, which were subject to SEA, and how the project contributes to the objectives of those plans and programmes. The relevant references should be included in the available project documentation as it among others represents added value of the project to the climate objectives in the plans and programmes.

Where a project falls under one or more plans and/or programmes that have not been subject to SEA but include climate objectives, it is recommended to include the relevant references in the project documentation.

E.2. **SEA AND THE MITIGATION OF CLIMATE CHANGE**

Table 16 provides indicative examples of key questions for the SEA of a public plan/programme in relation to the mitigation of climate change. The **optimal timing** of these questions (and those in Table 17 on adaptation) should be determined vis-à-vis the SEA and other related processes.

Table 16

Key questions for the SEA related to the mitigation of climate change

Main concerns related to:	Some key questions for identifying climate change mitigation issues	Examples of alternatives and measures related to climate change mitigation
Transition to a low-carbon economy and society	Consistency with the temperature goal of the Paris Agreement (Art. 2) and the transition to net zero GHG emissions and climate neutrality by 2050. Consistency with the EU long-term strategy and emission targets for 2030. Consistency with the National Energy and Climate Plan (NECP) (when amended in 2023 with regard to the new EU targets for 2030 and climate neutrality by 2050). Consistency with the 'energy efficiency first' principle. Consistency with the principle of 'do no significant harm' to the concerned environmental objectives.	Low-carbon transition of industry, housing, construction, agriculture, waste management, travel and transport, energy production, forestry and biodiversity towards climate neutrality by 2050.
Energy demand in industry	Will the proposed public plan/programme increase or decrease demand for energy in industry? Does the public plan/programme encourage or limit opportunities for low-carbon businesses and technologies?	Reducing demand for conventional energy (electricity or fuel) in industry Alternative low-carbon sources (onsite or through specific low-carbon energy supplier) Targeted support to businesses engaged in eco-innovations, low-carbon business and low-carbon technologies Potential synergies between adaptation and GHG emissions reduction
Energy demand in housing and construction	Will the public plan/programme increase or decrease demand for construction of housing and for energy use in housing?	Improve the energy performance of buildings e.g. Renovation Wave [4] Alternative low-carbon sources (onsite or through specific low-carbon energy suppliers) Potential synergies between adaptation and GHG emissions reduction

[4] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

Main concerns related to:	Some key questions for identifying climate change mitigation issues	Examples of alternatives and measures related to climate change mitigation
GHG emissions in agriculture	Will the public plan/programme increase or decrease generation of methane and nitrous oxide in agriculture? Will the public plan/programme increase or decrease the efficiency of the use of nitrogen in fertilising practices? Will the public plan/programme adversely affect or protect carbon rich soils?	Reducing excess of nitrogen in fertilising practices Managing methane (enteric and manure) Protecting natural carbon sinks, such as peat soils Potential synergies between adaptation and GHG emissions reduction Harvesting methane emissions for biogas production
GHG emissions in waste management	Will the public plan/programme increase waste generation? Will the proposed public plan/programme influence the waste management system? How will these changes affect emissions of carbon dioxide and methane from waste management?	Consider ways in which the public plan/programme can increase waste prevention, re-use and recycling, particularly to divert waste from landfill Consider ways of producing energy through waste incineration or producing biogas from wastewater and sludge Alternative low-carbon sources (onsite or through specific low-carbon energy supplier) Potential synergies between adaptation and GHG emissions reduction
Travel patterns and GHG emissions from transport	Will the public plan/programme increase personal travel – the number and length of journeys and the mode of travel? Will it entail a shift from more-emitting to less-emitting modes of travel (e.g. from personal cars to public transport or from buses to electric trains)? Can the public plan/programme significantly increase or decrease freight transport GHG emissions? How can the public plan/programme enhance or stimulate the provision of sustainable transport infrastructure or technologies – for instance electric vehicle charging points and hydrogen fuel cells?	Promote public plan/programme patterns that reduce the need to travel, such as e-services and tele-working Support car-free public plans/programmes Encourage walking and cycling Encourage public transport Provide transport choices to encourage a modal shift to cleaner modes (e.g. from cars to trains), such as an effective and integrated public transport system Transport demand management schemes Encourage car sharing Prioritise high density urban public plans/programmes (smaller housing at higher density) and reuse of brownfield land
GHG emissions from energy production	Will the public plan/programme increase or decrease energy consumption? How will these changes in energy demand affect the energy supply mix? What implications will this change in energy supply have on GHG emissions from energy production?	Generic recommendations are intentionally not provided as these are context-specific, depending upon the energy production capacity and energy supply sources of the area in question Potential synergies between adaptation and GHG emissions reduction
Forestry and biodiversity	What opportunities could the public plan/programme give for carbon sequestration via investment in forestry and biodiversity?	Investment in wetlands to support carbon protection to avoid emissions, and offset the public plan/programme's GHG emissions

