

# Deliverable D2.3: Policy-relevant WEFE scenarios

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Lead by UPM

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### **Abstract**

This deliverable details the narratives for the policy-relevant WEFE scenarios, the process followed to generate those scenarios, as well as the interlinkages between them and the climate and land use scenarios. The policy-relevant WEFE scenarios are baseline scenarios that represent future trends of the system assuming no additional policies beyond those already in place. The narratives for these scenarios are aligned with climate, land use and socioeconomic projections, and consider WEFE projections and envisaged policies and strategies at global and continental scales. The policy-relevant WEFE scenarios are developed within the global context, with a specific focus on the European scale. At the global level they take into account global agreements (UN 2030 Agenda, Paris Agreement, and trade agreements) and at the EU level account for ongoing policies and strategies. Also, at European level, the scenarios have been developed considering stakeholders' concerns and perspectives through the EU Nexus Dialogues (task 6.3).



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## Acronyms and abbreviations

AOGCM	Atmosphere-Ocean General Circulation Model
CAP	Common Agricultural Policy
CMIP	Common Management Information Protocol
COP	Conference of the Parties
CS	Case Study
D	Deliverable
EEA	European Environment Agency
ETS	Emissions Trading System
EU	European Union
F2F	Farm to Fork strategy
FAO	Food and Agriculture Organization
GATT	General Agreement on Tariffs and Trade
GDP	Gross domestic product
IAM	Integrated Assessment Models
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre - European Commission
LUH	Land-Use Harmonization
LUIISA	Land-Use based Integrated Sustainability Assessment modelling platform
NDC	Nationally Determined Contributions
OECD	Organization for Economic Cooperation and Development
RED	Renewable Energy Directive
RCP	Representative Concentration Pathways
SAF	Sustainable Assessment Framework
SDG	Sustainable Development Goals
SSP	Shared Socioeconomic Pathways
TFEU	Treaty on the Functioning of the European Union
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
WEFE	Water-Energy-Food-Environment
WFD	Water Framework Directive
WHO	World Health Organization
WP	Work package
WTO	World Trade Organization

# 1 Introduction

The policy-relevant WEFE scenarios are plausible scenarios that integrate current policies with climatic, socioeconomic, and land use scenarios in the context of the WEFE nexus. The objective of this deliverable is to present narratives for the policy-relevant WEFE scenarios in a global context, with a particular emphasis on the European scale. Additionally, this deliverable aims to outline the processes employed to develop these narratives and establish their connections with the climate and land use scenarios presented in D2.1.

In the process of developing the narratives, we reviewed and considered literature focusing on various IPCC studies and previous climate change narratives. Additionally, we took into account various agreements, strategies, and policies at the global and continental levels in the different sectors of the WEFE nexus. At the global level, relevant agreements and strategies that are accepted and binding for several countries in the international sphere were considered (e.g. Paris Agreement, Agenda 2030, and trade agreements). At the European level, the selected policies are the main policy frameworks, directives, and strategies implemented (ongoing and envisaged) by the European Union and its member states (e.g. EU Water Framework Directive, EU Common Agricultural Policy, EU Energy Directive, as well as the EU Directorate-General of Agriculture and Rural Development, Climate Action, Energy, and Environment). Based on these policies, we have identified a set of relevant policy objectives and indicators that will serve to measure policy compliance. The policy-relevant WEFE scenarios consider stakeholders' concerns and perspectives through the EU Nexus Dialogues (Task 6.3) and have also been co-designed with the project's WEFE nexus expert panel. In this regard, the policy-relevant WEFE scenarios are aligned with climate, land use, and socioeconomic projections, considering WEFE projections and envisaged policies and strategies at global and continental scales.

After reviewing the literature and policies, to develop the narratives of the scenarios we name each of the policy-relevant WEFE scenarios to align with the CMIP6 climate, socioeconomic, and land use scenarios presented in deliverable D2.1. In this regard, we introduce three main scenarios named (1) "Sustainable Development" aligned with SSP1-2.6, (2) "Weak cooperation" aligned with SSP3-7.0, and (3) "The Wrong Way" aligned with SSP5-8.5; along with two extreme scenarios, (4) "Emissions Neutrality" aligned with SSP1-1.9, and (5) "Global Risk" aligned with SSP5-8.5+ (upper extreme of SSP5-8.5). The policy-relevant WEFE scenarios are baseline scenarios that represent future trends of the system assuming no additional policies beyond those already in place. A baseline scenario serves as a comparison or counterfactual scenario to assess the impacts of alternative scenarios (e.g. policy changes). The difference between each scenario trajectory is determined by the degree of compliance or non-compliance of the different policy objectives. These policy-relevant WEFE scenarios will serve as counterfactual scenarios to assess nexus solution scenarios developed in the framework of the project (WP7). As a complement to the narratives, we present the targets to be achieved for most of the identified policy objectives. For the purpose of this research, a target is a quantifiable expression of an objective through an indicator, setting out what change to achieve and by when (see Glossary). The policy-relevant WEFE scenarios will be simulated in the GoNEXUS toolbox at a global and continental scale (WP3) and the results will be presented as evidence in Task 5.2, "Global scale WEFE diagnosis and evidence simulations".

The target audience of this deliverable is the GoNEXUS partners, in particular those working on large-scale WEFE modelling (WP3), scientists working on large-scale WEFE modelling, and global and continental (including the EU) stakeholders and decision-makers. This deliverable also serves as an umbrella for the modelling and development of GoNEXUS case studies at the local level (WP4) and the development of Task 2.3 (River basin/local socioeconomic and land use scenarios).

## 2 Process to develop a set of narratives for the policy-relevant WEFE scenarios

### 2.1 Understanding the WEFE nexus security, challenges, policies, and objectives.

The security of the WEFE nexus is threatened by the different impacts that socioeconomic activities have on the climate and the environment, and by the impacts of climate change on society. Figure 1 shows how these impacts represent nexus challenges and, in part, shape climate change, socioeconomic, and land use scenarios. In addition, these impacts pose challenges in the governance of the WEFE nexus, which should be addressed through political actions that develop solutions with clear objectives. These objectives should aim to achieve an adaptation to the impacts of climate on society and mitigation of the impacts of society on climate. The climatic, socioeconomic, and land use scenarios, as well as the current policies and objectives shape the policy-relevant WEFE scenario narratives that will be designed in this deliverable within the framework of the GoNEXUS project.

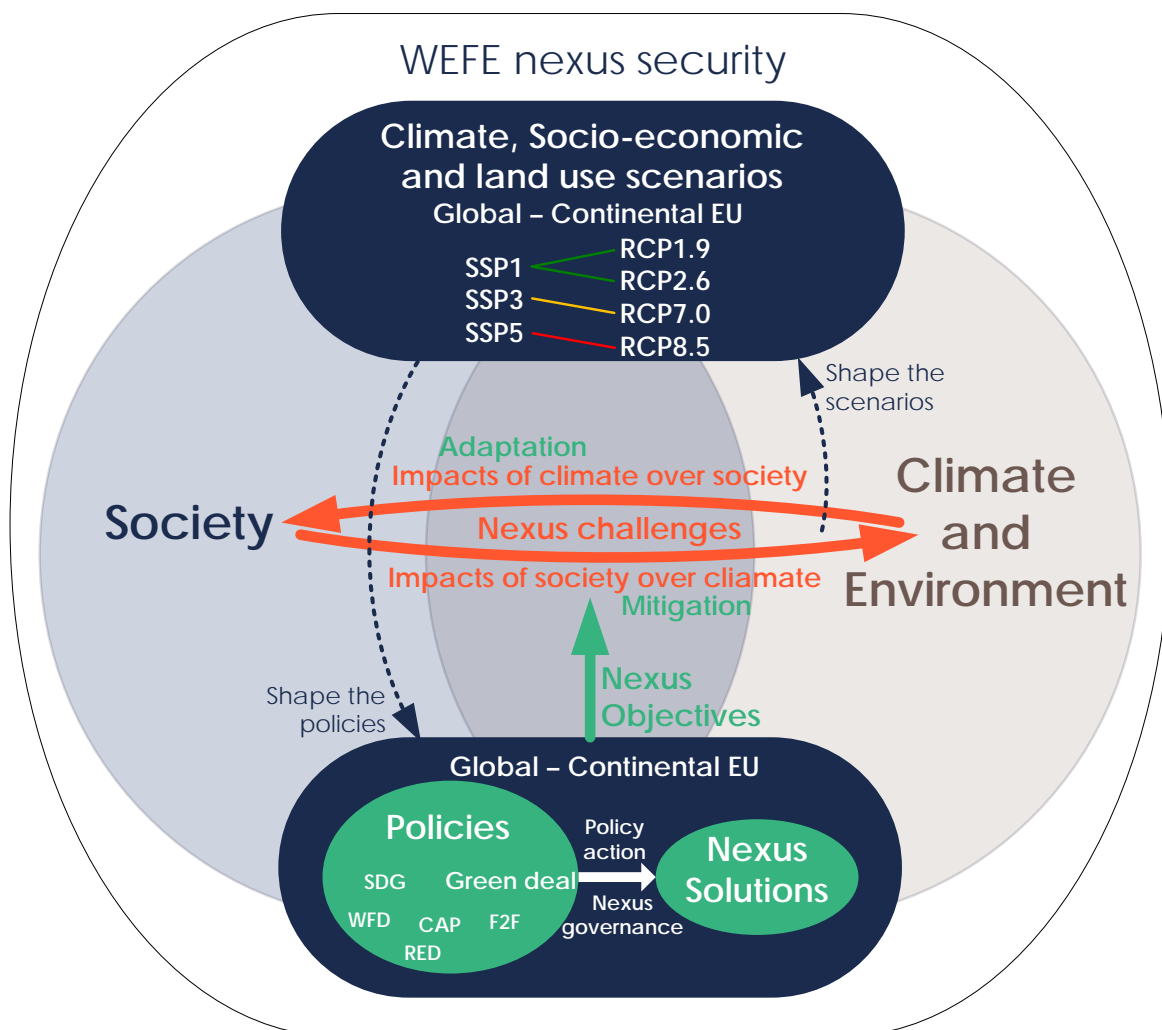


Figure 1. Understanding the WEFE nexus security, nexus challenges and nexus objectives. Source: own elaboration.



## 2.2 Inputs in the process for narratives development

The policy-relevant WEFE scenarios used in this project are plausible scenarios that incorporate current policies to the climatic, socioeconomic and land use scenarios in the context of the WEFE nexus. These scenarios will be developed within the global context, with a specific focus on the European scale and will take into account the strategies and policies for the WEFE nexus sectors. The scenarios will be described through a series of narratives and will be consistent with the different scenarios of the GoNEXUS project (Task 2.1, 2.2 and 2.3). They will serve as an umbrella for the development of the case studies and will help to provide consistency in the development of the models, nexus dialogues, and solutions assessment.

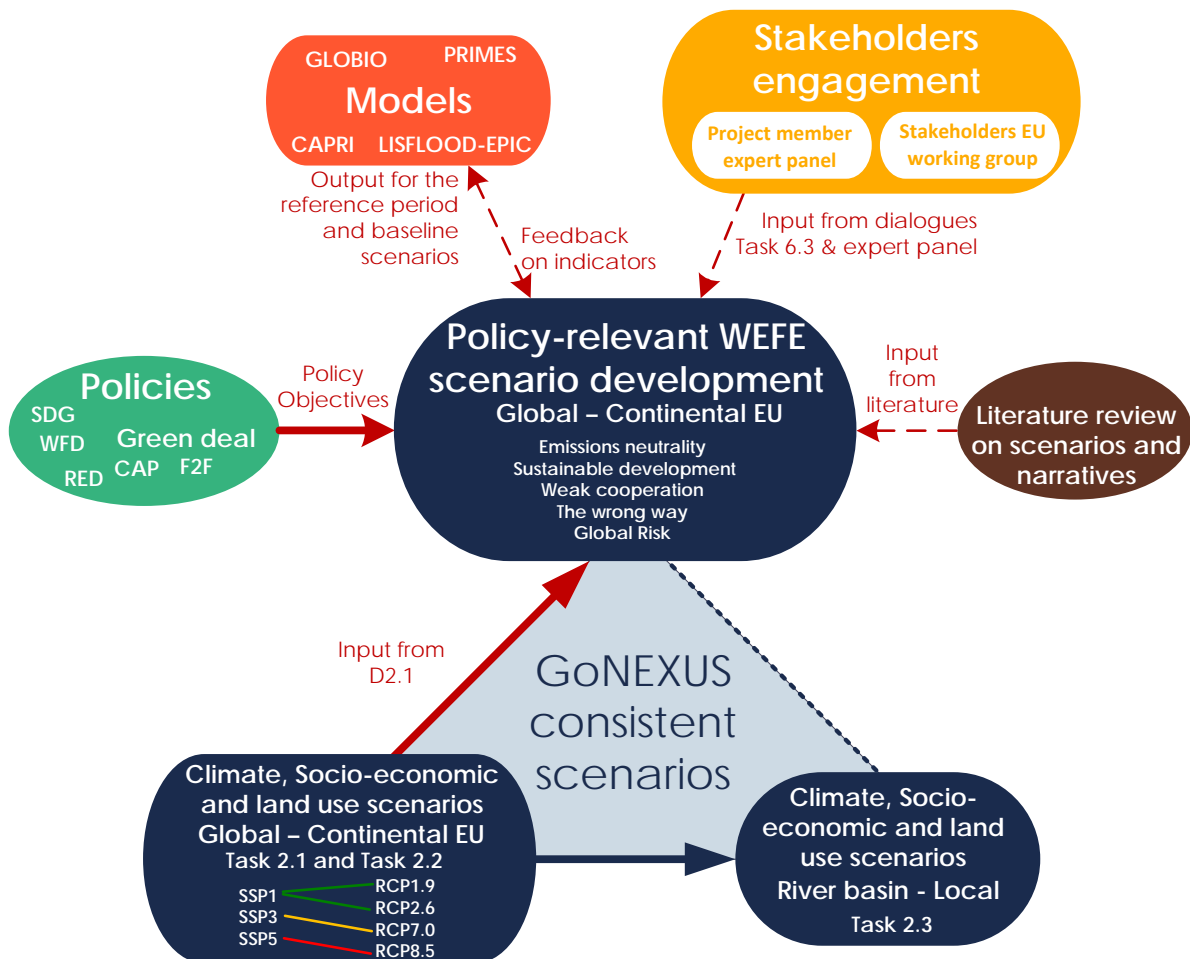


Figure 2. Inputs for Policy-relevant WEFE scenario development. Source: own elaboration.

