NEVERMORE

New **E**nabling **V**isions and Tools for **E**nd-use**R**s and stakeholders thanks to a common **MO**deling app**R**oach towards a Climat**E** neutral and resilient society

D4.1 Designing coherent scenarios across scales

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Abbreviations and acronyms

Acronym	Description
AEZ	Agro Ecological Zones
APT	Adaptation Policy Trajectories
AR5	Fifth Assessment Report
BAU	Business As Usual
CMIP6	Sixth Coupled Model Intercomparison Project (CMIP)
EAL	Expected Annual Losses
EASOC	East Asia and Oceania
EU27	European Union 27 Countries
FAS	Factors-Actors-Sectors
GD	Green Deal
GDPpc	Gross Domestic Product per capita
GG	Green Growth
GHG	Greenhouse Gases
IAM	Integrated Assessment Model
IAV	Impacts, Adaptation and Vulnerability
IPCC	Intergovernmental Panel on Climate Change
LATAM	Latin America except Mexico
LROW	LOCOMOTION Rest of the World
LULC	Land Use / Land Cover
MECD	Ministerial Conference on Environment and Development
PG	Post Growth
RCP	Representative Concentration Pathways
RES	Renewable Energy Sources
RF	Radiative Forcing
SAAS	Scope-Actions-Actors-Sectors
SDG	Sustainable Development Goals
SOWs	States of the World
SPAs	Shared Policy Assumptions
SRES	Special Report on Emissions Scenarios
SSP	Shared Socioeconomic Pathways
UK	United Kingdom
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change
USMCA	United States, Mexico & Canada

Table of Contents

EXECUTIVE SUMMARY **8**
1. INTRODUCTION **8**
2. TOOLBOX OF CONCEPTS **9**
3. THE ROLE OF SCENARIOS IN INTEGRATED ASSESSMENTS **11**
3.1. Scenarios and integrated assessment models 11
3.1.1. Policy-action scenarios in integrated assessments: the role of mitigation and adaptation 17
3.2. From global to regional, national and local scenarios: downscaling processes 23
4. SCENARIO METHODOLOGY **29**
4.1. The development of global to national scenarios 29
4.1.1. The WILIAM model 30
4.1.2. Building and running global, regional and national scenarios using WILIAM 30
4.2. The development of local scenarios 34
4.2.1. Local Models 34
4.2.2. Preliminary Link with WILIAM (ideas to link WILIAM and local scenarios) 37
4.2.3. The local storylines building processes 38
5. SCENARIO DESIGN AT GLOBAL, REGIONAL AND NATIONAL SCALES **41**
5.1. Selection of baseline and policy-action storylines 42
5.1.1. Further storylines for exploring specific what-if questions 46
5.2. Qualification of storylines 48
5.3. Quantification of storylines at global scale, EU and national scales 50
6. STORYLINES DESIGN AT LOCAL SCALE **51**
6.1. Local storylines: Results of the what-if consultations 51
6.1.1. What-if questions and preliminary policy-action storylines for Trentino 51
6.1.2. What-if questions and preliminary policy-action storylines for Sitia 56
6.1.3. What-if questions and preliminary policy-action storylines for Tulcea 61
6.1.4. What-if questions and preliminary policy-action storylines for Norrbotten 65
6.1.5. What-if questions and preliminary policy-action storylines for murcia 70
7. CONCLUSIONS **71**

List of Figures

Figure 1. The Representative Concentration Pathways (RCPs). Source: (van Vuuren et al., 2011) 13
Figure 2. Matrix representing how SSP pose different challenges for adaptation and mitigation. Source: (O'Neill et al., 2017) 14
Figure 3. Scenario matrix for SSPs-RCPs scenarios. Source: (O'Neill et al., 2016) 16
Figure 4. Representation of a general structure of Integrated Assessment Models. Source: (*Q&A: How 'Integrated Assessment Models' Are Used to Study Climate Change*, 2018) 16
Figure 5. NGFs Scenarios. Source: (*NGFS Scenarios Portal*, n.d.) 18
Figure 6. IAM and IAV community's links. Source: U.S Department of Energy (2009) 19
Figure 7. IAV, IAMs and Climate Models community's links identified at the time of the IPCC SAR and in 2009. U.S Department of Energy (2009) 20
Figure 8. Adaptation categories. Source: Suckall et al. (2018) 21
Figure 9. Drivers of government-led adaptation policy choice. Source: Suckall et al. (2018) . 22
Figure 10. Workflow for developing UK-SSPs scenarios. Source: Harmáčková et al. (2022) .. 25
Figure 11. Downscaling process for delta sub-national scenarios. Source: Kebede et al. (2018) 27
Figure 12. Schematic example of the hierarchy of the policy concepts. Source: (Luzzati, T et al., 2021) 31
Figure 13. Workflow for developing WILIAM global, regional/EU and national scenarios 32
Figure 14. Conceptual representation of the steps required to simulate a baseline scenario with the WILIAM model 32
Figure 15. Conceptual representation of the steps required to simulate a policy-action scenario with the WILIAM model 33
Figure 16. Transition from respective baselines to different storylines for 2 regions with different timing and speed. Source: (Markovska et al., 2021) 34
Figure 17. Schematic representation of the methodology at local scale 36
Figure 18. Slide 1 used in the Plenary Session to explain the what-if question exercise 40
Figure 19. Slide 2 used in the Plenary Session to explain the what-if question exercise 40
Figure 20. Slide 3 using during the Plenary Session to explain the what-if question exercise 40
Figure 21. Overview and main differences of Green Growth, Degrowth and Eu Green Deal. Source: (Ossewaarde & Ossewaarde-Lowtoo, 2020) 46

List of Tables

Table 1. Description of SSP scenarios. Source: (Riahi et al., 2017) 14
Table 2. Description of SSPs-RCPs scenarios. Source: (DKRZ, 2022) 15
Table 3. Main features of the NGFs scenarios 18
Table 4. Steps used in Mitter et al. (2019) to build local scenarios 27
Table 5. Steps used in the EVOKE Project to build local scenarios 28
Table 6. Example of a qualitative attribute table 32
Table 7. Scenario implementation in the WILIAM model differentiating (or not) by regions 33
Table 8. Steps needed to carry out the bottom-up method to generate local adapted storylines. 38
Table 9. The Scope-Actions-Actors-Sectors (SAAS) framework 41

Table 10. Structure to be filled by each case study to generate the what-if questions.....41
Table 11. Environmental and socio-economic general goals in the WILIAM storylines. Source: Markovska et al. (2021) 43
Table 12. Example 1 of scenario matrix architecture 47
Table 13. Example 2 of scenario matrix architecture 48
Table 14. Overall goals and storylines 48
Table 15. Qualitative attribute tables for WILIAM policy-action storylines.....49
Table 16. WILIAM Overall goals and indicators 50
Table 17. What-if questions for the Trentino case study 53
Table 18. What-if questions for the Sitia case study 57
Table 19. What-if questions for the Tulcea case study.....62
Table 20. What-if questions for the Norrbotten case study.....66
Table 21. What-if questions for the Murcia case study.....70

Executive summary

This deliverable contains information about storylines and scenarios at global, regional, national, and local level. In the NEVERMORE Project, the global, regional (focused on European Union) and national scenarios will feed the WILIAM Integrated Assessment Model. This deliverable contains a methodology to develop global to national scenarios to be introduced in WILIAM, including a comprehensive description of four qualitative scenario proposed. Regarding the local scale, this deliverable contains information about downscaling processes to develop local-adapted scenarios, including results of a bottom-up participatory process that can be useful to support the policy analysis and modelling.

1. Introduction

Climate change has on many occasions been described as humanity's biggest threat. Although the need to prepare our societies to tackle it is obvious and urgent, the existence of different actors with different interests sometimes slows down the entry into action. At both global and local levels, a lot of resources are being mobilised to try to reach the Paris Agreement goals of *'limit the global temperature increase in this century to 2 degrees Celsius while pursuing efforts to limit the increase even further to 1.5 degrees'.* However, it seems clear that these resources are not sufficient or not well enough managed to move forward at the pace the problem requires (Nieto et al., 2018).

There is an ongoing discussion in academia and society on what are the most desirable scenarios that can be realized to achieve Paris Agreement Goals. Sustainability seems to be a concept that many actors want to embrace and reach but proposing very different trajectories. Some defend technological innovations as the main driver to achieve sustainable societies. Others claim that the principle of *'leaving no one behind*' must be at the core of the ecological transition. Others argue that a radically different system is needed.

The use of scenarios is very useful in environmental assessments and policymaking, especially when uncertainty over the future and complexity of the systems involved are high. Scenarios are basically different possible trajectories or pathways that contain explanations on how societies could evolve, and these can be used for many kinds of analysis allowing us to make comparisons that support decision-taking.

One of the main objectives of the NEVERMORE project is to deliver multi-sectoral climate impact assessments under consistent and integrated socio-economic and climate scenarios, as well as evaluating adaptation and mitigation strategies towards a climate neutral and resilient society. This deliverable aims at setting the socio-economic storylines and scenarios that will be used to conduct the impacts and policy analyses at the different scales. Since the idea of coherence across scales is at the core of the project by combining bottom-up and top-down approaches, we have developed a scenario methodology that permits to guarantee that consistency.