E.3. **SEA AND THE ADAPTATION TO CLIMATE CHANGE**

The following table provides indicative examples of key questions for the SEA of a public plan/programme in relation to the adaptation to climate change.

Table 17

Key questions for the SEA related to the adaptation to climate change

Main concerns related to:	Some key questions for identifying climate change adaptation issues	Examples of alternatives and measures related to climate change adaptation
Transition to a climate-resilient economy and society	Consistency with the global goal on adaptation of the Paris Agreement Consistency with a transition towards climate resilience (with an adequate level of resilience to acute and chronic climate change impacts) Consistency with the relevant National/Regional/Local/City Strategy and/or plans on adaptation to climate change (where available) Consistency with the Member State reporting on adaptation as per the Regulation on Governance of the Energy Union and Climate Action Consistency with the EU Strategy on adaptation to climate change	See Annex F Recommendations in support of climate proofing
Heatwaves	What are the key terrestrial habitats and migration corridors that may be significantly affected by heatwaves? How will the proposed public plan/programme impact on them? What urban areas, population groups or economic activities are most vulnerable to heatwaves? How will the public plan/programme impact on them? Does the public plan/programme reduce or enhance the ‘urban heat island’ effect? Will the public plan/programme increase or reduce the resilience of landscape/forests to wild-fires?	Avoid development patterns that fragment habitat corridors or, for linear infrastructures, make sure that habitat continuity is restored in the most sensitive areas Improvements in urban structure e.g. expansion of green areas, open water surfaces and wind paths (along rivers and waterfronts) in urban areas to reduce the possible heat island effect Encourage greater use of green roofs, isolation, passive ventilation methods, and expansion of vegetated areas. Reduce man-made exhausts during heatwaves (industries, and car traffic) Awareness-raising about risks associated with heatwaves and action to reduce them Heatwave early warning systems and response plans Potential synergies between adaptation and GHG emission reduction