Within the framework of the GoNEXUS project, the process to develop a set of policy narratives for policy-relevant WEFE scenarios considers the following inputs (Figure 2):

- Climate, socioeconomic and land use scenarios at global and continental scales (Task 2.1 and Task 2.2). Input through deliverable D2.1.
- Current policies, and policy objectives at global and EU scales. Possible future policies were also identified to map future trends.
- Input from literature thorough review of scenario narratives in literature.
- Input from stakeholder engagement (Task 6.3) and project member expert panel, through dialogues.
- Feedback from models (WP3) on indicators and output for the reference period and baseline scenarios.

The development of the policy relevant WEFE scenario narratives incorporates current policies to the climatic, socioeconomic and land use scenarios (considered in deliverable D2.1) in a consistent way. The main policies considered include global agreements (UN 2030 Agenda, Paris Agreement, and trade agreements), strategies to mitigate and adapt to climate change and variability, exceptional measures (e.g. measures to alleviate the effects of the Russian invasion of Ukraine and ongoing war), international cooperation, and changes in consumption patterns. At the EU level, it will account for strategies such as the EU Green Deal, as well as other European policies such as greening the CAP, the net zero carbon emissions by 2050 objective and energy efficiency policies. The scenarios will be co-designed with the stakeholders including project member expert panel and stakeholders from EU working group.

Additionally, to complement the narratives, we will identify the targets of the policy objectives. To achieve this, we will consider feedback from models to identify indicators that measure the attainment of policy objectives. Furthermore, the narratives will serve as an output for the models, enabling them to better describe the reference period and simulate the baseline scenarios using the identified indicators as reference.

Linkages between policy, climate and global socioeconomic scenarios will be analysed to ensure that the policy-relevant WEFE scenarios portray a coherent overall narrative. Alignment with outlook projections developed by international institutions (e.g. Agricultural Outlook, Energy Outlook) will reinforce the identification of several nexus trajectories.

## 3 Background study analysis

In the literature, numerous studies address possible future climatic scenarios based on political, climate, socioeconomic, and land use scenarios. These studies generally focus their analyses on previous IPCC assessments (mainly based on the summaries for policymakers). In our case, we consider the most recent of these studies, encompassing CMIP5 and CMIP6 assessments, and incorporating various RCP and Shared SSP scenarios. Regarding the spatial scale, there are studies at multiple levels: global, continental, national and regional. Understanding these studies is crucial for developing narratives that are aligned and consistent with the previous work conducted. Some of the main studies considered are named below.

### 3.1 Main IPCC reports

#### **Report: Global Warming of 1.5°C**

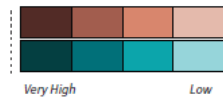
The report "Global Warming of 1.5°C" by the IPCC (2018) outlines the consequences of a global temperature rise of 1.5°C above pre-industrial levels and the corresponding pathways for global greenhouse gas emissions. This context involves strengthening the global response to climate change threats, pursuing sustainable development, and eradicating poverty. The report emphasizes that limiting global warming to 1.5°C, rather than 2°C, would yield less severe climate impacts, particularly if mitigation and adaptation efforts are harmonized to generate synergies while minimizing trade-offs. It establishes connections between mitigation options within energy demand, energy supply, and land sectors and the national-level Sustainable Development Goals (SDGs) (Figure 3). The report delineates how these sectoral mitigation measures can yield either positive outcomes (synergies) or negative outcomes (trade-offs) with the SDGs. Notably, the energy demand sector shows a higher potential for synergies than for trade-offs. The presented bars categorize the evaluated options based on confidence levels and consider the strength of connections between mitigation actions and SDGs. This report lays the groundwork for defining the most optimistic policy-relevant WEFE scenarios.

Length shows strength of connection



The overall size of the coloured bars depict the relative potential for synergies and trade-offs between the sectoral mitigation options and the SDGs.

Shades show level of confidence



The shades depict the level of confidence of the assessed potential for Trade-offs/Synergies.

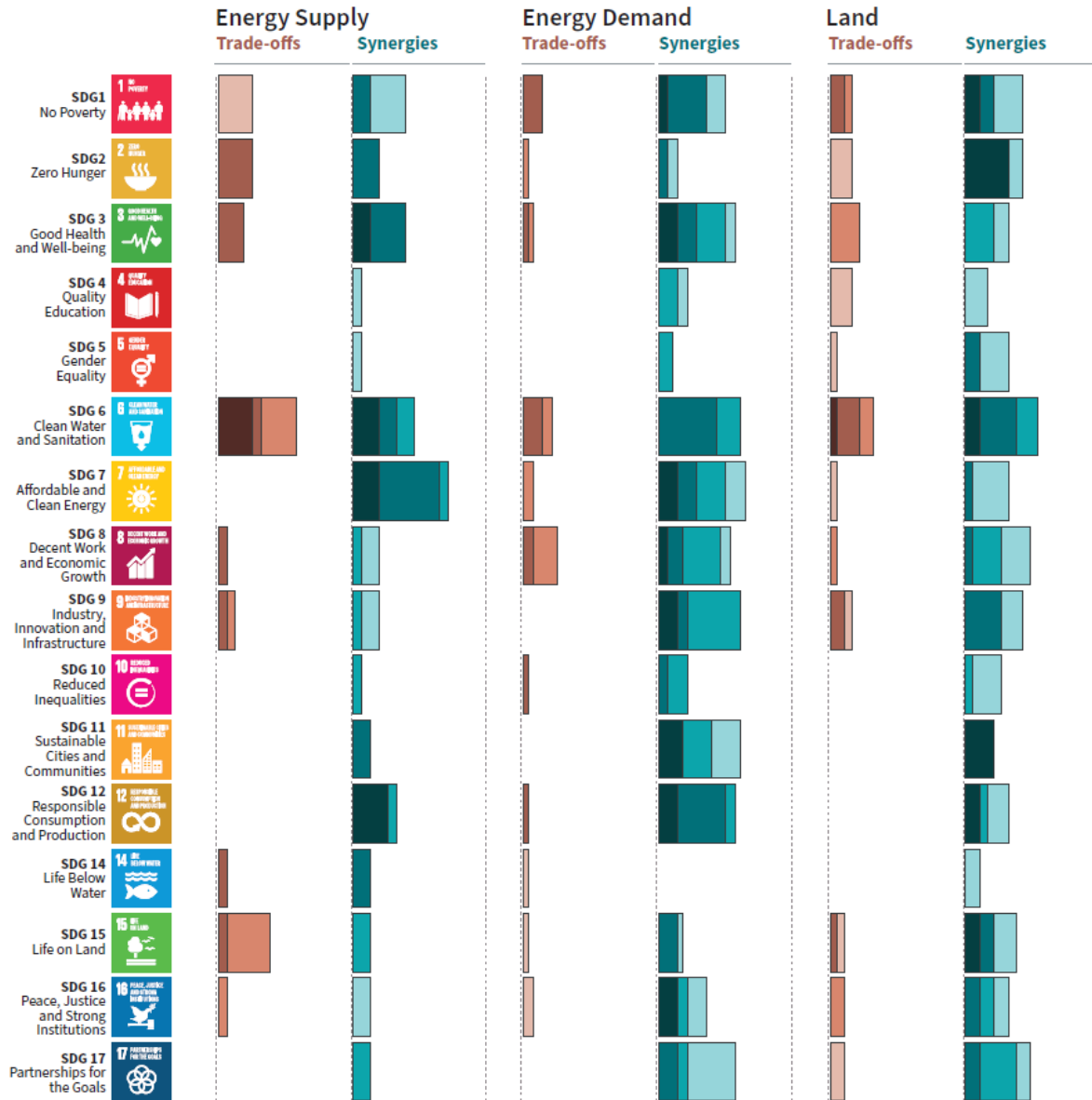


Figure 3. Potential synergies and trade-offs between the sectoral portfolio of climate change mitigation options and the Sustainable Development Goals. Source: IPCC (2018).

### Report: The Physical Science Basis

The IPCC's report (IPCC, 2021) titled "The Physical Science Basis," corresponding to CMIP6, elucidates the fundamental physical science underpinning climate change. It expounds upon the current climate condition, including changes and human influence, the comprehension of potential climate scenarios, region- and sector-specific climate information, and the need to limit anthropogenic climate change. Among its contributions, the report details changes in global surface temperature, evaluating them across selected 20-year intervals and considering five illustrative emissions scenarios (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5) as shown in Table 1. This report allows for the identification of

the global geophysical characteristics that will be described in the different policy-relevant WEFE scenario narratives.

Table 1. Changes in global surface temperature, which are assessed based on multiple lines of evidence, for selected 20-year time. Source: IPCC (2021)

Scenario	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
	Best estimate (°C)	Very likely range (°C)	Best estimate (°C)	Very likely range (°C)	Best estimate (°C)	Very likely range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

### Report: Climate Change, Impacts, Adaptation and Vulnerability

The IPCC (2022a) report addresses "Climate Change, Impacts, Adaptation and Vulnerability." This report acknowledges the interconnectedness of climate, ecosystems, biodiversity, and human societies (Figure 4), fostering a stronger integration of knowledge across the natural, ecological, social, and economic sciences. The evaluation of climate change's impacts and risks, as well as adaptation is set against concurrently unfolding non-climatic global trends, including biodiversity loss, unsustainable consumption of natural resources, land and ecosystem degradation, rapid urbanization, shifts in human demographics, socioeconomic inequalities, and a pandemic. This report highlights that adaptation plays a key role in reducing exposure and vulnerability to climate change. In human systems, adaptation can be anticipatory or reactive, as well as incremental and/ or transformational.

Additionally, this report places a specific emphasis on transformations and shifts within energy systems, land use, oceanic conditions, coastal and freshwater ecosystems, urban and rural environments, as well as industry and society. These transitions facilitate the necessary adjustments to ensure elevated levels of human health and well-being, bolstered economic and social resilience, enhanced ecosystem vitality, and overall planetary health. Such system shifts also play a crucial role in achieving lower levels of global warming that would circumvent various limits to adaptation. The report also evaluates both economic and non-economic losses and damages. This report designates the process of simultaneously implementing mitigation and adaptation to support sustainable development for all as climate-resilient development. The different levels of impacts will facilitate the determination of the socioeconomic, geopolitical, and various dimensions of the WEFE nexus situations in each of the policy-relevant WEFE scenario narratives.

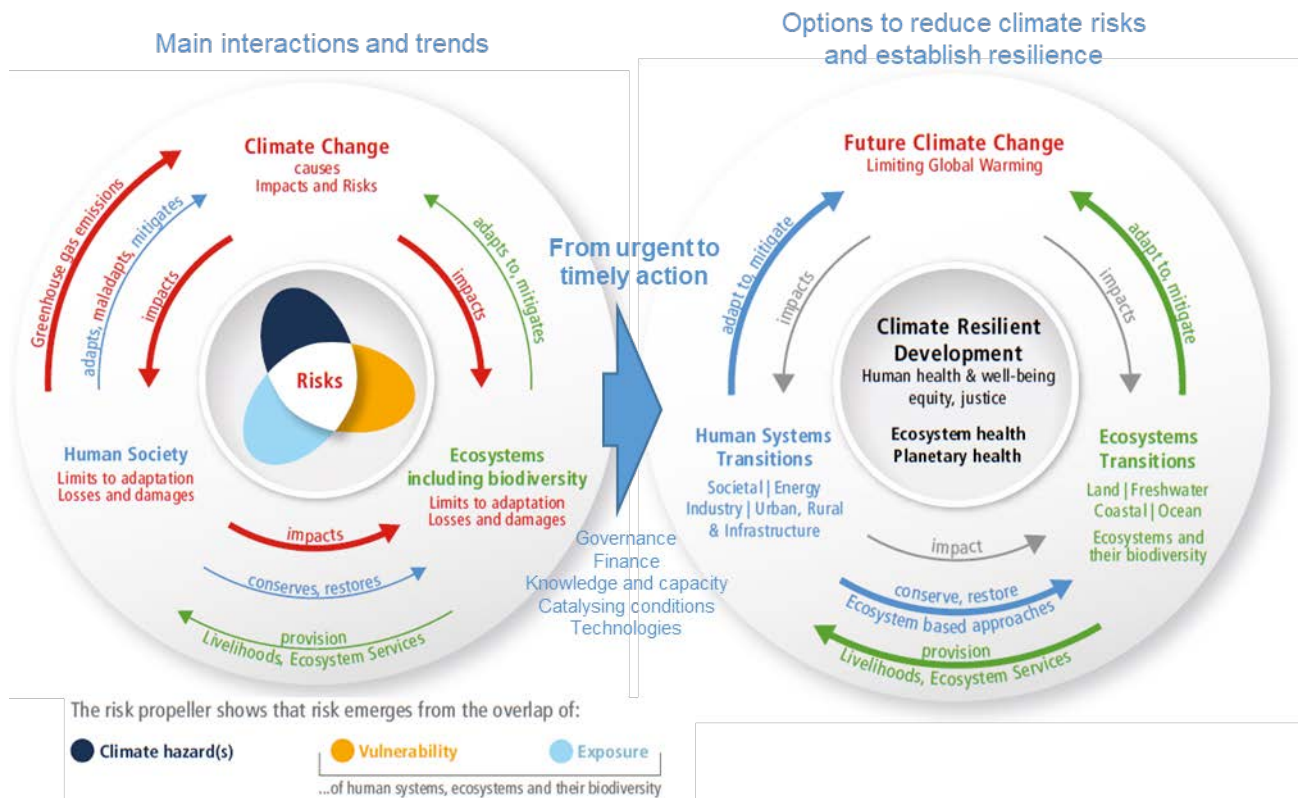


Figure 4. From climate risk to climate resilient development: climate, ecosystems (including biodiversity) and human society as coupled systems. Source: adapted from IPCC (2022a).

### Report: Mitigation of Climate Change

The report "Mitigation of Climate Change" (IPCC, 2022b) addresses the linkages between mitigation, adaptation, and sustainable development. It evaluates the scientific, technological, environmental, economic, and social aspects of climate change mitigation based on literature. Some key developments pertinent to this report encompass: a changing international landscape, a growing range of actors and strategies for mitigation, strong connections between climate change mitigation, adaptation, and development trajectories, novel approaches merging the assessment of existing commitments and actions with an evaluation of emissions reductions and their implications for long-term temperature outcomes, and a broader spectrum of analytical frameworks spanning various disciplines, including the social sciences. In this sense, identifying how mitigation measures can have a positive impact on the fight against climate change is fundamental for the development of policy-relevant WEF scenarios.