Specifically, this deliverable takes the work on scenarios generated under the LOCOMOTION H-2020 Project as a starting point and improve them in several ways:

- Extending the global storylines and scenarios by: i) including new dimensions such as adaptation and behavioural changes, with more complete qualitative information, and ii) including socio-economic indicators that can help to assess the coherence of each scenario.
- Improving the methodology to model global to national scenarios using the WILIAM Integrated Assessment Model (IAM).
- Generating new local-adapted storylines through a bottom-up process that includes participatory processes with stakeholders.

The deliverable is divided as follows: section 2 contains a toolbox of concepts that can facilitate the readers to approach to some concepts; section 3 contains a literature review on scenarios and storylines; section 4 contains the methodology generated for storyline and scenario development at the different scales; section 5 contains scenario outputs at global-regional/EU-national scale; and section 6 contains storyline outputs at local/case study scales.

2. Toolbox of concepts

In this section, we provide a common toolbox of concepts that help to define the scenario methodology used along the whole deliverable. These concepts are specifically generated to facilitate the integration of scenarios in the WILIAM model, although it can also be extended to other purposes (e.g., the local models), if necessary.

- **Storyline**: an a priori consistent story or narrative of how the future may evolve. It is a qualitative description of the trajectories of the economic, social, technological, environmental, and/or political evolution that the world may follow in the near future. Hence, it can more implicitly or explicitly include a certain number of policy objectives and targets.

Examples: Business as Usual, Fossil-fuelled Development, Inequality, Green Growth, Regional Rivalry, Post Growth…

- **Overall policy goal**: broad, general policy objective at societal level. These are the basis for developing policy recommendations. We further distinguish between overall goals identified as driving a given storyline (storyline goals) and those which the model users may want to check if a given storyline is able to fulfil (expanded overall goals). Considering a 'Green Growth' storyline, an example of a storyline goal is 'absolute decoupling of environmental pressures from economic growth'. An example of an expanded overall goal under a Green Growth story is 'Preserving or improving life expectancy'. Both types of overall goals act as 'benchmark' to gauge whether a simulated scenario leads to a desirable solution to the identified problems. They are also indicators that allow us to evaluate the feasibility of the storylines. They therefore require measurable variables that can be used as indicators to verify the fulfilment of these overall goals. Indicators can be compared against a threshold or a target. So far, the overall goals of WILIAM have been selected from the following sources and complemented with additional goals: climate change tipping points (Lenton et al., 2008), planetary boundaries (Rockström et al., 2009), UNFCCC Paris Agreement, UN Sustainable Development Goals (SDGs).

Examples: Full net decarbonisation by 2050; achieve full employment; maintain a certain level of societal equity; transition to 100% renewables; annual GDPpc growth of 3%; SDGs, etc.

- **Policy**: a set of ideas or a plan of what to do in particular situations that has been agreed by a group of targeted people, business organisation, government or political party. In the WILIAM framework, they consist of interventions typically promoted by institutions such as government and regulatory institutions. The concept is very general, which is why it is preferable to work with policy objectives, policy targets and policy measures.

Examples: Energy Policy, Trade Policy, Labour Policy, Health Policy, Environmental Policy…

- **Policy objective:** desired outcome of a policy. A generally formulated desired outcome of a policy. It is not to be confused with policy target, which refers to a specific quantified level or rate set for the chosen objective. We try to achieve them by means of modelling concrete policy measures, which may cater to more than one policy objective. WILIAM is designed to model policy measures rather than policy objectives or targets. However, in some modules of

WILIAM, there is not enough detail to introduce policy measures. In these specific cases, we will introduce policy targets.

Examples: Decarbonization, transition to renewables, reduce unemployment, reduce inequalities, GDP growth, increase exports, etc.

- **Policy target**: quantifiable intended effect (or expected outcome) of a policy measure. Also defined as the operationalization or quantification of the policy objective, although a policy target can be linked to more than one policy objective. When we introduce a policy measure in WILIAM, policy target is used to assess whether the policy measure meets its closest or direct aim. When this is not possible and we have to directly introduce the policy target in WILIAM, it is used to represent a policy itself and analyse the resulting consequences in the whole model.

Examples: 32% of renewable energy in total energy by 2030, increasing public transport passengers by 20%, reducing the same 20% of private transport passengers, reducing meat consumption in the diet by 10%, targets from the SDGs, etc.

- **Policy measure**: a specific intervention in different parts of the system, and which can be specified through quantifiable targets (policy targets) and is implemented through policy instruments such as financial aids, benefits, taxes, information campaigns, training, regulation, etc. The interventions are typically promoted by institutions such as governments and regulatory institutions to drive a technological, behavioural, infrastructure, etc. change with relation to current trends. Note that the same policy measure may contribute to reaching multiple targets. This is the smallest unit of the policy analysis in the WILIAM scenario framework.

Examples: Carbon tax, raising awareness, subsidies to specific technologies or R&D, new laws limiting or prohibiting the consumption or production of polluting products, etc.

- **Behavioural change:** a demand-side strategy included in a policy-action scenario. The interventions are carried out by citizens, nor private or public institutions. Technically, they work in a similar way to policies: we can set behavioural change objectives, behavioural change targets and behavioural change measures. As explained in Deliverable 2.1 “Society and climate change links and lifestyle changes measures”, some behavioural change will be included exogenously depending on scenarios but, as much as possible, they will be included as endogenous variables. When the latter, some political scenario assumptions will be done according to drivers and barriers of the behavioural change.

Examples: for exogenous behavioural change measures: diet shift, transport use shift, etc. For endogenous behavioural change measures, exogenous drivers and barriers can be environmental awareness, policy commitment, etc.

- **Scenario**: implementation of the storyline with quantitative inputs in each model. There are two types of scenarios:
  - Baseline or reference scenario: It is normally modelled as continuation of historic trends through extrapolation, but it can also be adjusted to represent other kinds of pathways (e.g., SSPs). Typically, the reference scenario highlights issues (e.g., the impossibility to reach certain objectives such as staying below 1.5°C average global temperature increase) that prompt us to simulate alternative futures by introducing specific policies. It also contains a set of specific assumptions that are called hypotheses.

- Policy-action scenario: It is modelled on top of the reference scenario. A series of policy measures are simulated to gauge their effectiveness in reaching the overall goals (see glossary below) of the storylines.

Examples: same names as for storylines.

- **Hypothesis:** an uncertain assumption, represented as a quantitative parameter, that does not depend on political actions or that, for the sake of simplicity and modelling feasibility, the modellers make fixed. In general, it can vary by generating different baseline scenarios, but it does not vary in policy-action scenarios. In the WILIAM framework, hypotheses can be changed to build different baseline scenarios. Others remain fix and are considered model parameters that do not change by any type of scenario.

Examples: non-renewable material reserves, Equilibrium Climate Sensitivity, Global Warming Potential, Hazard Uncertainty, etc.

- **Adaptive scenario:** The trajectory of the initially defined scenario can be modified due to the internal constraints present in the model. Thus, it is a scenario which does not attain its predefined overall goals. It is the final and more complete 'scenario output', and it varies depending on the model used to obtain the results. For instance, most of the core variables that would be basic to define scenario (e.g. the GHG emissions) are endogenous in WILIAM, so the WILIAM final set of the scenarios will be not only defined by the predefined inputs, but also by the model results.

Examples: same names as for storylines and scenarios.

3. The role of scenarios in Integrated Assessments

3.1. Scenarios and integrated assessment models

Scenarios are a key instrument widely used in environmental assessments. Their use allows informing policymakers on problems and responses related to sustainability that can emerge in different socio-economic trajectories. Since environmental problems are usually characterised by complex causal relationships and limited knowledge, scenarios emerged as one of the main ways of performing comparative analysis and dealing with uncertainty.

There exists a high variety of scenario approaches, but most of them are established on the following criteria: i) they have to be plausible, describing a rational path from 'here' to 'there' that makes explicit the necessary causal mechanisms and decisions taken; ii) they should be internally coherent; and iii) they have to be fascinating/interesting enough to promote strategic responses to be taken (Birkmann et al., 2015). Scenarios do not work as predictors of the future and do not attempt to provide the most likely pathway. Instead, they allow researchers and policymakers to assess and compare a set of 'what-if' questions under an ensemble of assumptions. Usually, the literature differentiates between storylines and scenarios, the storylines (also called narratives) being a qualitative description of the future development pathway, whereas the scenario is its quantitative description, based on a coherent and internally consistent set of assumptions on key variables and their relationships (van Vuuren et al., 2012) .