Main concerns related to:	Some key questions for identifying climate change adaptation issues	Examples of alternatives and measures related to climate change adaptation
Drought	What are the key terrestrial habitats and migration corridors and cultural heritage that may be significantly affected by droughts? How will the public plan/programme impact on them? Will the public plan/programme increase water demand and to what extent? Are there any potential significant risks associated with worsening water quality during droughts (e.g. increased pollution concentrations due to limited dilution, saline intrusion)? Which freshwater bodies will be exposed to excessive water pollution – especially during droughts when the pollution will become less diluted in reduced river volumes?	Encourage water efficiency measures Explore efficient use/re-use of rainwater and grey water Restrictions on excessive/non-essential use water use during droughts (depending on their severity) Minimise low flow withdrawals Restrictions for effluent discharges into water bodies during droughts Maintain and improve the resilience of watersheds and aquatic ecosystems by implementing practices that protect, maintain, and restore watershed processes and services
Flood regimes and extreme rainfall events	What infrastructure (e.g. existing or planned road segments, water supply, energy) is at risk due to its location in flood zones? Is the capacity of drainage networks sufficient to handle potential extreme rainfall? Does the design of drainage systems prevent channelling drainage water into lower laying areas? Will the proposed public plan/programme reduce or enhance the capacity of ecosystems and flood plains for natural flood management? Will the proposed public plan/programme increase the exposure of the vulnerable (e.g. the elderly, unwell or young people, as well as people that depend on natural resources for their income/livelihoods and cultural heritage + people with certain socio-economic characteristics that have lower adaptive capacity), or sensitive receptors (e.g. critical infrastructure) to floods, or impact cultural heritage?	Ensure that any existing or planned essential infrastructure is protected from future flood risk In high risk areas, consider arrangements for supply of goods/services that may be disturbed by floods Increase resilience to floods through use of sustainable drainage systems Enhance permeable surfaces and green spaces in new public plans/programmes Avoid decreasing storage volumes in flood plains
Storms and wind gusts	What areas and infrastructure and e.g. cultural heritage will be at risk because of storms and strong winds?	Ensure new infrastructure considers the impacts of increased high winds and storms In high-risk areas, consider arrangements for supply of goods/services that may be disturbed by increased storm events
Landslides	What property, persons or environmental assets and e.g. cultural heritage are at risk because of landslides and their vulnerability?	Avoid new developments in areas at risk from erosion Protect and expand native woodland cover In high-risk areas, consider arrangements for supply of goods/services that may be disturbed by land-slides

Main concerns related to:	Some key questions for identifying climate change adaptation issues	Examples of alternatives and measures related to climate change adaptation
Cold spells	What areas and critical infrastructure and e.g. cultural heritage will be at risk because of short periods of unusually cold weather, blizzards or frost?	Ensure that any existing or planned essential infrastructure is protected from cold spells
Freeze-thaw damage	What key infrastructure (e.g. roads, water pipes, cultural heritage) is at risk of freeze-thaw damage?	Ensure that key infrastructure (e.g. roads, water pipes) is able to resist wind action and to prevent moisture from entering the structure by (e.g. different formulations of materials)
Sea-level rise, storms, surge, coastal erosion, hydrological regimes, and saline intrusion	What are the key aquatic, riverine and coastal habitats and migration corridors and cultural heritage elements that may be significantly adversely affected by sea-level rise, coastal erosion, changes in hydrological regimes and salinity levels? How will the proposed public plan/programme impact on them? What are the key infrastructural assets (e.g. road segments and intersections, water supply infrastructure; energy infrastructure; industrial zones and major landfills) at risk due to their location in areas that may be inundated by sea-level rise or subject to coastal erosion? Will the proposed public plan/programme reduce or increase these risks? What areas may be affected by saline intrusion? Will the proposed public plan/programme reduce or increase these risks? Impact on costal populations and men/women that depend on coastal ecosystems for their incomes	Avoid public plans/programmes that promote development in coastal areas at risk of rising sea levels, coastal erosion and flooding, except for projects for which this risk is taken into account, such as port development Move water intakes and any economic activities that depend on the supply of clean water or ground water away from areas that will be affected by saline intrusion Potential synergies between adaptation and GHG emission reduction

ANNEX F

Recommendations in support of climate proofing

F.1. ENABLING FRAMEWORK AT NATIONAL, REGIONAL AND LOCAL LEVEL

Infrastructure projects are developed within a broad framework including for instance legislation, spatial strategies, sector strategies, plans, data, guidance, methodologies, tools, and design standards.

Member States fulfil an important role in defining the enabling framework supporting the development and climate proofing of infrastructure projects.

The enabling framework should have a clear climate-policy delivery focus, relying on regional strategies and local plans to realise the reduction of GHG emissions and the adaptation to climate change.

The enabling framework may for instance include the following and other relevant components:

— A clear national planning policy framework with strong attention to climate change policy, adequately underpinned by sectoral strategies, plans or programmes and legislation where applicable.

— Adequate attention to climate change adaptation and mitigation.