## 3.2 Other studies at global level

In addition to these IPCC reports, there are other studies that are relevant to developing the policy-relevant WEF scenarios. While most of these studies predate CMIP6, they provide significant insights on the geopolitics and socioeconomic development, water and energy demand, agricultural and land use trends, among others WEF dimensions. For instance, Soergel et al. (2021) analyse climate policies, economic development, education, technological progress, and less resource-intensive lifestyles to determine possible SDG fulfilment. They state that an additional sustainable development package, including international climate finance, progressive redistribution of carbon pricing revenues, sufficient and healthy nutrition, and improved access to modern energy, enables a more comprehensive sustainable development pathway. Older studies explore SSP land-use dynamics (Doelman et al. 2018). Van Vuren et al. (2017) analyse possible developments in global energy use and production, land use, emissions, and climate changes following the SSP1 storyline, consistent with the green growth (or sustainable development) paradigm. Furthermore, Riahi et al. (2017) present the

implications of SSPs scenarios over energy, land use, and emissions, and outline important plausible global developments that together would lead to different challenges for climate change mitigation and adaptation in the future. O'Neill et al. (2016) describe scenario model intercomparison project objectives and the experimental design of the CMIP6 scenarios. They present a matrix (Figure 5) to illustrate all possible scenarios based on combinations of the SSPs and RCPs for the CMIP6. The SSPs are presented on the x-axis and combinations of radiative forcing (RF) (RCPs) on the y-axis. The colour scheme represents the priority of each scenario, with Tier 1, depicted in blue, representing the top priority scenarios such as SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. Three of the Tier 1 scenarios are updated versions of previous CMIP5 RCP scenarios shown in green (RCP2.6, RCP4.5, and RCP8.5) for easy comparison between CMIP5 and CMIP6 projections. Tier 2 scenarios, indicated in yellow, include SSP1-1.9, SSP4-6.0, SSP4-3.4, and SSP5-3.4. These scenarios are either not feasible or have not been prioritized by the Scenario Model Intercomparison Project.

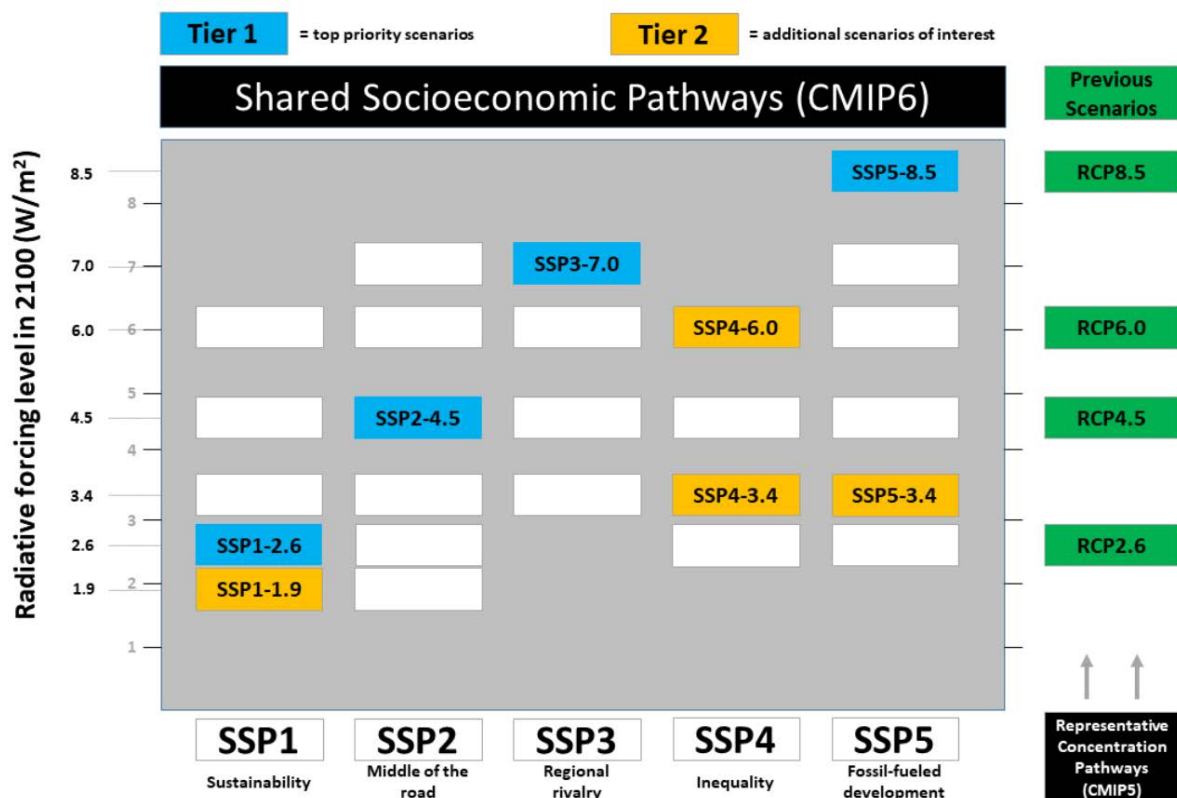


Figure 5. Possible scenarios combinations based on the SSPs and RCPs for the CMIP6. Source: base on O'Neill et al. (2016)

### 3.3 Studies at EU level

At the European level, the JRC study "Towards a Fair and Sustainable Europe 2050" (Matti et al., 2023) examines potential and essential changes within the European social and economic systems as the European Union strives to manage sustainability transitions towards 2050. The study focuses on strategic intervention areas including a new social contract, sustainability governance, societal and economic aspects, and global sustainability. It examines EU stakeholders' roles in addressing interventions collectively for sustainability transitions.

The availability of water resources across Europe has also been evaluated, mainly under different RCP scenarios. The European Environment Agency presents a report (EEA, 2021) that provides details on the current and future state of water resources in Europe. This report aims to update our understanding of water stress, including drought and water scarcity, in Europe to inform policymakers and interested stakeholders about the current situation. The report mentions that prospects for water stress in Europe are expected to worsen. In more detail, the report mentions that:

- Droughts are increasing in frequency, magnitude, and impact.
- Climate change is projected to cause seasonal reductions in water availability in most parts of Europe, except in north-eastern areas. The strongest impact is expected in southern and south-western Europe, with river discharge reductions in summer of up to 40 % in some basins, under a 3 °C temperature rise scenario. Large parts of western and central Europe will also be affected, albeit to a lesser degree. Changes in aquifer recharge follow roughly the same pattern.
- Improved water use efficiency could deliver a further reduction in water abstraction of 0.7 % per year over the coming years in the agricultural, industry and mining, and electricity production sectors.
- Although helpful, this will neither offset the climate change impacts on rainfall-dependent nature and on agriculture nor offset any strong local increases in water demand (see next point).
- Continued urbanisation and growth in coastal tourism will further concentrate water demand geographically. A warmer and drier climate could increase irrigation requirements by 20 %, adding to a stronger concentration of water demand in already drought-prone regions of Europe.

Furthermore, there are some modelling studies underpinning EU Policy debate, such as JRC PESETA IV<sup>1</sup> study, that aims to better understand the effects of climate change on Europe, for several climate change impacts in water resources and other sectors, and how these effects could be avoided with mitigation and adaptation policies (Bisselink et al., 2018; Bisselink et al., 2020).

The agricultural and food sector at the European level has also been evaluated to identify possible pathways. Mitter et al. (2020) describe five scenarios aligned with the SSPs for European agriculture and food systems that are plausible and internally consistent. They mention that these scenarios can be used by scientists, policymakers, and entrepreneurs to explore the challenges of global environmental change, considering an appropriate level of spatial and sectoral detail and systematic development. Additionally, Münch et al. (2023) conduct a comparative analysis of the CAP Strategic Plans and their effective contribution to the achievement of EU objectives. The different objectives of the CAP will be detailed in section 5.1.3.1.

## 4 Climate, socioeconomic and land use scenarios

For the selection of climate, socioeconomic, and land use scenarios that match with policy-relevant WEFE scenarios, we relied on the scenarios selected in Deliverable 2.1. Below, we outline the fundamental basis and provide a description of the selected scenarios.

### 4.1 Representative concentration pathways (RCPs) and Socioeconomic Pathways (SSPs)

The representative concentration pathways (RCPs) are a set of harmonized emission trajectories that aim to improve harmonization between integrated assessment models (IAMs) and climate models (van Vuuren et al., 2011). They have been used extensively in the fifth IPCC assessment report where they served as a basis for many experiments thus improving comparability across different fields of science.

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<sup>1</sup> [https://joint-research-centre.ec.europa.eu/peseta-projects/jrc-peseta-iv\\_en](https://joint-research-centre.ec.europa.eu/peseta-projects/jrc-peseta-iv_en)

The RCPs have been defined to cover the range of radiative forcing outcomes (and therefore temperature) that are available in the literature. The highest radiative forcing outcome is 8.5 W/m<sup>2</sup> in the year 2100 in RCP8.5, implying a temperature increase of >4°C. The lowest radiative forcing target is 2.6 W/m<sup>2</sup> in RCP2.6, which results in a 66% chance of limiting global warming to 2°C by the end of the century. In response to the Paris climate agreement where the parties agreed to ‘aim to limit climate warming to 1.5°C’ RCP1.9 was created, which aims to limit radiative forcing to 1.9 W/m<sup>2</sup> to keep global temperature change below 1.5°C (Van Vuuren et al. 2014).

Land use and socioeconomic scenarios (associated to socioeconomic drivers) will refer to the Shared Socioeconomic Pathways (SSPs) (obtained from O’Neill et al. 2014). These SSPs represent alternative visions of the future on the evolution of society and ecosystems. Similarly, to climate change scenarios, there are projections on land use and socioeconomic variables based on the SSPs. For CMIP6, a direct association between SSPs and RCPs is made, while this link was absent in CMIP5 (although not all RCPs in CMIP5 could be considered coherent with all SSPs).

## 4.2 Spatial scale

**At the global scale**, land use and socioeconomic scenarios will be obtained from the Land-Use Harmonization (LUH2) project, which is part of CMIP6. It includes datasets for all the SSPs from different Integrated Assessment Models (IAMs). Detailed information on these scenarios can be found in Hurtt et al. (2020). GoNEXUS will focus on the land use scenarios derived from the IAM IMAGE3, which is currently in use among the GoNEXUS partners. From IMAGE3, projections covering SSPs 1 to 3 are ready and SSP5 is under development. These projections offer 5 arcminutes worldwide maps at the monthly scale including the following variables:

- Land use and land cover (natural + urban + water bodies + 23 types of crops)
- Population
- GDP
- Energy consumption
- Electricity production
- Fraction of crop irrigated areas (irrigation type and groundwater pumping capacity)
- Access to water
- Fraction of population served by piped water (in major cities)

**At the continental scale (EU)**, GoNEXUS will use the land use and socioeconomic scenario obtained from the Land-Use based Integrated Sustainability Assessment modelling platform (LUIA<sup>2</sup>) developed by the JRC, which is used by the European Commission to evaluate the current EU policy set. Although it is not in full agreement with the trajectories derived from SSPs, it is taken as the baseline for the EU policies and scenarios. LUIA provides projections until 2050 for a spatial resolution of 100 meters for land use, population distribution, potential accessibility maps, and thematic indicators. On top of the SSPs, the impact of Next Generation EU on socioeconomic projections for the EU will be explored, updating the projections of the SSPs at the light of its development.

## 4.3 Scenario selection

For the GoNEXUS project, four climate, socioeconomic and land use scenarios are selected in the deliverable D2.1, in accordance with the CMIP6 framework. These scenarios extend into the near future, covering the period from 2015 to 2100. They are simulated using a coupled Atmosphere-Ocean General Circulation Model (AOGCM). The forcing for the CMIP6 SSP experiments is based on the shared SSPs, which are a set of emission scenarios driven by various socioeconomic assumptions. These

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<sup>2</sup> <https://data.jrc.ec.europa.eu/collection/luisa>



scenarios are combined with RCP, which represents global forcing pathways designed to achieve specific end-of-century radiative forcing targets. The selected scenarios are:

- **SSP1-1.9** is based on SSP1 with low climate change mitigation and adaptation challenges and RCP1.9, a future pathway with a radiative forcing of 1.9 W/m<sup>2</sup> in the year 2100. The SSP1-1.9 scenario fills a gap at the very low end of the range of plausible future forcing pathways. SSP1-1.9 forcing will be substantially below SSP1-2.6 in 2100. There is policy interest in low-forcing scenarios that would inform a possible goal of limiting global mean warming to 1.5°C above pre-industrial levels.
- **SSP1-2.6** is based on SSP1 with low climate change mitigation and adaptation challenges and RCP2.6, a future pathway with a radiative forcing of 2.6 W/m<sup>2</sup> in the year 2100. The SSP1-2.6 scenario represents the low end of plausible future forcing pathways. SSP1-2.6 depicts a "best case" future from a sustainability perspective.
- **SSP3-7.0** is based on SSP3 in which climate change mitigation and adaptation challenges are high and RCP7.0, a future pathway with a radiative forcing of 7.0 W/m<sup>2</sup> in the year 2100. The SSP3-7.0 scenario represents the medium to high end of plausible future forcing pathways. SSP3-7.0 fills a gap in the CMIP5 forcing pathways that is particularly important because it represents a forcing level common to several (unmitigated) SSP baseline pathways.
- **SSP5-8.5** is based on SSP5 in which climate change mitigation challenges dominate and RCP8.5, a future pathway with a radiative forcing of 8.5 W/m<sup>2</sup> in the year 2100. The SSP5-8.5 scenario represents the high end of plausible future forcing pathways. SSP5-8.5 is comparable to the CMIP5 experiment RCP8.5.

## 5 Relevant policies and strategies to plausible future policy-relevant WEF E scenarios

In this section, a series of current agreements at global level, and strategies and policies at European level are identified. Within the framework of these agreements, strategies and policies, a set of objectives are configured at different spatial scales. The degree of compliance (or non-compliance) with these objectives can shape the levels of socioeconomic growth, the impacts of mitigation and adaptation measures on climate, the security of the nexus, the extent of ecosystem conservation, among other factors at the global and European levels. All these compliance conditions and their effects give rise to the various scenarios presented in this deliverable as policy-relevant WEF E scenarios. The interrelationships that arise among the different dimensions of the nexus and the fulfilment of the objectives form a complex network of interactions. Consequently, addressing all these issues requires first identifying the key policies and related objectives.