The use of scenarios dates several decades back, although in the beginning the term 'scenario' was not used. As explained by van Vuuren et al. (2012), there are numerous scenarios that differentiating from each other by their purpose, main assumptions, methodology, etc. In this sense, the study proposes different concepts that help categorising scenarios according to their methodological approaches:

- Scenarios VS Forecast: projections-related literature usually distinguishes between projections or forecasting, which focus on an assessment of most likely development, to scenarios, which focus on the exploration of futures where probability statements are generally avoided.
- Deterministic VS Probabilistic: the probabilistic approach aims at specifying the probability of occurrence of a set of scenarios whereas the deterministic does not. Generally, the former is most common because it is not easy to attribute probability density functions to some assumptions.
- Process VS Product orientation: some scenarios are used for answering specific questions and, in those cases, the development itself is seen as a fruitful output - they are process-oriented. In other cases, scenarios pursue communicating results to a wide and diffuse scenario, so they are product oriented.
- Participatory VS Non-participatory: there are scenarios that are built through participatory processes such as workshops with the targeted stakeholders. This option is usually chosen when there is a specific targeted audience and where general applicability is not the priority. More general scenarios applied at global or wide regional scales are usually non-participatory.
- Qualitative VS Quantitative Scenarios: Usually the literature differentiates between storylines and scenarios, the storylines (also called narratives) being a qualitative description of the future development pathway, whereas the scenario a quantitative description, based on a coherent and internally consistent set of assumptions on key variables and their relationships. Usually, storylines are translated into scenarios, but not always. This depends on the objectives and information available.
- Explorative VS Normative: explorative scenarios refer to those exploring possible futures focusing on different hypotheses, whereas normative scenarios usually compare a central projection with variants that involve policy interventions. Typically, the central projection is called the baseline or reference. Normative scenarios are also called policy scenarios.
- Forecasting VS Backcasting: whereas the first strategy aims at defining scenarios from the base year onwards, the second defines a desirable future characterised by some endpoints and goes back to the reasons and actions that connect the present with those points.

There are also other ways to classify scenarios attending to their content. For instance, the same article suggests that most of scenarios can be classified according to i) a risk prone or risk averse nature of societies to environmental threats, ii) a global or regional way of management, iii) greater or lesser similarity to current trends, and iv) an attitude closer to cooperation or competitiveness.

Countless scenarios can be found in the literature, but there are some scenario families that stand out. This is the case of the scenarios used by the Intergovernmental Panel on Climate Change (IPCC). In the IPCC third and fourth assessment report, the Special Report on Emissions Scenarios (SRES) were used. They were a set of four greenhouse gas emissions explorative pathways: A1 representing rapid economic growth in a globalised and homogeneous world, A2 representing high economic development in a regionalised and heterogeneous world, B1 representing global environmental sustainability in an homogeneous world and B2 representing local environmental sustainability in a heterogeneous world. These scenarios represented a set of hypotheses on population, technological development, and economic growth, but they were only composed of a variable: the greenhouse gases emissions.

The SRES were replaced by the Representative Concentration Pathways (RCPs) in the fifth assessment report (AR5) of the IPCC. These scenarios contain greenhouse gas concentrations (not emissions) trajectories. This scenario family is composed of seven pathways: RCP 1.9, RCP 2.6, RCP 3.4, RCP 4.5,

RCP 6, RCP 7, RCP 8.5. Each one describes a different climate future by considering feasible greenhouse gases emissions and a possible range of radiative forcing values.

The RCP scenarios were defined in the AR5 IPCC Report. For this report, four new emission scenarios were developed, calling them as Representative Concentration Pathways (RCP) being characterized by their total Radiative Forcing (RF) for the year 2100, which oscillates between 2.6 and 8.5W/m². The four RCPs comprise a scenario in which mitigation efforts lead to a very low level of forcing (RCP2.6), two stabilization scenarios (RCP4.5 and RCP6.0) and a scenario with a very high level of GHG emissions (RCP8.5) (Figure 1). They also consider the effects of policies aimed at limiting climate change in the 20th century against the emission scenarios used in the IPCC AR4 in which the effects of possible policies or international agreements aimed at mitigating emissions were not included.

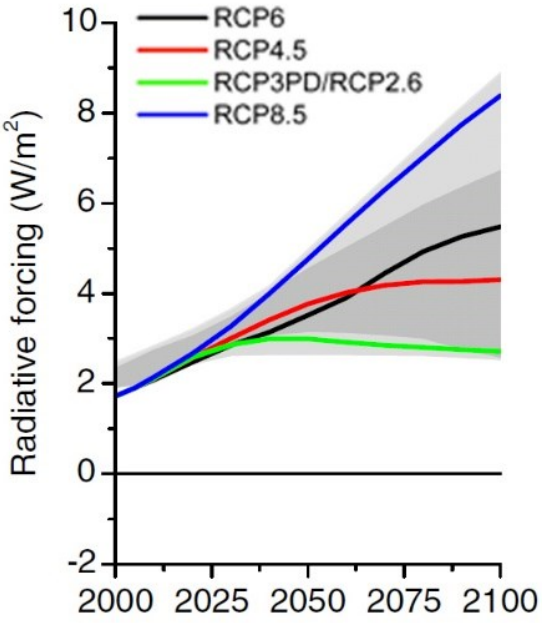


Figure 1. The Representative Concentration Pathways (RCPs). Source: (van Vuuren et al., 2011)

Currently, the RCPs are being substituted by the Shared Socioeconomic Pathways (SSPs), although RCPs are still sometimes used jointly with the SSPs. The SSPs are probably the most famous family of scenarios and include a more complete set of socio-economic assumptions. Actually, they were introduced only in a qualitative manner (as storylines and not scenarios) in O'Neill et al., (2014) but they have been quantified by different quantitative models.

The SSPs consist of five different explorative narratives (SSP1, SSP2, SSP3, SSP4 and SSP5) (Figure 2 and Table 1) that represent different socioeconomic pathways for the world. Each one represents a different pathway regarding demographics, human development, economy, institutions, technology, and environment (O'Neill et al., 2017). They differ from each other in that each one poses different challenges for mitigation and adaptation, but they do not include specific policies.

At the global level, the main tool used to quantify storylines and obtain scenarios are the Integrated Assessment Models (IAMs). IAMs are characterised by integrating different spheres (society, economy, biosphere, atmosphere, etc.) in a sole modelling framework. This kind of models mainly rely on inputs to simulate. These inputs usually vary according to some pre-existent (such as SSPs) or new scenarios, according to the model requirements and objectives.

Figure 2. Matrix representing how SSP pose different challenges for adaptation and mitigation. Source: (O'Neill et al., 2017)

Table 1. Description of SSP scenarios. Source: (Riahi et al., 2017)

SSP	Description
SSP1	**Sustainability – Taking the Green Road (Low challenges to mitigation and adaptation)** The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.
SSP2	**Middle of the Road (Medium challenges to mitigation and adaptation).** The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall, the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.
SSP3	**Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation).** A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.
SSP4	**Inequality – A Road Divided (Low challenges to mitigation, high challenges to adaptation)** Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally connected society that contributes to

	knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle- and high-income areas.
SSP5	**Fossil-fueled Development – Taking the Highway (High challenges to mitigation, low challenges to adaptation).** This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

Although it is true that SSPs are generally replacing RCP, they are many times used in common, creating the SSP-RCP scenarios that were used in the Sixth Assessment Report of the IPCC. As part of the Coupled Model Intercomparison Project 6 (CMIP6) new scenarios that represent the different socio-economic developments as well as different pathways of atmospheric greenhouse gas concentrations were developed. These scenarios are the basis for the sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC AR6). At the end, these scenarios provide economic and social reasons for the assumed emission pathways and changes in land use. The main characteristics of each scenario are provided in Table 2 while the matrix with the combination between SSPs and RCPs is provided in Figure 3.

Table 2. Description of SSPs-RCPs scenarios. Source: (DKRZ, 2022)

SSP-RCP	Description
SSP585	With an additional radiative forcing of 8.5 W/m² by the year 2100, this scenario represents the upper boundary of the range of scenarios described in the literature. It can be understood as an update of the CMIP5 scenario RCP8.5, now combined with socioeconomic reasons.
SSP370	With 7 W/m² by the year 2100, this scenario is in the upper-middle part of the full range of scenarios. It was newly introduced after the RCP scenarios, closing the gap between RCP6.0 and RCP8.5.
SSP245	As an update to scenario RCP4.5, SSP245 with an additional radiative forcing of 4.5 W/m² by the year 2100 represents the medium pathway of future greenhouse gas emissions. This scenario assumes that climate protection measures are being taken.
SSP126	This scenario with 2.6 W/m² by the year 2100 is a remake of the optimistic scenario RCP2.6 and was designed with the aim of simulating a development that is compatible with the 2°C target. This scenario, too, assumes climate protection measures being taken.

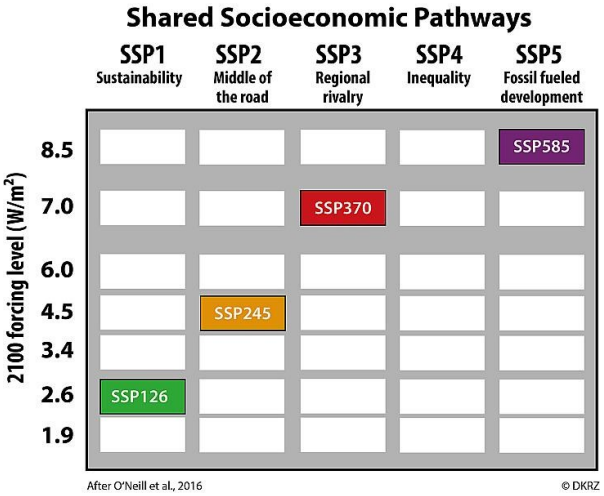


Figure 3. Scenario matrix for SSPs-RCPs scenarios. Source: (O'Neill et al., 2016)

Figure 4 shows in a general way how these kinds of models work. On the left of the figure there are some examples of inputs (GDP, Population, Policies, Other Assumptions) that must be pre-quantified outside of the model and that are used to initialise the model. These inputs follow different trajectories in each scenario and are usually quantified by means of assumptions on top of qualitative descriptions and historical values. Once they are introduced in the model, outputs (some examples on the right of the figure) are obtained.