— Integration of climate change in the relevant national/regional/local building codes, standards, practices, and other requirements and policies.

— Development of guidance documents on climate proofing suitable for the local context and in the local language.

— Integration of climate change considerations and assessment at the planning/strategic level. Planning processes giving due consideration to climate change and issues related to climate change mitigation and adaptation, for instance green infrastructure, biodiversity, food security, and flood risk assessment.

— GHG emission reductions in the transport sector are often achieved via strategic plans including, for instance, Sustainable Urban Mobility Plans where choices are made to favour modal options, which are less carbon-intensive but without compromising other environmental criteria. These choices, at plan level, must be supported for instance by specific traffic models and numerical analysis of GHG emissions.

— Urban planning could for instance consider the impact of settlement patterns and urban form on GHG emissions and climate resilience. It can steer development towards a 'decarbonised' lifestyle as well as reduce the need for construction material and associated emissions e.g. by favouring development in brownfield and urban infill sites and using existing water, waste, energy and transport systems rather than building in greenfield sites with larger infrastructure requirements

— Adaptation measures, for instance sustainable drainage systems and flood protection measures should be considered at plan-level as this will open up options for the development of land e.g. at higher densities and improve the resilience of existing infrastructure. As regards mitigation, the considerations could for instance include trade-offs between the emissions of construction (e.g. high vs medium rise), buildings' energy performance, and projects that continue to emit vis-à-vis the objective to reduce emissions at an aggregate (plan) level (on a credible pathway compatible with the GHG emission target for 2030 and climate neutrality by 2050) but without compromising other environmental criteria.

— Integration of climate change (climate neutrality and climate resilience) in national/regional guidance on Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA). Better use of the SEA as a strategic and proactive tool operating at the level of plans and programmes in accordance with the definition of the SEA Directive.

— Integration of climate change (mitigation, adaptation) and the National Energy and Climate Plan (NECP) into decision-making processes, such as national, regional and local/municipal climate change adaptation plans and national long-term renovation strategies.

— River basin management plans (following the EU Water Framework Directive); flood risk plans (following the EU Floods Directive); NATURA 2000 sites designated under the Bird and Habitats Directives; and risk management plans (local, national, regional);

— Providing national open data needed for climate proofing, mitigation and adaptation modelling, and common data for infrastructure planning and projects, e.g.:

  — Weather and climate data (observations, reanalysis and projections);

  — Topography, local plans, conservations;

  — Terrain data e.g. terrestrial data and height/altitude models;

  — Soil maps (soil types and classification, hydraulic conductivity);

  — Transport and other infrastructure;

  — Groundwater data e.g. for modelling of groundwater levels, inflow to watercourses and lakes, near terrain groundwater, and related floods;

  — Sewage and drains e.g. for the modelling of urban areas, overflow pollution and disconnection of rainwater from the sewer system;

  — Local plans e.g. large projects and building and construction works, including demolition of buildings;

  — Areas of particular value or importance, low-lying areas that may become wetlands, nature conservation areas, water supply plans, wastewater, soil contamination, lake and stream protection maps, drinking water areas;

  — Municipal flood mapping;

  — Sea and coast data e.g. coastal types, storm surge, sea-level rise, dike break, high-tide and extreme events statistics, ports and other infrastructure, areas on land that may be flooded, erosion maps, wave height and direction and energy, transport of sediments, nautical maps;

  — Precipitation and climate data e.g. cloudbursts, rain events, blue spot mapping;

  — Streams and lakes data e.g. for the hydraulic modelling of water flow, stowage, quality, and floods;

  — Building and housing register e.g. area, location, use, installations, water and drainage conditions, property and land value;

  — Energy Performance Certificates registers and databases

  — Insurance data on storm, cloudburst and flood damages to buildings.

— As regards transport projects, a national traffic model to better facilitate the analysis of GHG emissions, because a transport project would typically model traffic usage to calculate the carbon footprint.