### 5.1 Spatial scale frame of main policies and strategies

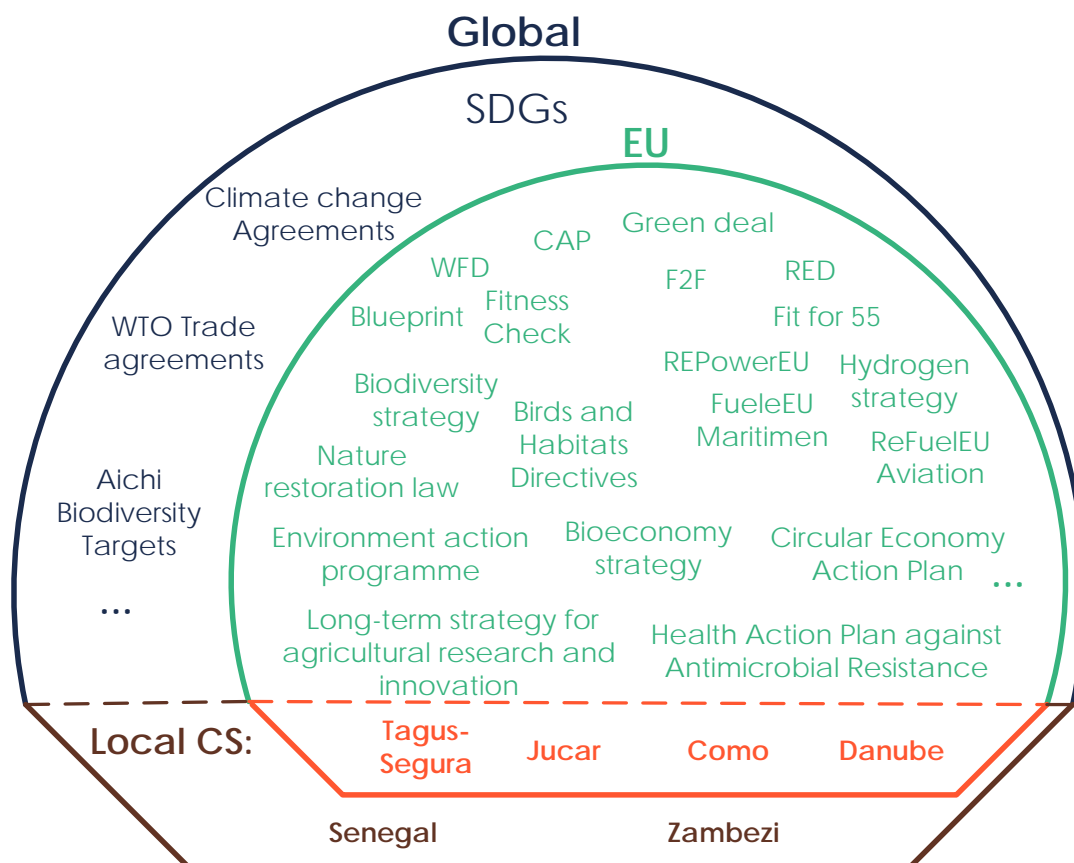


Figure 6. Policy framework for the development of policy-relevant WEF E scenarios in the GoNEXUS project case studies. Source: own elaboration.

The policy framework for the development of policy-relevant WEF E scenarios in the GoNEXUS project case studies includes policies at the global and European Union levels (Figure 6). The global policy framework determines the development of the global case study and serves as an umbrella for the rest of the project's case studies, whether they are continental or local case studies. Similarly, the European policy framework determines the development of the European Union case study and serves

as an umbrella for the local case studies whose basins are located within Europe (e.g. Tagus-Segura, Jucar, Como, and Danube).

## 5.2 Review of relevant global strategies and agreements

The main strategies and agreements identified for the development of the policy-relevant WEFE scenarios at the global level have been selected for their high level of acceptance and impact in the international global sphere. The following are the principal strategies and agreements identified.

### 5.2.1 Agenda 2030 for Sustainable Development

The 2030 Agenda for Sustainable Development<sup>3</sup> was adopted by the United Nations in 2015 as a blueprint for a better and more sustainable future for all. The agenda consists of 17 Sustainable Development Goals (SDGs), which are a set of global targets aimed at eradicating poverty, reducing inequality, and protecting the planet by 2030. The 17 SDGs are interdependent and cover a range of issues, including poverty, hunger, health, education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice and strong institutions, and partnerships for the goals.

### 5.2.2 Climate change agreements

Climate change is one of the biggest challenges facing the world today. Its impacts are felt across multiple sectors, including water, energy, food, and ecosystems. Rising temperatures and changes in precipitation patterns can affect water availability, which in turn affects energy and food production. Climate change also affects ecosystems, which play a crucial role in regulating the water cycle, storing carbon, and providing habitats for biodiversity. To face climate change, a holistic analysis and a joint effort between countries is necessary. In that sense, international community has been making concerted efforts to address it. This has led to the creation of climate change agreements, which are international treaties aimed at reducing greenhouse gas emissions and mitigating the impacts of climate change.

One of the most significant of these agreements is the United Nations Framework Convention on Climate Change (UNFCCC)<sup>4</sup>, which was adopted in 1992 and entered into force in 1994. The UNFCCC's ultimate objective is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. To achieve this objective, the UNFCCC has created a process of international negotiations and meetings, the Conference of the Parties (COP), which is held annually. One of the key outcomes of the UNFCCC process was the adoption of the Kyoto Protocol<sup>5</sup> in 1997. The Kyoto Protocol is a legally binding treaty that commits developed countries to reduce their greenhouse gas emissions by an average of 5.2% below 1990 levels over the period 2008-2012. Also, the Kyoto Protocol laid the foundations for a carbon market, allowing countries to buy and sell emissions permits, and provided incentives for countries to invest in clean technologies.

In 2015, the Paris Agreement<sup>6</sup> was adopted, building on the UNFCCC and the Kyoto Protocol. The Paris Agreement is a legally binding treaty that aims to limit global warming to well below 2 degrees Celsius

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<sup>3</sup> 2030 Agenda for Sustainable Development website: <https://sdgs.un.org/>

<sup>4</sup> United Nations Framework Convention on Climate Change website: <https://unfccc.int/>

<sup>5</sup> Kyoto Protocol: [https://unfccc.int/kyoto\\_protocol](https://unfccc.int/kyoto_protocol)

<sup>6</sup> The Paris Agreement: <https://unfccc.int/process-and-meetings/the-paris-agreement>

above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius. To achieve this objective, country Parties have submitted nationally determined contributions (NDCs), which outline their climate mitigation and adaptation measures. The Paris Agreement also established a system of transparency and accountability, requiring countries to report their emissions and progress towards their NDCs. It also created a mechanism to provide support to developing countries in their efforts to mitigate and adapt to climate change, including financing and technology transfer. Overall, the UNFCCC, the Kyoto Protocol, and the Paris Agreement have established a framework for international cooperation on climate change and provided incentives for countries to invest in clean technologies and reduce their emissions.

### 5.2.3 WTO trade agreements

During the early decades of the 20th century, the growing complexity of international trade interactions prompted the need for a platform to regulate and facilitate trade relations among countries. Consequently, the General Agreement on Tariffs and Trade (GATT) was established in 1947 to provide a multilateral approach to trade and to establish a system of globally recognized rules on trade (GATT, 1986). The Uruguay Round, signed in 1994, has been the largest multilateral agreement ever, including the Agreement on Agriculture<sup>7</sup>, which was one of the key outcomes of trade negotiations. Aiming to liberalize agricultural trade, the agreement called for the reduction of trade barriers, such as tariffs and quotas, and the elimination of export subsidies. The agreement also recognized the importance of food security and allowed developing countries to provide subsidies to their farmers to promote food security.

In 1995, the GATT was transformed as the World Trade Organization (WTO)<sup>8</sup> as a result of the Uruguay Round of trade negotiations. The WTO incorporated various earlier trade agreements, such as the Agreement on Textile and Clothing, or the Agreement on Agriculture. Furthermore, the WTO introduced new agreements such as the General Agreement on Trade in Services and the Agreement on Trade-Related Aspects of Intellectual Property Rights.

Later, the Doha round<sup>9</sup>, was launched in 2001 as a continuation<sup>9</sup> of the trade negotiations and aimed to achieve major reform of the international trading system through the introduction of lower trade barriers and revised trade rules. The Doha agenda covered a wide range of issues, including agriculture, services, and intellectual property. However, negotiations have stalled due to disagreements between countries. In this context, the relevance of preferential trade agreements is increasing.

In February 2017, the Trade Facilitation Agreement – aiming at facilitating the participation in international trade by reducing the time and cost of compliance for traders and operators – entered into force.

Focusing on the European context, the EU was initially designed to remove customs barriers and promote trade between its member states and been a key player in shaping the international trading system since its foundation (European Parliament, 2022). The EU is currently exploring new ways to modernize the WTO to meet the challenges and changing dynamics of the international trading system (European Commission, 2018a).

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<sup>7</sup> Uruguay round - Agreement on Agriculture: [https://www.wto.org/english/docs\\_e/legal\\_e/14-ag\\_01\\_e.htm](https://www.wto.org/english/docs_e/legal_e/14-ag_01_e.htm)

<sup>8</sup> WTO website: [www.wto.org](http://www.wto.org)

<sup>9</sup> Doha round: [https://www.wto.org/english/tratop\\_e/dda\\_e/dda\\_e.htm](https://www.wto.org/english/tratop_e/dda_e/dda_e.htm)

## 5.1 Review of relevant EU strategies and policies

### 5.1.1 Process of adoption policies, regulations, and directives in the EU

For this project, existing policies in the EU and the enabling environment to implement measures regionally or locally are important factors in the current state of how things work and the future outlook, as scenarios. Policies in the EU are shaped by different institutions and processes which yield policy instruments a set of guidelines, such as directives, regulations and laws (i.e. programmes of action, programme of measures) that are developed to address various challenges across different member states, concern the entire EU or respond to global challenges, such as climate change. The EU operates under a complex policy framework of different governing structures that together aim to set standards and set boundaries for policy instruments that collectively guide its actions and initiatives, and can be both binding or non-binding (voluntary or incentives based). This policy framework is designed to address a wide range of issues, from socioeconomic development to environmental sustainability, such as natural resource management, WEFE nexus security, and also foreign relations.

The EU is a union of 27 member states, each with its own interests and priorities. Therefore, the development of political goals is a complex and collaborative process involving multiple EU institutions. The main institutions involved in EU decision-making process are: (1) the European Parliament, representing EU citizens; (2) the Council of the European Union, representing EU governments; and (3) the European Commission, representing the EU's overall interests. EU policies are typically decided through the ordinary legislative procedure (formerly known as the 'co-decision' procedure). This is a process where the three main institutions come to agreement on legislation. Political goals are collectively developed by EU institutions, with the European Commission taking a central role. In this process, EU's strategy is developed and translated into policies and initiatives.

The Commission's process of identifying challenges, setting objectives, proposing policies, and implementing them reflects the EU's commitment to addressing a wide range of issues while respecting the diversity of its member states.

### 5.1.2 EU main strategies

Strategies are comprehensive plans or roadmaps that outline the long-term objectives and priorities of the EU. These strategies are developed to address specific challenges or opportunities and provide a coherent framework for action. Below are the main strategies related to the WEFE nexus in the EU.

#### The European Green Deal

The European Green Deal<sup>10</sup> (COM(2019) 640 final) (Figure 7) is a comprehensive and ambitious strategy proposed by the European Commission in December 2019 in response to the Paris Agreement and aims to achieve climate neutrality and sustainable growth within the EU, making EU as the world's first climate-neutral continent. This strategy seeks to transform the EU into a modern, resource-efficient, and competitive economy, ensuring:

- no net emissions of greenhouse gases by 2050
- decouple economic growth from resource use
- no person and no place left behind.

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<sup>10</sup> [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en)

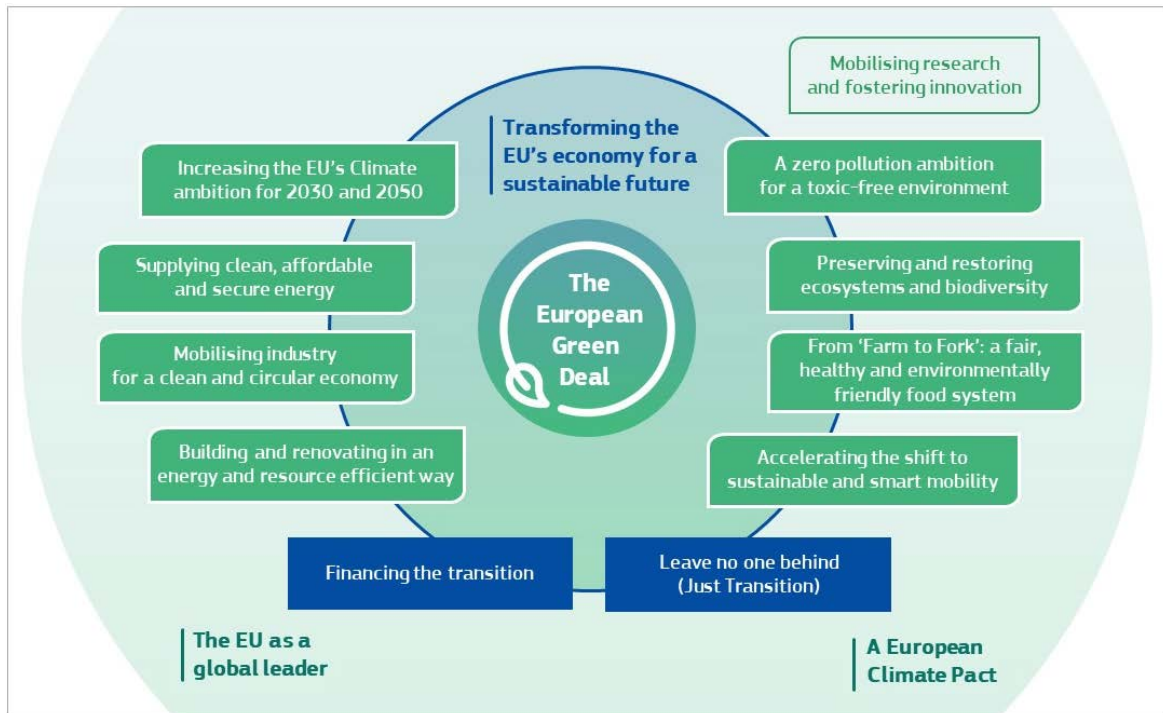


Figure 7. The European Green Deal. Source: European commission (2019).

Climate action is at the heart of the European Green Deal. The Green Deal outlines an array of policy initiatives and measures that address various aspects of sustainability, including decarbonization, biodiversity, pollution, and sustainable development. At its core, the Green Deal seeks to restructure the EU economy while promoting clean energy, sustainable industry, and circular economy practices.