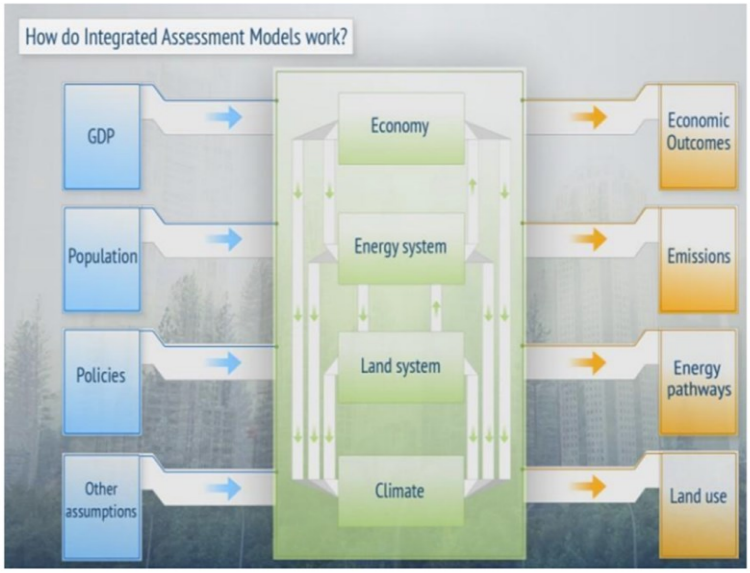


Figure 4. Representation of a general structure of Integrated Assessment Models. Source: (*Q&A: How 'Integrated Assessment Models' Are Used to Study Climate Change*, 2018)

It is important to highlight this close link between Integrated Assessment Models and scenarios: IAMs need scenarios to simulate, and, at the same time, they extend the scenarios by providing new quantitative variables. For instance, the SSPs have been quantified several times by using different IAMs. It is also important to remark that there can be substantial differences in the quantification depending on the model structure and equations.

Following the different scenario categories expressed in van Vuuren et al. (2012) and described previously, SSPs are explorative scenarios (they do not include explicit policies), deterministic, initially qualitative but also quantified, and with an orientation on products. Scenarios used by IAMs are typically deterministic, although there exist some recent attempts that try to attribute probabilities of occurrence to scenarios (Huard et al., 2022).

Despite its widespread use, SSPs have also received critiques. As mentioned above, the structure of the IAM used to quantify a scenario can strongly determine the results. For instance, most of the models used in the beginning of the quantification process of IPCCs do not include climate change impacts or fossil resources depletion. These elements could hinder economic growth but excluding them from the model structure implies that there are no biophysical limits or constraints to economic development. This could bias the scenarios and may even reduce the logical sense or feasible meaning of the storylines (e.g. SSP5, characterised by a fossil fuel driven economic growth, could be meaningless) (Gambhir et al., 2019; Rosen & Guenther, 2015).

Rosen & Guenther (2015) also criticised some of the IAMs used to quantify SSPs because, since they do not include climate change impacts and they do not account for costs of inaction. This makes SSPs weak to be a counterfactual or a reference to which to compare mitigation costs, since non-mitigation costs are not well captured. Summarising, the no consideration of feedback loops can hinder or reinforce projected outputs that in the end take part of the scenario quantitative variable.

Concluding, scenarios are used as inputs in IAMs but are in turn complemented with the model outputs, that could be again inputs of other models. At the end, a quantitative scenario is composed of exogenous inputs quantified through assumptions and endogenous outputs obtained by means of an IAM.

3.1.1. Policy-action scenarios in integrated assessments: the role of mitigation and adaptation

As mentioned above, SSPs are explorative scenarios widely used. They do not include any specific mitigation or adaptation policy action, although they can be classified according to the challenges they mean for mitigation and adaptation policies (Figure 2). IAMs and other research communities have developed policy-action scenarios that help, in the context of exploring sustainable pathways, to discover what are the set of policies that allow to reach the Paris Agreement objectives sooner and by what means.

For instance, the Network for Greening the Financial System (NGFs) Climate Scenarios are created by the Network of Central Banks and Supervisors for Greening the Financial System with the support of climate experts and scientists. They designed a set of hypothetical scenarios in which the idea of mitigation is at the core. Thus, the different scenarios can be classified by considering the level of climate change, physical risk and transition risk that each mitigation pathway involves (Figure 5). In their scenario methodology, Integrated Assessment Models are used to evaluate transition risks whereas climate impacts are evaluated through Earth System Models, Climate Impact Models and Natural Catastrophe Models.

The NGFs are composed of six storylines: Net Zero 2050; Below 2ºC; Divergent Net Zero; Delayed Transition; Nationally Determined Contributions; Current Policies.

All these scenarios differ on assumptions regarding technological change, carbon dioxide removal (CDR) potential, policy reaction, policy ambition and regionality (Table 3). To our understanding, it is not completely clear if these scenarios fit well in the category of 'policy-action scenarios' because they also involve non-strictly political assumptions such as the CDR potential, which also depends on biophysical constraints. This demonstrates that the differences between explorative and policy-action scenarios are not always straightforward.

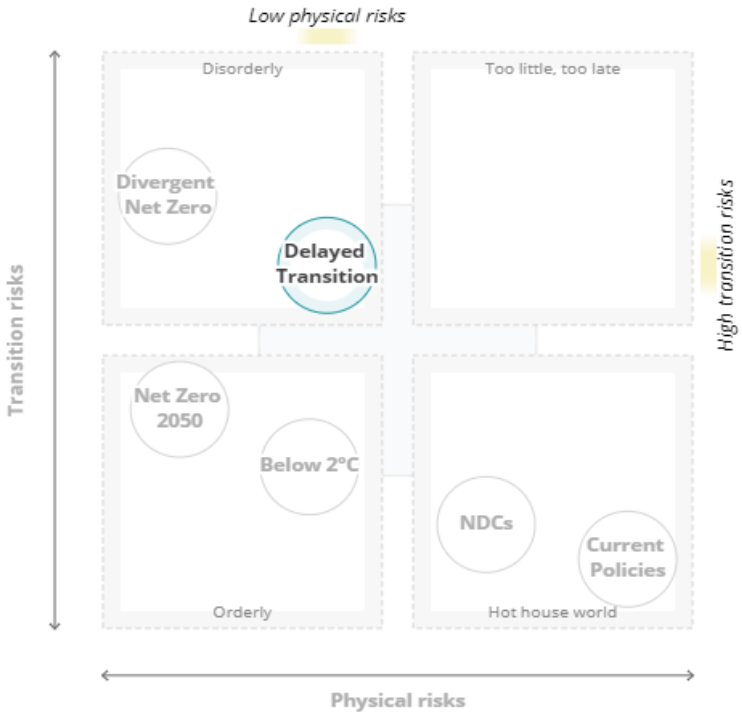


Figure 5. NGFs Scenarios. Source: (*NGFS Scenarios Portal*, n.d.)

Table 3. Main features of the NGFs scenarios

NGFs scenarios	Policy ambition	Policy reaction	Technology change	CDR	Regional policy variation
Net Zero 2050	High	Immediate and smooth	Fast change	Medium-high use	Medium variation
Below 2ºC	Medium-high	Immediate and smooth	Moderate change	Medium-high use	Low variation
Divergent Net Zero	Medium-high	Immediate but divergent	Fast change	Low-medium use	Medium variation
Delayed Transition	Medium-high	Delayed	Slow/Fast change (depending on regions)	Low-medium use	High variation
Nationally Determined Contributions	Medium-low	NDCs	Slow change	Low-medium use	Medium variation
Current Policies	Low	None - current policies	Slow change	Low use	Low variation

Another interesting scenario family that includes political assumptions (although they are neither strictly explorative nor normative) are the ones proposed by the World Energy Council, focused on setting paradigms that support energy decision-makers to think about the future of energy planning. These are three:

- *Modern Jazz*, which assumes a market-led scenario shaped by high and fast innovation, economic growth, and inequalities.

- *Unfinished Symphony,* which makes hypotheses of a governmental-led scenario characterised by long-term public planning and united global action looking for equality.
- *Hard Rock*, which assumes a fragmented and multi-polar world characterised by rival regionality, high protectionism and de-globalization. Populism and rival regionality. Collaboration takes place only in close regions.

These scenarios do not initially include specific policy interventions, but they set the general political stance: the first assumes that the transition is driven by the private sector; the second sets a public driven transition, and the third one symbolises a populist (public-led but without international collaboration) transition. The objective of these scenarios is to guide the energy transition, so they focus on those points interesting from the energy planning point of view.