The EEA Report No 06/2020 ([1]) elaborates on the monitoring and evaluation of national adaptation policies throughout the adaptation policy cycle in the EU and EEA member countries.

In 2018, the Commission undertook a study ([2]) 'Climate change adaptation of major infrastructure projects' mapping legislation, tools, methodologies and datasets supporting the climate proofing of infrastructure in the Member States. The study report is available as background information to help enhancing the enabling framework.

([1]) EEA Report No 06/2020, Monitoring and evaluation of national adaptation policies throughout the policy cycle, European Environment Agency, https://www.eea.europa.eu/publications/national-adaptation-policies

([2]) 2018 Study on 'Climate change adaptation of major infrastructure projects' undertaken for DG REGIO: https://ec.europa.eu/regional_policy/en/information/publications/studies/2018/climate-change-adaptation-of-major-infrastructure-projects

ANNEX G

Glossary

The majority of the following definitions are derived from the IPCC Glossary [1] or otherwise indicated:

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.

Adaptation options: The array of strategies and measures that are available and appropriate for addressing adaptation. They include a wide range of actions that can be categorized as structural, institutional, ecological or behavioural.

Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Carbon dioxide (CO_2): A naturally occurring gas, CO_2 is also a by-product of burning fossil fuels (such as oil, gas and coal), of burning biomass, of land use changes (LUC), and of industrial processes (e.g. cement production). It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a Global Warming Potential (GWP) of 1.

Climate: Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate change: Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes.

Climate extreme (extreme weather or climate event): The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes.'

Climate neutrality: Concept of a state in which human activities result in no net effect on the climate system. Achieving such a state would require balancing of residual emissions with emission (carbon dioxide) removal as well as accounting for regional or local biogeophysical effects of human activities that, for example, affect surface albedo or local climate.

Climate projection: A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of GHG and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized.

[1] IPCC Glossary accompanying the special report on global warming of 1,5 °C: https://www.ipcc.ch/report/sr15/glossary/

CO_2 equivalent (CO_2-eq) emission: The amount of carbon dioxide (CO_2) emission that would cause the same integrated radiative forcing or temperature change, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. There are a number of ways to compute such equivalent emissions and choose appropriate time horizons. Most typically, the CO_2-equivalent emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for a 100-year time horizon. For a mix of GHGs it is obtained by summing the CO_2-equivalent emissions of each gas. CO_2-equivalent emission is a common scale for comparing emissions of different GHGs but does not imply equivalence of the corresponding climate change responses. There is generally no connection between CO_2-equivalent emissions and resulting CO_2-equivalent concentrations.

Cost-benefit analysis: Monetary assessment of all negative and positive impacts associated with a given action. Cost-benefit analysis enables comparison of different interventions, investments or strategies and reveal how a given investment or policy effort pays off for a particular person, company or country. Cost-benefit analyses representing society's point of view are important for climate change decision making, but there are difficulties in aggregating costs and benefits across different actors and across timescales.

Critical Infrastructure: an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions.

Cultural heritage ([2]): encompasses several main categories of heritage. Tangible cultural heritage includes movable cultural heritage (paintings, sculptures, coins, manuscripts), immovable cultural heritage (monuments, archaeological sites, and so on), underwater cultural heritage (shipwrecks, underwater ruins and cities). Intangible cultural heritage includes oral traditions, performing arts, and rituals.

Disaster ([3]): Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Environmental Impact Assessment (EIA): the process of carrying out an EIA as required by Directive 2011/92/EU, as amended by Directive 2014/52/EU on assessment of the effects of certain public and private Projects on the environment. The main steps of the EIA process are: preparation of the EIA Report, publicity and consultation, and decision-making.

European Critical Infrastructure (ECI): critical infrastructure located in Member States the disruption or destruction of which would have a significant impact on at least two Member States ([4]).

Exposure ([5]): The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.

Extreme weather event: An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10^{th} or 90^{th} percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season).