To accomplish climate neutrality, the strategy emphasizes the adoption of renewable energy sources, energy efficiency improvements, and the enhancement of carbon sinks. It also advocates for the development of a circular economy that reduces waste and encourages the sustainable use of resources. Protect and restore biodiversity, safeguarding ecosystems and promoting sustainable agriculture (Farm to Fork strategy) are also key components of the Green Deal. It emphasizes the importance of halting deforestation, promoting sustainable farming practices, and reducing the use of harmful chemicals in agriculture. The deal also highlights the need for a fair and just transition for all citizens, especially those in vulnerable or high-emission sectors, ensuring that no one is left behind in the shift toward sustainability. Furthermore, the deal seeks to strengthen the EU's position as a global leader in environmental policy. It emphasizes the need for diplomatic initiatives to promote environmental sustainability globally and encourages international cooperation to combat climate change.

### Farm to Fork strategy (F2F)

The Farm-to-Fork strategy<sup>11</sup> is at the heart of the Green Deal. It broadly addresses the challenges of sustainable food systems and recognizes the inextricable links between healthy societies and a healthy planet. It is also at the heart of the Commission's agenda to achieve the UN Sustainable Development Goals (SDGs). All citizens and actors in the value chain, in the EU and elsewhere, should benefit from a just transition, especially in the wake of the COVID-19 pandemic and the economic downturn. A transition to a sustainable food system can bring environmental, health and social benefits, offer

<sup>11</sup> [https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy\\_en](https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en)

economic advantages and ensure that exiting the crisis puts us on a sustainable path (European Commission, 2020).

The sustainability of food systems is a global issue and food systems will have to adapt to meet various challenges. With this strategy, the EU can play a key role in setting global standards. It sets key objectives in priority areas for the EU. In addition to new policy initiatives, implementation of existing legislation, in particular on pesticide use and environmental protection, is essential to ensure a just transition.

The use of chemical pesticides in agriculture contributes to soil, water and air pollution, biodiversity loss and can harm non-target plants, insects, birds, mammals, and amphibians. The Commission will take additional action to reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030.

The excess of nutrients (especially nitrogen and phosphorus) in the environment, stemming from excess use and the fact that not all nutrients used in agriculture are effectively absorbed by plants, is another major source of air, soil and water pollution. It has reduced biodiversity in rivers, lakes, wetlands and seas. The Commission will act to reduce nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility. This will reduce the use of fertilisers by at least 20% by 2030.

Agriculture is responsible for 10.3% of the EU's greenhouse gas emissions, almost 70% of which come from the animal sector. These are non-CO<sub>2</sub> greenhouse gases (methane and nitrous oxide). In addition, 68% of the total agricultural area is used for animal production.

The market for organic food will continue to grow and organic farming needs to be further promoted. It has a positive impact on biodiversity, creates jobs and attracts young farmers. The Commission will present an action plan on organic farming. This approach should lead to the target of at least 25% of EU agricultural land being farmed organically by 2030 and a significant increase in organic aquaculture.

### **EU Biodiversity Strategy for 2030**

The European Union (EU) Biodiversity Strategy for 2030<sup>12</sup> is a comprehensive and ambitious plan to protect and restore biodiversity and ecosystems. The strategy outlines specific targets and measures to be taken by the EU and its member states to halt the loss of biodiversity and promote its restoration, as well as to enable a sustainable transition. The strategy recognizes the importance of biodiversity for human well-being and economic prosperity, as well as for the provision of essential ecosystem services such as pollination, soil fertility, and water purification. It emphasizes the need for a transformative change in the way we produce and consume goods and services, and the role of biodiversity and ecosystems in achieving this change. It is the proposal for the EU's contribution to the upcoming international negotiations on the global post-2020 biodiversity framework and core part of the European Green Deal.

### **EU Strategy on Adaptation to Climate Change**

The EU Strategy on Adaptation to Climate Change<sup>13</sup> (COM (2021) 82 final) sets out how the European Union can adapt to the unavoidable impacts of climate change and become climate resilient by 2050. The Strategy has four principle objectives: to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change. Smarter adaptation involves data-driven actions accessible to all, expanding knowledge and improving Climate-ADAPT. Faster adaptation stresses the urgency of comprehensive climate risk reduction and freshwater preservation. Systemic

<sup>12</sup> [https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030\\_en](https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en)

<sup>13</sup> [https://climate.ec.europa.eu/eu-action/adaptation-climate-change/eu-adaptation-strategy\\_en](https://climate.ec.europa.eu/eu-action/adaptation-climate-change/eu-adaptation-strategy_en)

adaptation integrates climate resilience into policies and supports adaptation strategies at all governance levels, including fiscal integration, nature-based solutions, and local initiatives. Stepping up international action means boosting EU support, prioritizing aid, and enhancing global engagement for climate resilience.

### Bioeconomy strategies

The European Union's strategy for A Sustainable Bioeconomy for Europe (Figure 8) (European Commission, 2018b) was launched in 2018 to establish a sustainable and circular bioeconomy that can reduce the EU's dependency on fossil fuels, protect the environment, and create new economic opportunities for EU citizens. The strategy aims to utilize renewable biological resources from agriculture, forestry, and fisheries, as well as from waste streams, to produce food, energy, and other products. This will be done by promoting the development of bio-based industries that use innovative

technologies and processes to maximize the value and sustainability of biological resources.

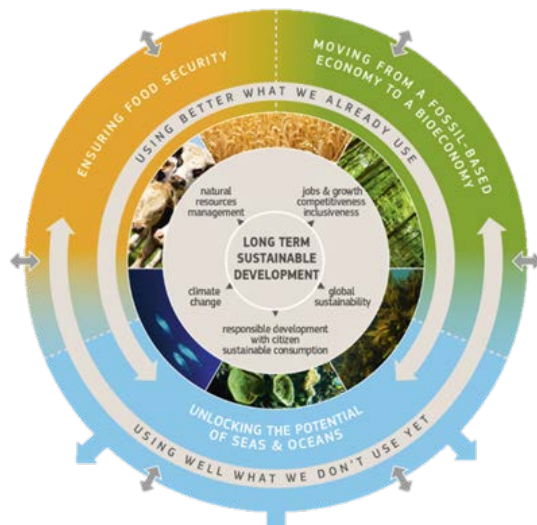


Figure 8. EU Bioeconomy strategy.

Furthermore, a sustainable and circular bioeconomy can enhance climate change adaptation and resilience by promoting ecosystem restoration, supporting indigenous and local livelihoods based on biological products and services, and fostering more sustainable management of forests and fisheries. Several countries have identified the circular bioeconomy as a strategy to fulfil their nationally determined contributions. Some countries have incorporated bioeconomy practices in their climate agenda, while others have explicitly included bioeconomy strategies and policies as crucial components in their approach to achieving Paris Agreement targets.

### The Blueprint to Safeguard Europe's Water resources

The Blueprint to Safeguard Europe's Water Resources (COM/2012/0673), is a long-term strategy (horizon 2050) introduced in 2012, that aims to ensure the availability of a sufficient level of quality water for all legitimate uses by better implementing current EU water policy, integrating water policy objectives into other policy areas and filling gaps in the current framework. It envisages the establishment by the Member States of water accounts and water efficiency targets, as well as the development of EU standards for water reuse.

#### 5.1.3 WEF E nexus policies, regulations, and directives in the EU

For decision-making, strategies are translated into regulations and directives in the EU policy development process. Regulations are binding legal acts that are directly applicable in all member states. They have the force of law and do not require national implementation. Regulations are used to create a single set of rules and standards across the EU, ensuring a level playing field in areas such as competition policy, consumer protection, and environmental standards. Directives, on the other hand, are legal acts that set out specific goals that all member states shall achieve but allow flexibility in how those goals are met. Member states are required to transpose directives into national law, adapting them to their specific circumstances. Below are the main policies, regulations and directives related to the WEF E nexus in the EU.

##### 5.1.3.1 The Common Agricultural Policy (CAP)



The Common Agricultural Policy<sup>14</sup> (CAP) has legal basis under articles 38 to 44 of the Treaty on the Functioning of the European Union (TFEU). The CAP is the main EU policy for the Agricultural sector and is common for all EU countries. It aims to:

- Support farmers and improve agricultural productivity, ensuring a stable supply of affordable food.
- Safeguard European Union farmers to make a reasonable living.
- Help tackle climate change and the sustainable management of natural resources.
- Maintain rural areas and landscapes across the EU.
- Keep the rural economy alive by promoting jobs in farming, agri-food industries and associated sectors.

The CAP was established in 1962 and has undergone several reforms since then. In the 2014-2020 programming period, the CAP was reformed to strengthen the competitiveness of the agricultural sector, promote sustainable farming and innovation, support jobs and growth in rural areas and to move financial assistance towards the productive use of land. The 2014-20 CAP had two main pillars: the first pillar provides direct payments to farmers based on the amount of land they cultivate, and the second pillar provides funding for rural development initiatives. The direct payments under the first pillar are intended to stabilize farmers' incomes and ensure that they can continue to produce food at affordable prices for EU consumers. The second pillar provides funding for projects that promote sustainable agriculture, protect the environment, and support rural communities.

The new CAP for the period 2023-2027, aims to increase the focus on environmental sustainability, climate change, and support for small and medium-sized farms. The new policy introduces several changes, such as the requirement for farmers to implement more environmentally friendly practices to receive direct payments, a greater focus on research and innovation to improve sustainability and productivity, and new measures to support young farmers and facilitate generational renewal. The new CAP also seeks to simplify administrative procedures and ensure greater transparency and accountability in the distribution of funds.

The following four regulations set out the different elements of the CAP work:

- EU Regulation 1308/2013 on a common organization of the markets in agricultural products;
- EU Regulation 1306/2013 on the financing, management and monitoring of the CAP.

The new CAP covers three regulations, which will generally apply from 1 January 2023:

- EU Regulation 2021/2116, repealing EU Regulation 1306/2013 on the financing, management and monitoring of the CAP.
- EU Regulation 2021/2115, establishing rules on support for national CAP strategic plans, and repealing EU Regulations 1305/2013 and 1307/2013.
- EU Regulation 2021/2117, amending EU Regulations 1308/2013 on the common organisation of the agricultural markets; 1151/2012 on quality schemes for agricultural products; 251/2014 on geographical indications for aromatised wine products; and 228/2013 laying down measures for agriculture in the outermost regions of the EU.

### 5.1.3.2 Water policies

#### **Water Framework Directive (WFD)**

Water Framework Directive (WFD) (Directive 2000/60/EC) established an EU-wide obligatory legal framework for the protection of all the different water bodies, whether surface waters, transitional

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<sup>14</sup> <https://www.europarl.europa.eu/factsheets/en/sheet/103/the-common-agricultural-policy-cap-and-the-treaty>

waters, coastal waters, and groundwater. The directive aims to prevent and reduce pollution, promote sustainable water use, protect and improve the aquatic environment, and mitigate the effects of floods and droughts, with the overall objective of achieving good environmental status for all waters. Member States are required to draw up river basin management plans and specific programmes of measures to achieve these objectives.

The WFD is supported by more targeted directives. Among them:

- The Groundwater Directive (Directive 2006/118/EC) provides for specific criteria for the assessment of good chemical status, the identification of significant and sustained upward trends, and the definition of starting points for trend reversals.
- The Drinking Water Directive (Directive (EU) 2020/2184) defines essential quality standards for water intended for human consumption and requires Member States to regularly monitor the quality of water using a 'sampling points' method.
- The Bathing Water Directive (Directive 2006/7/EC) aims to enhance public health and environmental protection by laying down provisions for the monitoring and classification of bathing water and informing the public about it.
- The Environmental Quality Standards Directive (Directive 2008/105/EC) establishes limits on concentrations of priority substances presenting a significant risk to the aquatic environment at EU level and eight other pollutants in surface waters.
- The Urban Wastewater Treatment Directive (Council Directive 91/271/EEC) aims to protect the environment from the adverse effects of urban wastewater discharges and discharges from industry.
- The Nitrates Directive (Council Directive 91/676/EEC) aims to protect waters from nitrates from agricultural sources.
- The EU Floods Directive (Directive 2007/60/EC) aims to reduce and manage the risks posed by floods to human health, the environment, infrastructure, and property.

These directives provide specific criteria for the assessment of water quality and establish minimum standards and timetables for the collection, treatment, and discharge of urban wastewater. The WFD is broadly fit for purpose, but its implementation needs to be sped up (Weisner et al., 2022) as mentioned in the Fitness Check of the EU Water Legislation (see below).

### **Fitness Check of the EU Water Legislation**

The Fitness Check of the EU Water Legislation<sup>15</sup> is a comprehensive assessment conducted by the European Commission to evaluate the effectiveness, efficiency, coherence, relevance, and EU added value of the current EU water policies and their implementation. The Fitness Check aimed to determine if the current policies are suitable for achieving the EU's long-term objectives (horizon 2050), such as ensuring sustainable water use and protecting aquatic ecosystems.

The Fitness Check covered the assessment of water-related directives, including the Groundwater Directive, the Drinking Water Directive, the Bathing Water Directive, the Nitrates Directive, the Urban Wastewater Treatment Directive, the Environmental Quality Standards Directive, and the Floods Directive.

The Fitness Check found that the EU water legislation has been effective in improving the water quality and management of EU's water resources. However, the assessment also identified several challenges and areas for improvement, such as the lack of implementation in some Member States, insufficient funding, and limited integration with other policies. The Fitness Check recommended several actions,

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<sup>15</sup> <https://www.europarl.europa.eu/factsheets/en/sheet/74/water-protection-and-management>

including improving implementation and enforcement, strengthening governance and stakeholder involvement, and enhancing coherence with other policy areas.

The Fitness Check also highlighted the need to address emerging challenges, such as climate change, water scarcity, and emerging pollutants. The assessment recognized the importance of adopting a holistic and integrated approach to water management, considering the water-energy-food nexus and the circular economy principles.

### 5.1.3.3 EU energy policy and climate law

The EU energy policy has legal basis under articles 194 of the TFEU. The European Union has developed a comprehensive energy policy to address the challenges of climate change, energy security, and competitiveness in energy sector. The objectives of the energy policy are:

- Diversify Europe's sources of energy, ensuring energy security through solidarity and cooperation between EU countries.
- Ensure the functioning of a fully integrated internal energy market, enabling the free flow of energy through the EU through adequate infrastructure and without technical or regulatory barriers.
- Improve energy efficiency and reduce dependence on energy imports, cut emissions, and drive jobs and growth.
- Decarbonize the economy and move towards a low-carbon economy in line with the Paris Agreement.
- Promote research in low-carbon and clean energy technologies and prioritize research and innovation to drive the energy transition and improve competitiveness.