As mentioned above, one of the things that make the scenario families differ from one another is their purpose. That is why scenarios are increasingly growing in the literature, differing in the dimensions, variables, temporal scales, regional scales, etc. Scenarios used in Integrated Assessment Models usually focus on mitigation aspects, whereas less attention is paid to impacts and adaptation. This is so because this kind of models are usually better suited to analyse mitigation responses, with complex and detailed representations of the energy sector that allow to represent a wide variety of mitigation strategies. On the other hand, researchers belonging to the Impacts, Adaptation and Vulnerability (IAV) community have been more focused on climate change and adaptation analyses, but they have not typically included socioeconomic scenarios in the analysis, but only climate scenarios.

Both IAM and IAV communities work in analysing problems and developing responses related to the climate crisis, and both use Natural Earth Systems information, but in the end, they use different methods and focus on different scopes (Figure 6). Nevertheless, strong synergies could emerge if there would be a closer relationship between more communities, as identified by the report from U.S Department of Energy (2009) (Figure 7) and other authors (Absar & Preston, 2015).

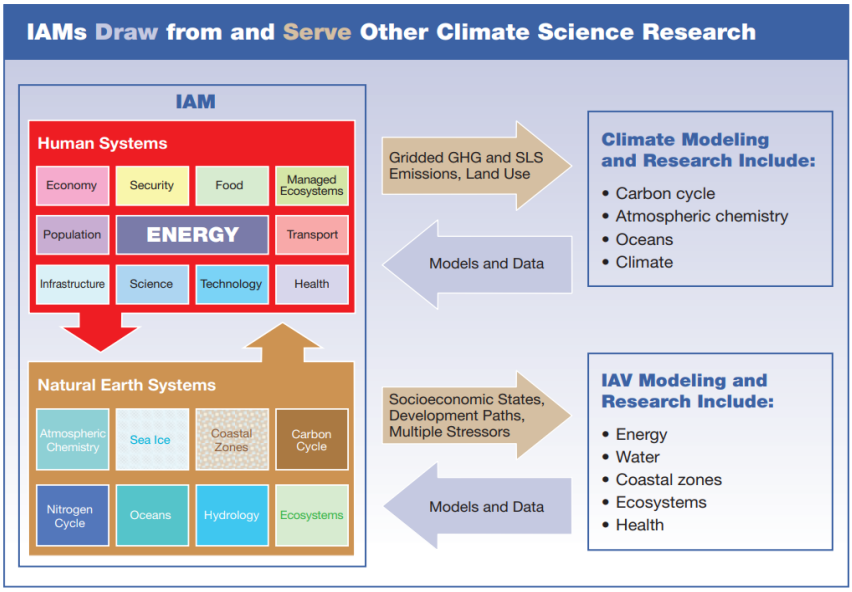


Figure 6. IAM and IAV community's links. Source: U.S Department of Energy (2009)

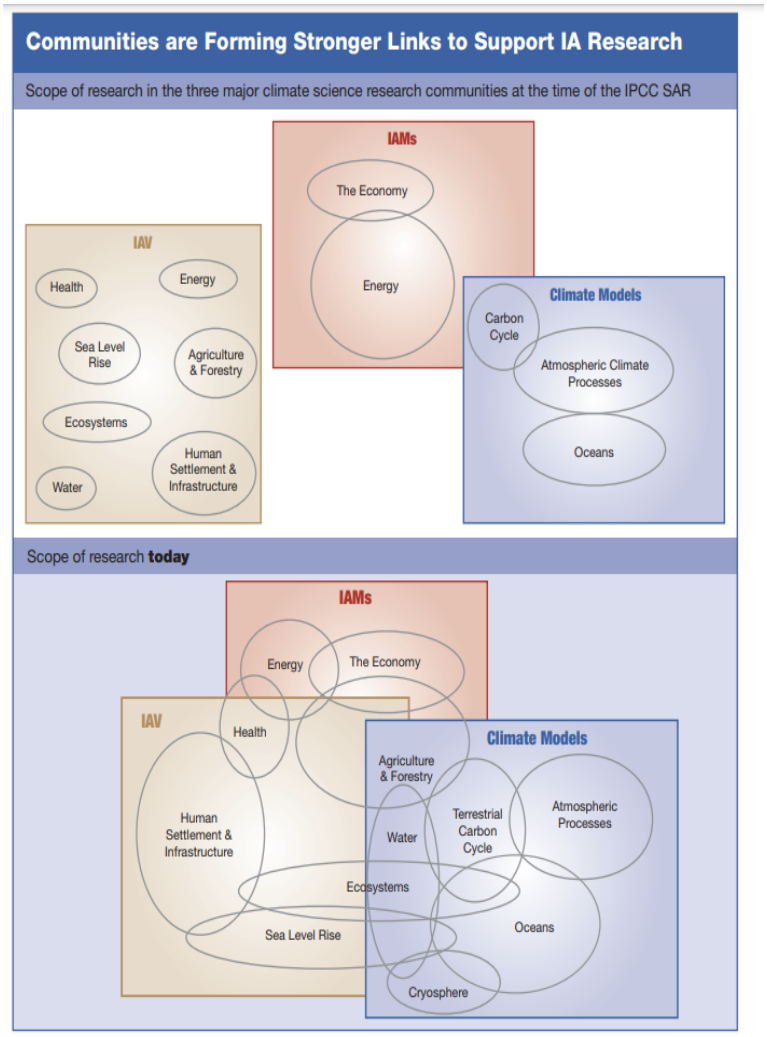


Figure 7. IAV, IAMs and Climate Models community's links identified at the time of the IPCC SAR and in 2009. U.S Department of Energy (2009)

The U.S Department of Energy (2009) report specifically mention scenarios as a specific tool to be used to close the gap between IAM and IAV communities by highlighting the need of *'collaboration between the IAM and IAV communities in developing families of socioeconomic scenarios and storylines that can be used to enhance consistency in this regard across the portfolios of IAM and IAV research'.*

IAV communities are not used to implement socioeconomic variabilities depending on global complex processes, since they are generally much more focused on capturing well the particular targeted geographics and sectors. For IAMs, the quantitative socioeconomic scenarios that work as inputs are usually criticised for not explicitly incorporating qualitative aspects of social systems. This could lead to market imperfections, institutional constraints or delayed policy implementation (Absar & Preston, 2015).

A closer relationship between IAV and IAM communities could lend a hand to the former on providing socioeconomic boundary conditions. On their behalf, IAMs can take information from the IAV community to explore the effects of climate uncertainties, as well as including vulnerability and adaptation as a dimension in socioeconomic scenarios.

There are some recent attempts to include the adaptation dimension in integrated assessment modelling frameworks (Absar & Preston, 2015). An example is the work done in the scope of the DECCMA Project focused on analysing climate change impacts and adaptation in delta systems. Within this project, Suckall et al. (2018) published a theoretical framework to develop adaptation directions

or scenarios, that were after applied by Kebede et al. (2018) and translated into Adaptation Policy Trajectories (APTs) consistent with the Shared Policy Assumptions (SPA) concept. These specific policy-action scenarios can be applied on top of RCP-SSPs combinations, which are used as different baseline combinations.

Since (to our knowledge) general adaptation narratives are not very common in literature, it was worth to deepen into the work done on adaptation scenarios by Suckall et al. (2018). This study developed different policy adaptation scenarios around three categories defined by adaptation aims: i) addressing drivers of vulnerability, ii) reducing disaster risk, and iii) building resilience. Thus, they set 13 classes of adaptation where different policies and measures can fall in (Figure 8). These categories allow classification of adaptation measures and propose some questions, such as:

- Adaptation form: what does it look like?
- Adaptation purposefulness: why is it being undertaken?
- Adaptation provider & beneficiary: who is providing it and who is benefiting from it?
- Adaptation timing: is it occurring in response (ex-post) or in anticipation (ex-ante) to climate change?
- Adaptation function & effects: how will drivers of vulnerability be addressed, disaster risk reduced, and/or landscape/ecosystem resilience built?

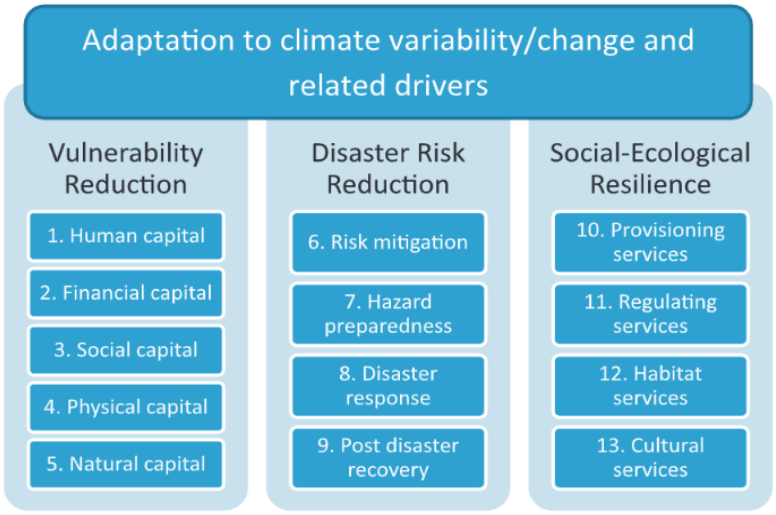


Figure 8. Adaptation categories. Source: Suckall et al. (2018)

By answering these questions, we could characterise policy measures but also policy-action scenarios, which contain sets of similar policy measures. The study also proposes two axes to think about the directions of adaptation policy. These are two key limiting variables that influence adaptation policy choice and are helpful to group policy measures by conforming storylines or scenarios. These two variables / axes are the investment cost and the political effort or significance[1]. According to the authors, all kinds of policy measures could be integrated into four narratives distributed across these

[1] This article only refers to public (government-led) adaptation.

two axes: a) Minimum Intervention, b) Capacity Expansion, c) Efficiency Enhancement, d) System Restructuring (Figure 9).