([2]) www.unesco.org/new/en/culture/themes/illicit-trafficking-of-cultural-property/unesco-database-of-national-cultural-heritage-laws/frequently-asked-questions/definition-of-the-cultural-heritage/
([3]) IPCC SREX Glossary: https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf
([4]) See Directive 2008/114/EC.
([5]) IPCC SREX Glossary: https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf

Global Warming Potential (GWP): An index, based on radiative properties of GHG, measuring the radiative forcing following a pulse emission of a unit mass of a given greenhouse gas in the present day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide. The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in causing radiative forcing. The Kyoto Protocol is based on GWPs from pulse emissions over a 100-year time frame.

Greenhouse gas (GHG): Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary GHGs in the earth's atmosphere. Moreover, there are a number of entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Hazard: The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Infrastructure: See the definition in chapter 1 of this guidance.

Impacts (consequences, outcomes): The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial.

Mitigation (of climate change): A human intervention to reduce emissions or enhance the sinks of greenhouse gases. Note that this encompasses carbon dioxide removal (CDR) options.

Representative concentration pathways (RCPs): Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover (Moss et al., 2008). The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes the fact that not only the long-term concentration levels, but also the trajectory taken over time to reach that outcome are of interest (Moss et al., 2010). RCPs were used to develop climate projections in CMIP5.

RCP2.6: One pathway where radiative forcing peaks at approximately 3 W/m^2 and then declines to be limited at 2,6 W/m^2 in 2100 (the corresponding Extended Concentration Pathway, or ECP, has constant emissions after 2100).

RCP4.5 and RCP6.0: Two intermediate stabilisation pathways in which radiative forcing is limited at approximately 4,5 W/m^2 and 6,0 W/m^2 in 2100 (the corresponding ECPs have constant concentrations after 2150).

RCP8.5: One high pathway which leads to > 8,5 W/m^2 in 2100 (the corresponding ECP has constant emissions after 2100 until 2150 and constant concentrations after 2250).

Risk: The potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain. In the context of the assessment of climate impacts, the term risk is often used to refer to the potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence.

Risk assessment: The qualitative and/or quantitative scientific estimation of risks ([6])

Risk management: Plans, actions, strategies or policies to reduce the likelihood and/or consequences of risks or to respond to consequences.

Sensitivity ([7]): Sensitivity is the degree to which a system is affected, either adversely or beneficially, by *climate variability* or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to *sea-level rise*).

Slow onset events: Slow onset events include e.g. temperature increase, sea-level rise, desertification, glacial retreat and related impacts, ocean acidification, land and forest degradation, average precipitation, salinization, and loss of biodiversity. As regards the statistical distribution of a climate variable (and how it may shift in a changing climate), slow onset events will often reflect how the mean value is changing (whereas extreme events are related to the tail ends of the distribution).

Strategic Environmental Assessment (SEA): the process of carrying out an environmental assessment as required by Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment. The main steps of the SEA process are preparation of the SEA Report, publicity and consultation, and decision-making.

Urban resilience: The measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming towards sustainability.

Vulnerability [IPCC AR4 ([8])]: Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of *climate change*, including *climate variability* and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its *sensitivity*, and its adaptive capacity.

Vulnerability [IPCC AR5 ([9])]: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

([6]) Directive 2008/114/EC defines 'risk analysis' as the consideration of relevant threat scenarios, in order to assess the vulnerability and the potential impact of disruption or destruction of (critical) infrastructure. This is a broader definition than climate risk assessment.

([7]) IPCC AR4 Glossary WG2: https://archive.ipcc.ch/pdf/glossary/ar4-wg2.pdf

([8]) IPCC AR4 Climate Change 2007: Impacts, Adaptation, and Vulnerability, Appendix I: Glossary, https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg2-app-1.pdf

([9]) IPCC AR5 SYR, Synthesis Report, Annex II: Glossary, https://www.ipcc.ch/site/assets/uploads/2019/01/SYRAR5-Glossary_en.pdf