The policy agenda is driven by the alignment of the EU energy targets to the climate targets of the new Fit For 55 package. In that sense the policy framework aims to achieving a reduction in greenhouse gas by increasing the share of renewable energies, reducing energy, improving energy efficiency, and interconnecting the EU's electricity systems. The EU has also adopted the Energy Union strategy and the 'Clean Energy for All Europeans' package, which consists of eight legislative proposals covering governance, electricity market design, energy efficiency, renewable energy, and the regulator. Furthermore, the EU energy policy aims to complete the internal energy market, which secures energy supplies, ensures affordable energy prices, and opens up the least costly path to climate neutrality.

#### **The Fit for 55 package**

The Fit for 55 package<sup>16</sup> (COM/2021/550 final) is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with the climate goals agreed by the Council and the European Parliament. The Fit for 55 package have the goal of reducing greenhouse gas emissions by 55% by 2030 compared to 1990 levels and make the EU carbon-neutral by 2050.

#### **Renewable Energy Directive (RED)**

The Renewable Energy Directive (Directive 2009/28/EC; COM(2021)0557) provides the legal framework for promoting clean energy development across all sectors of the EU economy, fostering collaboration among EU countries in pursuit of this objective. Its revised version (Directive (EU) 2018/2001) seeks to accelerate the EU's transition to clean energy, setting an overarching European renewable energy target of 32% by 2030. It also includes provisions to ensure the adoption of renewables in the transportation sector and for heating and cooling purposes. The directive establishes

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<sup>16</sup> <https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/>

uniform principles and regulations for supporting renewable energy schemes, outlines sustainability criteria for biomass, and guarantees the right to produce and consume renewable energy, encouraging the establishment of renewable energy communities. Moreover, it outlines measures to eliminate obstacles, stimulate investments, and drive down costs in renewable energy technologies, empowering individuals and businesses to actively engage in the shift toward clean energy.

**Other EU energy and climate directives:**

- Electricity market design: The Electricity Directive ((EU) 2019/944).
- Energy efficiency Targets: Energy Efficiency Directive ((EU) 2018/2002).

**5.1.3.4 EU Nature and biodiversity rules**

The EU aims to protect nature and biodiversity with rules such as the Birds (Directive 79/409/EEC) and Habitats (Council Directive 92/43/EEC) Directives. The overarching objective of both directives is to ensure the maintenance or restoration of the species and habitat types they protect to a favourable conservation status throughout their natural distribution within the EU. The goal is not merely to halt their decline or disappearance but to promote their recovery to a level where they can thrive sustainably in the long term.

## 5.2 Main WEF E policy objectives

### 5.2.1 At Global level

**Paris Agreement**

Long-term temperature goal

Limit global temperature increase to well below 2°C above pre-industrial levels, while pursuing efforts to limit the increase to 1.5°C.

Global peaking and 'climate neutrality'

To achieve the temperature goal, country Parties aim to reach global peaking of greenhouse gas emissions (GHGs) as soon as possible, recognizing peaking will take longer for developing country Parties, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of the century.

Mitigation

The Paris Agreement establishes binding commitments by all Parties to prepare, communicate and maintain a NDC and to pursue domestic measures to achieve them. It also prescribes that Parties shall communicate their NDCs every 5 years and provide information necessary for clarity and transparency. To set a firm foundation for higher ambition, each successive NDC will represent a progression beyond the previous one and reflect the highest possible ambition. Developed countries should continue to take the lead by undertaking absolute economy-wide reduction targets, while developing countries should continue enhancing their mitigation efforts, and are encouraged to move toward economy-wide targets over time in the light of different national circumstances.

Sinks and reservoirs

The Paris Agreement also encourages Parties to conserve and enhance, as appropriate, sinks and reservoirs of GHGs, including forests.

Voluntary cooperation/Market- and non-market-based approaches

The Paris Agreement recognizes the possibility of voluntary cooperation among Parties to allow for higher ambition and sets out principles – including environmental integrity, transparency and robust accounting – for any cooperation that involves internationally transferal of mitigation outcomes. It

establishes a mechanism to contribute to the mitigation of GHG emissions and support sustainable development, and defines a framework for non-market approaches to sustainable development.

#### Adaptation

The Paris Agreement establishes a global goal on adaptation – of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change in the context of the temperature goal of the Agreement. It aims to significantly strengthen national adaptation efforts, including through support and international cooperation. It recognizes that adaptation is a global challenge faced by all. All Parties should engage in adaptation, including by formulating and implementing National Adaptation Plans, and should submit and periodically update an adaptation communication describing their priorities, needs, plans and actions. The adaptation efforts of developing countries should be recognized.

#### Loss and damage

The Paris Agreement recognizes the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage. Parties are to enhance understanding, action and support, including through the Warsaw International Mechanism, on a cooperative and facilitative basis with respect to loss and damage associated with the adverse effects of climate change.

#### Finance, technology and capacity-building support

The Paris Agreement reaffirms the obligations of developed countries to support the efforts of developing country Parties to build clean, climate-resilient futures, while for the first time encouraging voluntary contributions by other Parties. Provision of resources should also aim to achieve a balance between adaptation and mitigation. In addition to reporting on finance already provided, developed country Parties commit to submit indicative information on future support every two years, including projected levels of public finance. The agreement also provides that the Financial Mechanism of the Convention, including the Green Climate Fund shall serve the Agreement. International cooperation on climate-safe technology development and transfer and building capacity in the developing world are also strengthened: a technology framework is established under the Agreement and capacity-building activities will be strengthened through, inter alia, enhanced support for capacity building actions in developing country Parties and appropriate institutional arrangements. Climate change education, training as well as public awareness, participation and access to information is also to be enhanced under the Agreement.

Climate change education, training, public awareness, public participation, and public access to information is also to be enhanced under the Agreement.

#### Transparency, implementation, and compliance

The Paris Agreement relies on a robust transparency and accounting system to provide clarity on action and support by Parties, with flexibility for their differing capabilities of Parties. In addition to reporting information on mitigation, adaptation and support, the Agreement requires that the information submitted by each Party undergoes international technical expert review. The Agreement also includes a mechanism that will facilitate implementation and promote compliance in a non-adversarial and non-punitive manner, and will report annually to the CMA.

#### Global Stocktake

A “global stocktake”, to take place in 2023 and every 5 years thereafter, will assess collective progress toward achieving the purpose of the Agreement in a comprehensive and facilitative manner. It will be based on the best available science and its long-term global goal. Its outcome will inform Parties in

updating and enhancing their actions and support and enhancing international cooperation on climate action.




Decision

Also sets out a number of measures to enhance action prior to 2020, including strengthening the technical examination process, enhancement of provision of urgent finance, technology and support and measures to strengthen high-level engagement. For 2018 a facilitative dialogue is envisaged to take stock of collective progress towards the long-term emission reduction goal. The decision also welcomes the efforts of all non-Party stakeholders to address and respond to climate change, including those of civil society, the private sector, financial institutions, cities and other subnational authorities. These stakeholders are invited to scale up their efforts and showcase them via the Non-State Actor Zone for Climate Action platform<sup>17</sup>. Parties also recognized the need to strengthen the knowledge, technologies, practices and efforts of local communities and indigenous peoples, as well as the important role of providing incentives through tools such as domestic policies and carbon pricing.



**SDGs target in GoNEXUS and WEFE nexus context**






The SDGs list a series of goals that outline a set of objectives divided into specific targets closely linked to the WEFE nexus. Numerous studies have explored the correlation between the SDGs and the WEFE nexus (Carmona-Moreno et al., 2021; Carmona-Moreno et al., 2019; Stephan et al., 2018). Table 2 highlights key goals and targets that intersect with the WEFE nexus.

Table 2. List of SDG target identified in the WEFE nexus context. Source: own elaboration

SDG's Goals and Targets	
<p>6. Ensure access to water and sanitation for all</p> 	6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
	6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
	6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
	6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
	6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
<p>7. Ensure access to affordable, reliable, sustainable and modern energy for all</p> 	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix
	7.3 By 2030, double the global rate of improvement in energy efficiency
	7.A By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
<p>2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture</p> 	2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
	2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.
	2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.
	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that

<sup>17</sup> <http://climateaction.unfccc.int>

SDG's Goals and Targets	
	<p>strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.</p> <p>2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.</p> <p>2.A Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries.</p> <p>2.B Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.</p> <p>2.C Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.</p>
<p>13. Take urgent action to combat climate change and its impacts</p> 	<p>13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries</p> <p>13.2 Integrate climate change measures into national policies, strategies and planning</p> <p>13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning</p> <p>13.A Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible</p> <p>13.B Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities</p>
<p>15. Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss</p> 	<p>15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements</p> <p>15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally</p> <p>15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world</p> <p>15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development</p> <p>15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species</p> <p>15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed</p> <p>15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products</p> <p>15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species</p> <p>15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts</p> <p>15.A Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems</p> <p>15.B Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation</p> <p>15.C Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities</p>
<p>12. Ensure sustainable consumption and production patterns</p>	<p>12.2 By 2030, achieve the sustainable management and efficient use of natural resources</p> <p>12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses</p> <p>12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment</p>

SDG's Goals and Targets	
 <p>12 RESPONSIBLE CONSUMPTION AND PRODUCTION</p>	12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
 <p>5 GENDER EQUALITY</p>	5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision making in political, economic, and public life  5.A Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws
 <p>1 NO POVERTY</p>	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance  1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters
 <p>3 GOOD HEALTH AND WELL-BEING</p>	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
 <p>17 PARTNERSHIPS FOR THE GOALS</p>	17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda 17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence 17.14 Enhance policy coherence for sustainable development 17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries

## WTO objectives

### Improving people's lives

The fundamental goal of the WTO is to improve the welfare of people around the world. The WTO's founding Marrakesh agreement recognizes that trade should be conducted with a view to raising standards of living, ensuring full employment, increasing real income and expanding global trade in goods and services while allowing for the optimal use of the world's resources.

### Negotiating trade rules

The WTO was born out of five decades of negotiations aimed at progressively reducing obstacles to trade. Where countries have faced trade barriers and wanted them lowered, the negotiations have helped to open markets for trade. Conversely, in some circumstances, WTO rules support maintaining trade barriers – for example, to protect consumers or the environment.

### Overseeing WTO agreements

At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations. Essentially contracts, these documents provide the rules for international commerce and bind governments to keep their trade policies within agreed limits. Their goal is to help producers of goods and services, exporters and importers conduct their business, with a view to raising standards of living, while allowing governments to meet social and environmental objectives.

### Maintaining open trade



The system's overriding purpose is to help trade flow as freely as possible – provided there are no undesirable side effects – because this stimulates economic growth and employment and supports the integration of developing countries into the international trading system. Its rules have to be transparent and predictable, to ensure that individuals, companies and governments know what the trade rules are around the world, and to assure them that there will be no sudden changes of policy.

### Settling disputes

Trade relations often involve conflicting interests. Agreements, including those painstakingly negotiated in the WTO, often need interpreting. The most harmonious way to settle these differences is through a neutral procedure based on an agreed legal foundation. That is the purpose behind the dispute settlement process written into the WTO agreements.

### **Other global objectives**

In addition to the agreements and objectives mentioned above, there are other targets that also have a degree of relevance in the international sphere such as the Aichi Biodiversity Targets<sup>18</sup> or World Health Organization Global Targets 2025.

### 5.2.2 At EU Level

Based on the study "Towards a fair and sustainable Europe 2050" (Matti et al., 2023) the EU, the "2023 Strategic Foresight Report: sustainability and well-being at the heart of Europe's Open Strategic Autonomy" (European Commission, 2023) analyses how to put sustainability and people's rights, and well-being at the centre of Europe's open strategic autonomy and suggests ten concrete actions to achieve this goal. These actions are:

1. Ensure a new European social contract with renewed welfare policies and a focus on high-quality social services.
2. Deepen the Single Market to champion a resilient net-zero economy, with a focus on Open Strategic Autonomy and economic security.
3. Boost the EU's offer on the global stage to strengthen cooperation with key partners.
4. Support shifts in production and consumption towards sustainability, targeting regulation and fostering balanced lifestyles.
5. Move towards a 'Europe of investments' through public action to catalyse financial flows for the transitions.
6. Make public budgets fit for sustainability through an efficient tax framework and public spending.
7. Further shift policy and economic indicators towards sustainable and inclusive wellbeing, including by adjusting GDP for different factors.
8. Ensure that all Europeans can contribute to the transition by increasing labour market participation and focusing on future skills.
9. Strengthen democracy with generational fairness at the heart of policymaking to reinforce the support for the transitions.
10. Complement civil protection with 'civil prevention' by reinforcing the EU's toolbox on preparedness and response.

In addition to the proposed actions for this report, we have compiled a list of objectives from various policy frameworks of the European Union across the different dimensions of the WEF nexus project. From this list, we work with project member expert panel to determine the most relevant objectives in the European case stud. Below is the list of the nineteen policy-relevant objectives selected (Table 3.).

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<sup>18</sup> <https://www.cbd.int/sp/targets/>

Table 3. Set of relevant policy objectives identified for the EU case study. Source: own elaboration.