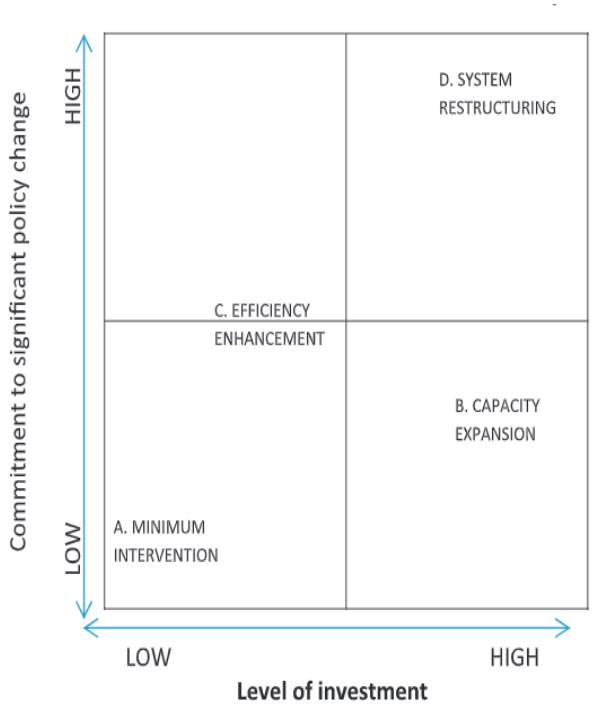


Figure 9. Drivers of government-led adaptation policy choice. Source: Suckall et al. (2018)

- *Minimum Intervention*: it aims to protect citizens from some climate impacts by pursuing the lowest cost adaptation policies. This scenario focuses on areas where maximum policy impact can be achieved at the lowest cost, requiring low levels of commitment to policy changes and promoting adaptation measures that require small investments. It indicates either a fundamental preference for a non-interventionist government or a lack of ambition or capability on the part of the government. There is hardly any planning for anticipating climate events, instead, the government contributes with emergency responses.
- *Capacity Expansion*: it promotes climate-resilient economic growth, but not with the objective of altering current economic structure. A high level of investment is required to equip the economy for future change, but the focus is on the climate proofing industry and improving the ability to adapt to changes.
- *Efficiency Enhancement:* it is an ambitious scenario that promotes efficient management and exploitation of the current system, looking at ways of adapting to climate change focusing on people wellbeing and behavioural change (e.g., distributing labour, balancing livelihood choices, best utilising ecosystem services, etc.). It is focused on efficiency but not in an economistic approach, concentrating on distributing labour and taking care of ecosystems and livelihoods. This scenario also deals with managerial change instead of infrastructural investment, although this is an interventionist approach too. In addition, it implicitly includes a reasonable commitment to significant policy change as the system moves to training and supporting people to adapt to long term change.
- *System Restructuring*: it adopts a preventive fundamental change at every level aiming to completely transform the current social and ecological system. It is built on a societal understanding of the need to significantly and radically modify the landscape to create long term system restructuring despite the short-term costs accumulated on some sectors or social groups. This scenario includes three scenarios: i) 'protect', focusing on a wide investment on

protective infrastructure as well as land protection; ii) 'accommodate': making a significant change on livelihoods to change to a more nature-friendly lifestyle; and iii) 'retreat': restructuring and relocating the landscape.

A key concept when exploring policy-action scenarios are the Shared Policy Assumptions (SPAs). SPAs allow capturing key policy attributes such as goals, instruments and barriers, both in mitigation and adaptation measures (Kriegler et al., 2014). They are usually applied on top of explorative scenarios that work as baseline, as in the previously mentioned study (Kebede et al., 2018). They use a 'scenario matrix architecture', which is basically a matrix to combine two scenarios with different key assumptions and explore their jointly implications. This is typically used to explore the application of specific policy measures alongside baseline explorative scenarios. This is the case of Frame et al. (2018) that developed a set of mitigation and adaptation scenarios that can be used to create different combinations relative to SSP-RCP combinations.

The adaptation scenarios proposed by Frame et al. (2018) are two: a) incremental and focused on short-term gains, and b) strategic and transformational. In the first one, adaptation policies are mainly reactive, whereas in the second one adaptation intends to fulfil moral obligations related to guaranteeing security in a long-term and anticipated sense.

The inclusion of climate change impacts in Integrated Assessment Models is more complex. Most (global) IAMs include equations that allow the calculation of GHG emissions, GHG concentration and temperature increase. In turn, if climate change impacts are included, it should be done endogenously dependent on these outputs. The case is different for region-specific IAMs which could include climate change impacts as an exogenous scenario-dependent variable. Nevertheless, this deliverable is focused on socio-economic scenarios, so how to treat climate uncertainties will be included in modelling-related deliverables of WP4 and WP6.

Behavioural change is another interesting dimension to be included in scenarios that has not been further developed so far in the IAM communities. Instead, IAMs have been more focused on representing supply-side mitigation solutions without paying much attention to the lifestyle potential (Nikas et al., 2020). However, increasing attention is given to the potential of behavioural change and social innovation to reduce GHG emissions (Shukla et al., 2022). In this sense, its inclusion in IAMs is key, and scenarios stand out as one of the numerous strategies to represent it (van den Berg et al., 2019). An example of storylines with a focus on behavioural change are those presented in Neuvonen et al. (2014).

3.2. From global to regional, national and local scenarios: downscaling processes

The regional analysis of climate change risks requires reproducible, consistent and robust methodologies to downscaling global socioeconomic scenarios in a coherent way that are useful for multiple projects and contexts (Harmáčková et al., 2022). Instead of developing new scenarios from scratch, literature is moving into downscaling methodologies, which allows comparisons across scales even though better coordination is still needed (Kok et al., 2019). And just as there are many scenarios depending on the purposes and scales, there exists also a wide variety of downscaling approaches.

Absar & Preston (2015) differentiates between two methodologies for developing region-specific scenarios: the top down and bottom-up approaches. Top-down approaches are best suited for situations in which a starting point scenario at global level must be translated into a regional scale. This involves the use of downscaling (for quantitative scenarios) and nesting (for qualitative storylines) methods that guarantee a certain degree of legitimacy and coherence between both the scenarios across scales.

On the other hand, bottom-up approaches often employ participatory methods for scenario development and, afterwards, link those scenarios to global trends. This last approach allows more flexibility for scenario creators which are not limited by prior elements. Nevertheless, the comparability of the storylines generated is lower.

IAV communities are not used to conduct their analysis at global levels. Carrying out downscaling of socio-economic scenarios can be helpful to analyse concepts such as exposure, vulnerability and adaptive capacity (Hallegatte et al., 2011; Harmáčková et al., 2022). In this sense, standardised scenarios such as SRES, RCP or SSP are sometimes used for vulnerability or impact assessments, either for providing the boundary conditions of the analysis or for creating new regional scenarios (Wilbanks & Ebi, 2013).

Participatory processes and stakeholder engagement gain in importance when building regional scenarios, in contrast to global scenarios. As explained in Harmáčková et al. (2022), it has been widely recognized that stakeholder engagement is a powerful feature of scenario co-design, as it allows professional and personal knowledge (e.g. sectoral, geographical, knowledge of different local contexts) to be captured within regional scenarios. In addition, regional scenarios gain credibility, legitimacy and salience when diverse stakeholders groups are included in the scenario downscaling processes, and this also increases the usefulness of the final downscaled scenario products (Harmáčková et al., 2022; Rounsevell & Metzger, 2010).

Participatory processes, nevertheless, have to be cautiously conducted because they are generally very resource-intensive for both researchers and stakeholders and can lead to discontinuous engagement and fatigue (Mitter et al., 2019).

An example at the regional scale (considering 'regional' as a higher scale than national, that is, groups of countries) is the one conducted in the CLIMSAVE Project, a pan-European project aimed at exploring climate change impacts and vulnerabilities, and the IMPRESSIONS project, more focused on mitigation and adaptation. In order to conduct the impact analysis, they developed a set of four socioeconomic qualitative scenarios for Europe. Kok et al. (2019) tested a conceptual approach to link scenarios across geographical scales. They took the global SSPs and specific European scenarios as a starting point and made them match by analysing similarities and differences. Afterwards, they applied downscaling techniques and participatory methods to develop four European SSPs.