WEFE dimensions	Objective	Description
Water	Secure supply of drinking water	Guarantee a stable and secure supply of drinking water, by encouraging the incorporation of the risks of climate change in risk analyses of water management.
Water	Reduce water use	Reduce water use by raising the water-saving requirements for products, encouraging water efficiency and savings, and by promoting the wider use of drought management plans as well as sustainable soil management and land-use.
Water	Ensure climate-resilient, sustainable use and management of water across sectors	Ensure climate-resilient, sustainable use and management of water across sectors and borders by improving coordination of thematic plans and other mechanisms, such as water resource allocation and water-permits.
Water Environment	Good status for all water bodies	Achieve good status or potential for all water bodies by 2027
Water Food	Encourage water reuse in irrigation to reduce water abstraction	Encourage and facilitate water reuse in agricultural irrigation to reduce water abstractions. The Regulation on minimum requirements for water reuse for agricultural irrigation entered into force in June 2020. The new rules will apply from 26 June 2023 and are expected to encourage and facilitate water reuse in the EU.
Energy Climate Environment	Increase renewables	Increase the overall binding target from the current 32% to a new level of 42.5% of renewables in the EU energy mix by 2030.
Energy	Reduction energy consumption	Achieve a reduction of 11.7% for final energy consumption by 2030 compared to the 2020 reference.
Food Environment	Reduce the risk and use of chemical pesticides	Reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030.
Food Environment	Reduce Antimicrobial Resistance	Reduce overall EU sales of antimicrobials for farmed animals and in aquaculture by 50% by 2030.
Food Environment	Foster Organic Farming	Increase the area of agricultural land under organic farming management to at least 25% and significantly increase the adoption of agro-ecological practices in agriculture.
Food Environment	Fertilisers use reduction	Reduce the losses of nutrients from fertilisers by 50%, resulting in the reduction of the use of fertilisers by at least 20%.
Food	Food waste reduction	Encourage food waste reduction. Member States are required to take the necessary measures to reduce food waste by the end of 2030, by 10%, in processing and manufacturing; and by 30% (per capita), jointly at retail and consumption (restaurants, food services and households).
Environment Land	Greenhouse gas removals in the Land Use Change and Forestry sector (LULUCF)	Achieve 310 million tons of CO2 equivalent of greenhouse gas removals in the Land Use Change and Forestry sector (LULUCF) and reverse the current trend of diminishing CO2 removals and increase the quality and quantity of the EU's forests and other natural carbon sinks.
Environment	Increase Forest quantity	Plant at least 3 billion additional trees per year in the EU by 2030, following sustainable re- and afforestation practices while fully respecting ecological principles, and implement a roadmap to achieve this goal.
Climate Environment	Reduce emissions to 55% by 2030	Reduce emissions by 50% to 55% by 2030, compared to 1990 levels
Climate	Reduction transport emissions	Achieve a 90% reduction in overall transport emissions (compared to 1990 levels) by 2050.
Environment Land	Legally protect land area	Legally protect a minimum of 30% of the EU's land and sea area; a third of these are to be strictly protected (totally undisturbed by human activity). This is a minimum of an extra 4% compared to 2022.
Environment Water	Restore free-flowing rivers	Restore at least 25,000 km of free-flowing rivers.
Environment Biodiversity	Preserving biodiversity	To ensure that Europe's biodiversity will be on the path to recovery by 2030

### 5.2.3 Indicators to measure objectives

To assess the achievement of policy objectives, utilizing indicators for quantitative analysis is essential. An indicator system offers a structured framework for monitoring and evaluating specific parameters, aiding in the assessment of policy implementation and goal attainment. Policy and Objective design often include predetermined indicators, targets, and scopes to be reached (e.g. Achieve a reduction of 11.7% in final energy consumption by 2030 compared to the 2020 reference). However, objectives are not always accompanied by such direct indicators; sometimes, there is insufficient data for measurement or the calculations are complex (e.g. Achieve good status or potential for all water

bodies by 2027). Different levels of target fulfilment can be aligned with each policy-relevant WEFE scenario, considering the synergies and trade-offs among the components of the nexus, enabling a more comprehensive analysis of the scenarios.

At global level, one of the primary indicator systems is the SDG indicators (<https://unstats.un.org/sdgs/dataportal>). For instance, the “Sustainable Development Goals Report 2023 (UN, 2023) provides a powerful call to action, presenting a candid assessment of the SDGs based on the latest data and estimates. Additionally, various sources of data and indicators are available, including:

- UN Data (<https://data.un.org/>)
- World Bank Open Data (<https://data.worldbank.org/indicator>)
- FAO stats (<https://www.fao.org/faostat>)
- OECD data (<https://data.oecd.org/>)
- WHO data (<https://www.who.int/data>)
- Biodiversity Indicators Partnership (<https://www.bipindicators.net/>)
- International Energy Agency (<https://www.iea.org/data-and-statistics>)

At the European level, there are also diverse indicator systems and databases. Eurostat (<https://ec.europa.eu/eurostat>) serves as the primary statistical source for the European Union, publishing high-quality statistics and indicators at the European scale to facilitate country and region comparisons. Furthermore, other sector-specific databases exist within the European Union, such as the Agri-food Data Portal (<https://agridata.ec.europa.eu>) in the agricultural sector, or the European Environmental Agency Indicators (<https://www.eea.europa.eu/ims>) (EEA, 2018a).

Within the GoNEXUS project, a dynamic indicator system called the "Sustainable Assessment Framework" (SAF) has been developed, allowing for the evaluation of different case studies and solutions across various scenarios. As a complement to the SAF and drawing from the aforementioned indicator systems and policy objectives, future research will work with a set of indicators to illustrate how compliance with the targets aligns with the scenarios (see Section 7.3).

## 6 Stakeholder engagement

To develop the narrative of the policy-relevant WEFE scenarios, stakeholder feedback is essential. Stakeholder input was gathered through workshops and dialogues which served as feedback for scenario design and as factors to consider in the upcoming simulations of the scenarios within each model in the framework of the GoNEXUS project.

### 6.1 Input from expert panel

Within the project framework, a project member expert panel collaborated to develop various policy-relevant WEFE scenarios. Using the Canvas methodology, the proposed scenarios from Section 6.1 were presented to the panel to gather feedback and relevant insights for the selected scenarios. For each scenario, seven domains were developed, including the dimensions of the WEFE nexus. The domains covered were:

- Policy objectives achievement
- Climate
- Socioeconomic
- Water
- Energy
- Food
- Ecosystems

Additionally, an "others" section was included for experts to address any aspect not covered by the previous domains. Input from each of these domains was considered in the policy-relevant WEFE scenarios development.

The workshop took place during the annual project meeting in May 2023 in Como, Italy. The participating experts were the GoNEXUS project partners representing various sectors of the WEFE nexus, thus contributing diverse perspectives to scenario development. This approach ensured a multi-actor and multi-sectoral focus on potential future scenarios.

### 6.2 Dialogues with stakeholders

In March 2023, a European-level meeting was conducted with stakeholders represented in a European working group, namely the Ad-Hoc Task Group on Water Scarcity and Droughts of the EU water Policy Common Implementation Strategy, enabling the clarification of key points to consider when simulating various policy-relevant WEFE scenarios with each model within the framework of the project. This group was targeted as droughts and water scarcity were considered as key for all scenarios to be addressed at the EU level. Some relevant points include:

- The data and projections from different models for various scenarios must be robust and reliable.
- Executing different policy-relevant WEFE scenarios is a tool to address uncertainties in decision-making.
- It is essential to determine impacts generated by resource scarcity in each scenario at the social, economic, and environmental levels.
- The significance of measuring policy objective attainment through an appropriate indicator system.

## 7 Policy-relevant WEF E scenarios

### 7.1 Policy-relevant WEF E scenarios overview

The policy-relevant WEF E scenarios are plausible scenarios that integrate current policies with climate, socioeconomic, and land use scenarios in the WEF E nexus context. After reviewing the literature and policy, to develop the narratives of the scenarios we name each of the policy-relevant WEF E scenarios to align with the CMIP6 climate, socioeconomic, and land use scenarios presented in deliverable D2.1 (Section 4). We introduce three main scenarios named "Sustainable Development," "Weak cooperation," and "Global Risk," along with two extreme scenarios, "Emissions Neutrality," and "Global Risk." These five policy-relevant WEF E scenarios align with the climate, socioeconomic, and land use scenarios as follows:

- "Emissions neutrality" aligned with SSP1-1.9
- "Sustainable development" aligned with SSP1-2.6
- "Weak cooperation" aligned with SSP3-7.0
- "The wrong way" aligned with SSP5-8.5
- "Global Risk" aligned with SSP5-8.5+<sup>19</sup>

The policy-relevant WEF E scenarios are baseline scenarios that represent future trends of the system assuming no additional policies (mentioned in section 5) beyond those already in place. The difference between the scenario trajectories is determined by the degree of compliance or non-compliance of the policy objectives. A baseline scenario serves as a comparison or counterfactual scenario to assess impacts of alternative scenarios (e.g. policy changes), therefore, they will serve to assess the different solution (WP7) within the framework of the project. Figure 10 shows representative hypothetical trajectories of the three main policy-relevant WEF E scenarios and the reference period. In the "Sustainable development" scenario (depicted in green), more positive impacts on WEF E indicators are expected, while in "The wrong way" scenario (depicted in red), more negative impacts are expected.

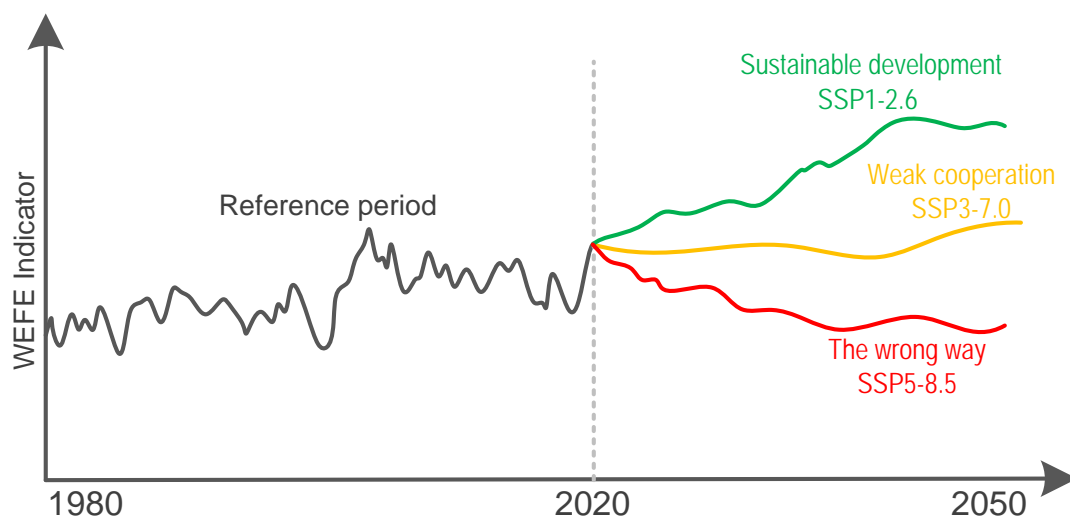


Figure 9. Illustration of the policy-relevant WEF E scenarios in contrast and the reference period. Source: own elaboration.

<sup>19</sup> SSP5-8.5+ represents the upper limit of the IPCC CMIP6 SSP5-8.5 scenario, indicating a long-term (2081-2100) average temperature increase of 5.7°C above pre-industrial levels.

## 7.2 Policy-relevant WEFE scenario narratives

The primary aim of this deliverable is to introduce narratives for policy-relevant WEFE scenarios, providing a framework for the analysis of nexus solutions in more advanced stages of the GoNEXUS project. Building upon the existing narratives outlined in the socioeconomic, environmental, and land use scenarios (Sections 3 and 4), we have incorporated a policy dimension (Section 5) to design the narratives for the policy-relevant WEFE scenarios, taking into account the input from stakeholders (Section 6). The narratives are designed in a global context with a focus on the EU. Below we present the narratives for each of the scenarios.

### 7.2.1 “Emissions neutrality”: SSP1-1.9

The “Emissions neutrality” scenario SSP1-1.9 is the most optimistic and ambitious scenario. It envisions a world capable of achieving the most ambitious goals of the Paris Agreement, including reaching **net-zero global emissions** by 2050 and limiting the increase in global surface temperature to 1.5°C above pre-industrial levels, followed by a downward trend and stabilization around 1.4°C by the end of the century (2100). This scenario assumes significant changes in human behaviour, including a shift towards more **sustainable lifestyles and consumption patterns**, driven by a focus on equity and general well-being above economic growth. The scenario depicts an environmental awareness in societies around the world, and a move toward less resource intensive lifestyles. This shift is also driven by high levels of investment in education and health, as well as a high degree of care for social inclusion cultural heritage and the environment conservation. The improvements in human well-being will also lead to a **low increase of population**. There will be **excellent cooperation** among different countries, with reduced tariffs and subsidies in international trade while strengthening local businesses globally. All of this will lead to the achievement of sustainable development goals globally. Additionally, this scenario assumes rapid and far-reaching transitions in energy, land use, urbanization, and industrial systems, resulting in very low levels of greenhouse gas emissions. Furthermore, it implies significant technological advancements, which will allow for a **renewable energy matrix**, and will include the development and implementation of **carbon dioxide removal technologies**. **Lower water demand and improved water efficiency**, coupled with the mitigation of global warming, will enable achieving water security and improving the condition of aquatic and terrestrial ecosystems. Through strategies such as F2F, and Biodiversity strategy the environmental and climate impact of the food system is reverted, preserving food productivity, and **guaranteeing food security** in the face of climate change and the loss of biodiversity globally. These actions will allow to achieve the targets of the WFD and most of the objectives of the EU Biodiversity Strategy. The resulting climate framework would not be significantly different from the current one, albeit with greater impacts related to the higher magnitude of warming. Despite more frequent extreme weather events, under this scenario the world is able to **avoid most of the worst impacts of climate change**. This scenario is desirable as it allows for adaptation without excessive difficulties. In general terms challenges for adaptation and mitigation are low.

### 7.2.2 “Sustainable development”: SSP1-2.6

The “Sustainable Development” scenario SSP1-2.6 presents an optimistic outlook towards **reducing global CO2 emissions**, although not as quickly as the SSP1-1.9 scenario, by achieving net-zero global emissions after 2050. This scenario is characterized by socioeconomic trends that are similar to the first scenario, but it assumes a higher temperature increase. Specifically, it is projected that by the end of the century, the global surface temperature will increase by approximately 1.8°C above pre-industrial levels. In this scenario, there is a strong emphasis on **sustainable development**, with a central commitment to achieving sustainable development goals. Within the socioeconomic trend, the world shifts gradually towards a more sustainable path, emphasizing inclusive development that respects environmental boundaries. This shift is driven by increasing evidence and accounting for the

social, cultural, and economic costs of environmental degradation and inequality. **Inequality is reduced both across and within countries**, and improvements in human well-being lead to a relatively low increase in population. Through policies such as the RED, the development of environmentally friendly technologies will be encouraged, and **renewable energy sources** such as wind, solar, and hydropower will constitute a substantial proportion of the energy mix. This will result in a significant reduction of greenhouse gas emissions from the energy sector, paving the way towards a more sustainable future. **Relatively lower water demand and improved water efficiency** will enable achieving water security and improving the condition of aquatic and terrestrial ecosystems in a significant number of regions. Adopting strategies such as Farm to Fork and promoting organic farming practices will effectively reduce the environmental and climate impacts of the food system. This scenario also involves extending protected areas to make at least a third of terrestrial area unavailable for agricultural expansion. Such practices will help **reduce the use of chemical** pesticides, soil, water, and air pollution, biodiversity loss, and non-target species harm, thus ensuring **food security** in the face of climate change and biodiversity losses. In the Sustainable Development scenario, a **reduction in consumption of animal products** is expected to decrease the environmental impact of food consumption. Research will be conducted to improve crop yields and irrigation efficiency, while minimizing food waste to increase competitiveness and strengthen links in the food supply chain. These actions will allow to achieve most of the targets of the WFD and many of the objectives of the EU Biodiversity Strategy. Additionally, a global trend towards abolishing current import tariffs and export subsidies will be observed, while granting preferences to regionally produced agricultural products. In this scenario, the challenges for adaptation are low, while the challenges for mitigation are intermediate.