The participatory method proposed by Kok et al. (2019) consisted of a two-day meeting with 22 participants from the IMPRESSIONS Project selected by fulfilling geographical diversity, age, gender and sectoral and methodological expertise criteria. The specific techniques used were: initial mapping of the scenarios, outlining of the storylines, and quantification of parameters. The output of the workshop was a first draft of the storylines. After the workshop, stories of about one page in length were written. Regarding the quantification, the authors proposed a semi-quantification method. First, they divided each storyline in different time slices and selected the most important variables. After, they applied a code where 0 indicated no change; +/++/+++ indicated low/medium/high increase as compared to the base year; -/–/— indicated low/medium/high decrease compared to the base year.

An example of scenario downscaling of scenarios at national level is the one proposed by the study of Harmáčková et al. (2022) (Figure 10). The authors have developed an iterative approach to downscale and co-design the SSP scenarios based on stakeholder's collaboration. The approach was applied for the United Kingdom and includes several user-oriented scenario products: i) a set of categories of socioeconomic drivers including their dimensions, ii) extended regional storylines, iii) system diagrams, and iv) semi-quantitative trends of key socioeconomic indicators. These outputs are used for further modelling but also for other purposes of the policy communities. The study started from a first version of UK-SSPs and aimed at developing a fine-tuned second version. The method is characterised by intensive stakeholder participation, including a stakeholder workshop, a set of semi-

structured interviews and a follow-up survey. Also, the co-design method was completely conducted online. They suggested their method to be used as a reproducible and robust 'blueprint' and emphasised the iterative nature of the downscaling method, demonstrating that a second iteration in the participatory approaches helps to validate and enrich the scenarios.

The UK-SSPs workshop, which consisted of several sessions, was held online, involving 37 stakeholders covering sectoral, organisational, individual and geographical diversity, aiming at democratising the process and increasing the legitimacy. An array of exercises was prepared, including elicitation of key dimensions, refining of the extended narratives and development of and system diagrams and indicators. Afterwards, the information generated was processed to check coverage and consistency. Finally, the data processing stage ended up in a set of draft full narrative which included an abstract, a detailed description of the scenario in three time slices and a summary of the narrative for each UK nation, emphasising regional differences.

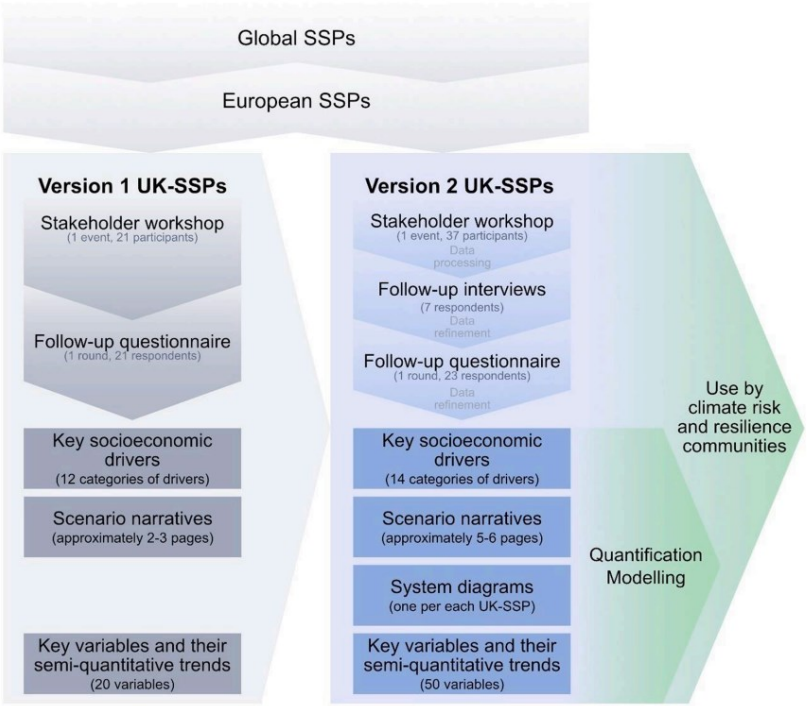


Figure 10. Workflow for developing UK-SSPs scenarios. Source: Harmáčková et al. (2022)

The follow-up interviews were used to work on inconsistencies and gaps detected during the data processing stage. The follow-up surveys were used to gather feedback from stakeholders on whether their contributions were correctly interpreted and elaborated. All this information helped to a better construction of the scenario outputs.

There is also much literature regarding downscaling from global to sub-national scenarios. Although the majority of approaches use SSP as the reference scenario to be downscaled, in most of the cases, methods applied are (at least partially) reproducible to other scales.

For instance, Suchá et al. (2022) proposed a methodology that combines downscaling of SSPs to city level and collaborative scenario building through stakeholders' engagement. This study developed land use/land cover (LULC) scenarios aimed at being used for adaptation planning. The method is applied for three pilot cities starting from SSPs at global level and combining them with participatory methods and land use modelling techniques. The participatory methods mainly consisted of two workshops. Specific techniques used were structured brainstorming (including voting mechanisms

that allowed to combine participant's thoughts and ideas in heterogeneous groups) and backcasting approaches such as the nominal group technique (Gallagher et al., 1993). Information collected was evaluated by the research team, taking into account relevance and priority of stakeholder's inputs regarding logic and feasibility and integrated into the scenarios.

Reimann et al. (2018) provided regionalization of the SSPs for the Mediterranean coastal zones. The outputs of the study are regionalized qualitative narratives and quantitative projections for population. For the narrative development, they used a top-down nesting approach in which global scenarios served as boundary conditions for the regionalized narratives but also regionalized socioeconomic information was consistently derived. This study did not include participatory processes in the regionalization, but it is interesting in several senses: i) it applied methods for gridding global population projections and ii) the outputs were specifically aimed at being used in risk analysis (considering hazard, vulnerability and exposure analysis). Another example of generating national and local SSPs to be used in risk analysis is the one proposed by Frame et al. (2018). This study highlighted the need to link exposure and vulnerability to changes in socioeconomic trends and offers a methodology based on nested scenarios from global to national to local, combining top-down and bottom-up approaches.

Absar & Preston (2015) also developed sub-national and sectoral extensions of the global SSP storylines that can be used to explore implications of alternative sub-national socioeconomic futures for the assessment of climate change impacts and adaptation, specifically to analyse effects on adaptive capacity (which is often considered as a component of vulnerability). The authors used a somewhat systematic method to develop nested socioeconomic storylines or storylines extensions which is called the Factor-Actor-Sector framework. Within the Factor-Actor-Sector framework, there are three elements: factors, that represent an aspect of the system on which there are policy issues of particular interest; actors, that represent individuals or organisations with capacity to provoke changes; and sectors, that represent an area of the system. This framework helps to address the complexity of a socioeconomic system in a systematic and structured way to enable researchers and stakeholders to define aspects on which to define the scenarios. Explicit identification of these elements is essential.

Kebede et al. (2018) applied the RCP-SSP-SPA full global scenario framework at sub-national scales by combining both expert-based and participatory methods (-Figure 11). The authors developed a multi-scale hybrid scenario framework applied to deltas. They recognize that deltas are regions with very particular characteristics and have their own specific problems. Thus, it is extremely important to consider exogenous drivers but also endogenous ones. In the framework, downscaled SSPs and biophysical scenarios were considered with an element of confidence, but stakeholders' expertise and interests were reflected too. This study outlined four steps for the scenario development: i) preliminary expert-led storytelling to create narratives, ii) evaluation and validation by the stakeholders to identify tweaks needed, iii) expert-led revision in the light of stakeholder's comments, and vi) stakeholders-led engagement to refine and finalise the scenarios.

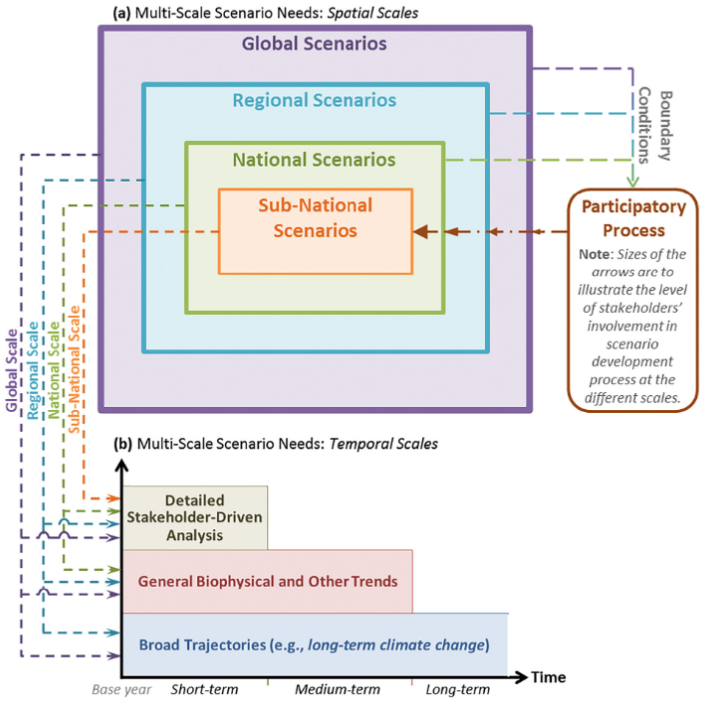


Figure 11. Downscaling process for delta sub-national scenarios. Source: Kebede et al. (2018)

Among the top-down downscaling methods it is worth to highlight the study of Mitter et al. (2019) that develops a systematic protocol to downscale scenarios (it is applied to SSPs downscaling) that contributes to enhance conceptual and methodological transparency, rigour, and scientific credibility. The method is composed of nine steps that contribute to six quality criteria: plausibility, consistency, salience, legitimacy, richness and creativity. According to the study, the design of the scenario needs some requirements that fulfil the quality criteria. The process design requirements mean that the building scenario process should be science-driven, iterative, top-down and nested, consecutive, participatory and interdisciplinary.