### 7.2.3 “Weak cooperation”: SSP3-7.0

The "Weak cooperation" scenario SSP3-7.0 is an intermediate to negative scenario in which **countries become increasingly competitive with each other**, prioritizing national security rather than cooperating to achieve sustainable development. In this scenario, greenhouse gas emissions and temperatures continue to increase regularly, with CO<sub>2</sub> emissions almost doubling from current levels by 2100. By the end of the century, the global surface temperature is projected to have risen by 3.6°C above pre-industrial levels. Under the SSP3-7.0 scenario the world is facing a future that is increasingly fragmented, characterized by **economic and geopolitical tensions**. Regional rivalries hinder international cooperation and development, impeding progress in mitigating climate change and achieving sustainable development goals. This results in an **uneven socioeconomic development** where rapid growth occurs in more developed regions, and slow growth in developing countries. Population growth is high in developing countries, leading to income divergence and pockets of extreme poverty alongside moderate wealth. There are low investments in education and technological development, limited progress in human development, and a lack of effective institutions. In some regions, there is a move towards more authoritarian forms of government with highly regulated economies. Inequality persists, **consumption is material-intensive**, and countries prioritize their energy and food security goals at the expense of broader-based development. Challenges to adaptation are high for many groups in all regions. Fast population growth and intensity to achieve food and energy security lead to growing water use intensity. This, combined with the significant increase in droughts due to climate change, aggravates **water scarcity and water insecurity**.

The low technological development and high material-intensive results in economic activity remain strongly linked to **high levels of final energy demand**. Due to concerns about energy security, there is a preference for **standard carbon base technologies and fuel preferences based solely on price**, which limits the development of renewable energy sources. In addition, trade barriers for fossil fuel supply and the slow development of renewable energy technologies result in traditional biofuels being phased out at a slower rate. As a result, there is continued **reliance on fossil fuels**, limited technological advancements, and a lack of investment in climate change adaptation. In the realm of agriculture,

intensive agriculture is promoted, crop yield and irrigation efficiency rise in proportion to GDP, while the efficiency of livestock productivity remains stagnant at existing regional levels. The consumption of animal products and food waste continues to follow the current trend. Protected areas for land use remain at current levels, and the scarcity of nature reserves and **unsustainable agricultural practices** (e.g. use of hazardous chemicals pesticides) contribute to the reduction of ecosystem services such as pollination, leading to lower yields and efficiencies in some regions. These actions will make it difficult to achieve the WFD targets and the objectives of the EU Biodiversity Strategy. Due to concerns about self-sufficiency and food scarcity, **import and export barriers of agricultural commodities** increase significantly. Growing resource intensity (land use and water use), fossil fuel dependency and strong environmental degradation along with difficulty in achieving international cooperation and slow technological change imply high challenges to mitigation and intermediate challenges for adaptation.

#### 7.2.4 “The wrong way”: SSP5-8.5

“The wrong Way” scenario SSP5-8.5 is a **pessimistic scenario** that must be avoided. This scenario is socioeconomically similar to SSP3-7.0, but with even more **exacerbated use of fossil fuels**. The world economy experiences rapid growth, driven by extensive fossil fuel exploitation and highly **energy-intensive lifestyles**, resulting in a substantial increase in greenhouse gas emissions and global temperature. In this scenario, current levels of CO<sub>2</sub> emissions are projected to nearly double by 2050. By 2100, the global surface temperature will have increased by a tragic 4.4°C above pre-industrial levels. The scenario also assumes limited progress in climate adaptation and a significant increase in the **frequency and severity of climate-related disasters**, leading to substantial economic and social disruptions. This scenario envisions a future world where policies are fragmented, and governance is focused on national self-interests. Developing countries experience rapid macro-economic growth base on the use of fossil fuels, but developed countries continue to dominate the global economy. In this scenario, the world experiences **high levels of population growth**, income inequality, and **fossil fuel dependency**. These factors lead to increased resource intensity, including land and water use, and **strong environmental degradation**. Under this scenario, the world is highly fragmented, with not only rivalry between nations and regions but also within nations. Societies are strongly polarized and divided. Furthermore, adaptation to climate change and mitigation efforts are hindered by political fragmentation, leading to high challenges for both. **Water security is a significant concern** in SSP5-8.5, as demand for water increases rapidly, and water quality declines due to pollution and over-extraction, preventing the achievement of most WFD targets. In this scenario, several of the RED directives are violated. In that sense, the energy sector remains largely reliant on fossil fuels, with limited technological advancements in renewable energy sources. Agriculture faces **significant challenges in food production and security**, as crop yields are negatively impacted by climate change, land degradation, and water scarcity. In this scenario, little relevance is given to strategies such as F2F and Biodiversity strategy, the **use of pesticides and chemicals will be prioritized** to increase agricultural yields, harming ecosystems. Conservation of ecosystems and biodiversity is limited in this scenario due to the **prioritization of economic growth over environmental protection**. Land use is characterized by deforestation and conversion of natural habitats for agriculture and urbanization, further contributing to environmental degradation. The SSP5-8.5 presents a challenging future that requires significant efforts to mitigate and adapt to climate change, address socioeconomic inequalities, and prioritize environmental conservation.

#### 7.2.1 “Global Risk”: SSP5-8.5+

The “Global Risk” SSP5-8.5+ scenario is similar to “The wrong way” SSP5-8.5 scenario but with intensified **geopolitical conflicts and armed wars** as the primary drivers of socioeconomic crises, environmental damage, and scarcity of food and natural resources. This scenario represents **the upper extreme of SSP5-8.5**, projecting a long-term (2081-2100) average temperature increase by a catastrophic 5.7°C above pre-industrial levels. The global population will decrease, largely due to



**collateral casualties from armed conflicts.** Investment, industry, and technological development will focus on military weaponry rather than renewable energy sources or sustainable development. **Fossil fuels will largely dominate the energy mix.** The conflicts will revolve around controlling natural resources, particularly oil and gas, mineral deposits, and even water and arable land. Consequently, widespread **famine and migration** will ensue, driven by war, climate crises, and hunger.

### 7.3 Matching policy-relevant WEFE Scenarios and the achievement of the policy objectives

As a complement to the presented narratives, this section delves deeper into how the achievement of policy objectives (outlined in Section 5.2) shapes the various trajectories of the policy-relevant WEFE scenarios with a focus on the EU. Compliance in policy design is typically measured using indicators (see section 5.2.3), and therefore, the different levels of compliance for each indicator serve as thresholds for each scenario. Table 4 provides a general estimate of policy objective compliance for each scenario.

Table 4. Policy objective compliance for each scenario. Source: own elaboration.

Policy-relevant WEFE scenarios	Climate-socioeconomic scenarios	Policy objectives achievement
Emissions neutrality	SSP1-1.9	High
Sustainable development	SSP1-2.6	High-Medium
Weak cooperation	SSP3-7.0	Medium
The wrong way	SSP5-8.5	Low
Global Risk	SSP5-8.5+	Very low

For this scheme, we infer that the compliance of policy objectives in the different dimensions of the WEFE nexus progresses equitably. However, interactions within the WEFE nexus often involve various trade-offs; the compliance of objectives in one dimension of the nexus can lead to non-compliance with objectives in other dimensions of the nexus. Additionally, inferring the achievement policy objectives considering different spatial levels (i.e., global and continental) also presents complex implications. Despite the EU relevance in the global context, there is a weak link between EU policy objective compliance to the CMIP6 scenarios, while a strong link exists the other way.

To quantitatively determine the compliance of the policy objectives that consider these complex interactions, it is essential to work with models that go beyond mere inferences. Detailed quantitative analysis with model results for the policy-relevant WEFE scenarios is beyond the scope of this deliverable and will be developed in later stages of the project. However, in the framework of this deliverable, we lay the groundwork for this analysis by identifying the relevant policy objectives (section 5.2) and indicators frames for the European case study.

Within the GoNEXUS project model toolbox, the models to be used for analysing the European case study and the policy-relevant scenarios are as follows. The LISFLOOD-EPIC model will provide detailed insights into the water sector, including indicators related to water demand and allocation. For the food sector, the CAPRI model will offer indicators pertaining to food production, agricultural land use,

food prices, and trade. In the energy sector, the PRIMES model will provide indicators related to energy prices and production from various sources in the energy matrix. Lastly, the GLOBIO model will be utilized to analyse ecosystems, with indicators related to biodiversity conservation and habitats. Figure 11 illustrates the models employed for each sector of the WEFE nexus.

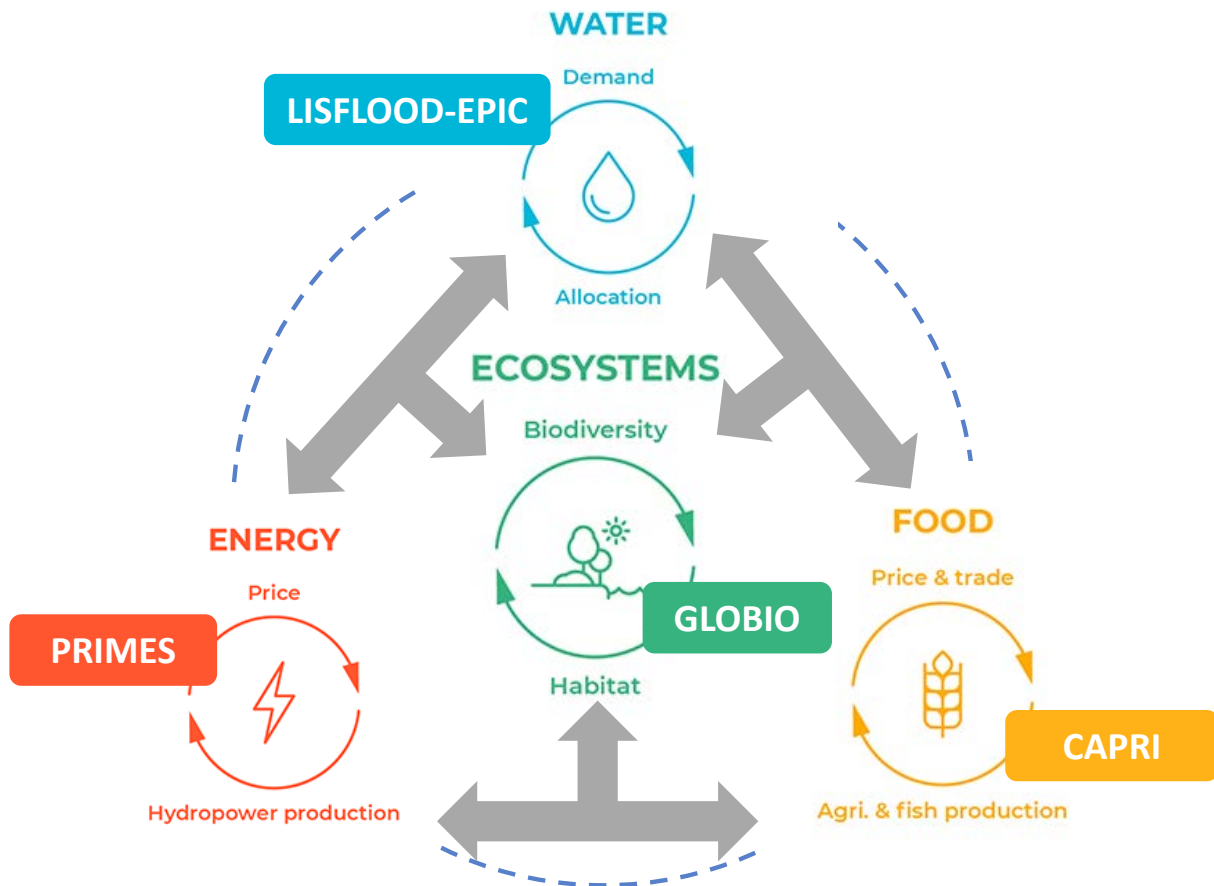


Figure 10. The models used to analyse the different sectors of the nexus for the EU case study. Source: own elaboration.

The forthcoming research steps associated with this deliverable will establish connections between relevant policy objectives, potential related indicators, and targets for the European case study. Within this context, a target is outlined as a quantifiable expression of an objective through an indicator, setting out what change to achieve and by when. The achievement of the targets will serve as a threshold to align the most optimistic policy-relevant WEFE scenarios (i.e., Emissions neutrality and Sustainable development) and will lay the groundwork for the quantitative analysis of the scenarios. The policy-relevant WEFE scenarios will be simulated in the GoNEXUS toolbox at a global and continental scale (WP3) and the results will be presented as evidence in Task 5.2, "Global scale WEFE diagnosis and evidence simulations". These results will provide a quantitative context for the policy-relevant WEFE scenarios and align each scenario quantitatively with the level of compliance of the identified policy objectives.

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# Annexes

## Annex 1: Glossary

**Indicator:** A tool to measure the degree of achievement of an objective. Indicators are used to measure actual achievements against established objectives (through targets) and/or to identify trends or patterns. Indicators should be in accordance with the so-called RACER criteria: relevant, accepted, credible, easy, and robust.

**Reference period (or historical reference):** A past period (simulated or historical data) that represents historical system evolution. The reference period serves as a starting or reference point against which differences are calculated (e.g. climate anomalies expressed as relative to the reference period).

**Scenario:** A plausible description of how the future may develop based on a set of coherent and consistent assumptions about key driving forces (e.g. rate of technological change, population growth) and relationships. Please note that scenarios are not predictions or forecasts, but are used to provide insight into the implications of future developments and planned policy interventions.

**Scenario - baseline:** Baseline scenarios represent future trends of the system assuming no additional policies beyond those already in place. A baseline scenario serves as a comparison or counterfactual scenario to assess impacts of alternative scenarios (e.g. policy changes).

**Narrative (or Storyline):** A qualitative description of the relationships and dynamics of a scenario, focusing on the characteristics, general logic and developments underlying a particular quantitative scenario. A narrative highlights key scenario features and causal connections between driving forces, helping to interpret potential trajectories. Narratives can be used to describe plural and conditional possible futures of a system, in contrast to unique and definitive futures.

**Target:** is a quantifiable expression of an objective through an indicator, setting out what change to achieve and by when.