The steps suggested by Mitter et al. (2019) to downscale scenarios are shown in Table 4 and linked to the quality criteria they satisfy. The authors also highlighted the importance of making clear the scenario goals and targets, as well as of creating organised stakeholder groups (e.g. differentiating between engagement levels) and co-design processes to avoid consultation fatigue.

Table 4. Steps used in Mitter et al. (2019) to build local scenarios

Steps	Description	Quality criteria
Step 1	**Defining key characteristics of the storylines.** This process should be science- or stakeholder-driven. Goals of the storylines, main target groups, thematic foci, spatial and temporal scale have to be made clear.	Salience
Step 2	**Establishing a team and setting-up a stakeholder group.** It is recommendable to create different working groups with varying interests, backgrounds, responsibilities and engagement levels.	Salience, consistency, richness, legitimacy and creativity
Step 3	**Defining storyline elements.** The authors suggest a three-step procedure: i) identification of boundary conditions, ii) enriching and refining the boundaries and	Salience, legitimacy, consistency,

	iii) clustering and prioritising the storyline elements. The use of specific conceptual frameworks is also recommended.	richness and creativity
Step 4	**Drafting storylines.** Particular attention should be paid to the narrative flow to create clear, understandable and useful storylines. Stakeholders have to be involved.	Plausibility, richness, creativity, and salience
Step 5	**Consistency checks.** Stakeholders and researchers will determine whether or not the storylines elements are consistent, sufficient in detail and contrasting among the different storylines.	Legitimacy, consistency
Step 6	**Developing presentation formats.** Visualisation formats are developed to summarise and illustrate major differences and commonalities. Examples are morphological tables, scenario maps or causal loop diagrams.	Saliency, richness and legitimacy
Step 7	**Peer and stakeholder review of the storylines.** This step highlights the iterative nature of the process. The review should focus on goal achievement, clarity and readability. Several rounds may be needed.	Plausibility, consistency, salience, richness and creativity
Step 8	**Dissemination.** This will be adjusted to the target groups. Examples are articles, conference presentations, policy briefs, etc.	Salience
Step 9	**Evaluating collaboration for storyline development.** This step is relevant over the entire process. Process design requirements have to be present. Questionnaires and evaluation forms can provide insights on how to improve the co-design processes.	

These are not the only available steps proposed to conduct scenario downscaling. For instance, the EVOKE Project aims at reframing the risk and uncertainty associated with climate data into knowledge products more understandable and useful for end-users concerned with risk mitigation and adaptation. In the Deliverable 2.1 'Local set of scenarios' they proposed a step-by-step process to downscale SSPs into local scenarios (Table 5).

Table 5. Steps used in the EVOKE Project to build local scenarios

Steps	Description
Step 1	**Determine global scenarios as boundary conditions.** Global scenarios (e.g., SSPs) are selected and boundary key elements are identified (e.g. demographics, economy, technology). Specific elements are selected to ensure the narrative is as short as possible to facilitate its communication.
Step 2	**Establish local scenario elements.** Review of locally relevant literature and analysis of data are conducted. Questions such as *'What is the demographic structure of the population? What are the population trends? What are the major issues of political and socioeconomic important in each case study? How are politics embedded in the region? What are the biggest companies in the city?'* are proposed.
Step 3	**Determine plausible future developments of each scenario element.** The SSPs developments are taken as a basis, adapted at local scale, and enhanced with further socioeconomic context based on the local elements.
Step 4	**Draft scenario narratives.** A full-text narrative is drafted with the help of the local elements established in the previous step.
Step 5	**Facilitate feedback and discussion with local stakeholders.** The narratives are discussed with stakeholders to ensure plausibility and acceptance. Other visualisation tools can be used at this stage.
Step 6	**Refine scenario narratives based on stakeholder feedback.** The commentaries are integrated into the narratives. Iterations are carried out with new discussions to increase the acceptance.

Our literature review showed that, as opposed to global quantitative scenarios, co-design and co-production methods are much more present in local scenario building than in global scenario building.

Also, the variety of methods in both the top-down and bottom-up approaches is huge. In general, local scenarios are more 'process-oriented' than global scenarios (van Vuuren et al., 2012).

Literature review also suggested that there exists great potential for linking global and local scenarios. At the local level, scenarios should be informed by potential global trends and development patterns such as regional economic growth or population growth. In contrast, local scenario approaches can check whether topics and indicators included in global analyses are sufficiently relevant (Birkmann et al., 2015).

4. Scenario Methodology

The NEVERMORE project is featured by its intention to create an integrated common assessment framework for modelling, simulating, and evaluating impacts of both climate change and policy measures at different scales, with different models and involving numerous stakeholders and a high variety of disciplines and approaches. Such an ambitious multi-disciplinary project requires coherent and well-defined methods to guarantee alignment across disciplines and common understandings. In this sense, here we describe a scenario building methodology that aims to define a coherent way to develop scenarios across different scales and for different purposes.

The main use of scenarios is to feed the models. On the one hand, we have the WILIAM model which covers global, regional (including EU) and national scales and, on the other hand, we have the local models which will be applied to the five local studies. Scenario-related tasks are usually planned at the beginning of projects. Although this makes sense for many purposes, sometimes it is difficult to know all the exogenous inputs that the models will need at such an initial stage: the WILIAM model is currently being finished within the coetaneous LOCOMOTION-H2020 project, but the development of the local models corresponds to tasks that will be carried out during the next NEVERMORE project years. This means that we still cannot define very specific scenarios, since we do not have all the information yet. For instance, local models are still at an early stage so it is not sure how scenarios will be introduced there, and more alignment work to bring together both modelling approaches is still needed.

In this situation, we have developed a methodology based on the work done in LOCOMOTION-H2020 and we have improved and adapted it to the needs of NEVERMORE in different ways. First, we have improved the scenario methodology with new qualitative information for the storylines and more defined steps and concepts to scenario modelling. Second, we have carried out a bottom-up participatory process to develop new ideas on local-adapted storylines that can also inspire the work at higher scale levels.

The sub-sections in this section contain information about the scenario methodology at different scales. Section 4.1 includes information on the methodology to model global, regional, and national scenarios by using WILIAM. Section 4.2 includes information on the methodology to develop storylines adapted to local case studies.

4.1. The development of global to national scenarios

In this section we explain the methodology that we use to create global and regional/EU and national scenarios that will be implemented in the WILIAM model.

The section is divided in different sub-sections: 4.1.1 explains the main characteristics of the WILIAM Integrated Assessment Model; and 4.1.2 explains the core of the scenario building and running. The toolbox of concepts that is placed at the beginning of this document (section 2) is key for the understanding of this section.

4.1.1. The WILIAM model

WILIAM is a dynamic simulation Integrated Assessment Model that is being designed in the scope of the LOCOMOTION Project and that has been created on the basis of the MEDEAS model (Capellán-Pérez et al., 2020). The model is prepared to run from 2005 to 2050, although it is planned to update the model to be able to simulate until a more extended simulation horizon (probably 2075 or 2100 if possible).

The regional coverage of the model is global, being the whole world disaggregated into 9 regions: European Union (EU-27), United Kingdom (UK), United States, Mexico & Canada (USMCA), China, Russia, Latin America Excepting Mexico (LATAM), India, East Asia & Oceania (EASOC) and LOCOMOTION Rest of the World (LROW). These regions have been created following political criteria (de Blas Sanz et al., (2021) for more information on this). Some parts of the model are further disaggregated considering 35 regions by considering each European Union country as a region. Also, other parts of the model are disaggregated into Agro Ecological Zones (AEZ) (see deliverable 6.3 "Climate change impacts and adaptation module" of LOCOMOTION, https://www.locomotion-h2020.eu/resources/main-project-reports/, for more information on this).

The WILIAM model is structured in five main modules: economy and finance, energy, materials, environment, and demography and society. More information about how the modules are linked with each other can be found in de Blas Sanz et al. (2021)[2].Each module has a different level of development, economy, energy, and environment (especially the land-use sub-module) being the most detailed ones. This determines the granularity with which we can apply one or another policy or represent different climate change impacts.

One thing to highlight about WILIAM is the high quantity of feedback loops and endogenous variables that the model has, in contrast to other models. There is also a high level of disaggregation: most of the variables are matrices with 'REGIONS' as a dimension, but there also exist other qualitative dimensions that vary depending on the module. Examples are land use types, economic industries, types of households (by level of income or family characteristics), energy sources, age cohorts, etc.

As most of the Integrated Assessment Models, WILIAM requires inputs to work. There exist two kinds of inputs in WILIAM: model parameters and scenario parameters. Model parameters are those exogenous inputs predefined by the modeller that do not change across scenarios, whereas scenario parameters do change. We provide a further description on scenario-related concepts in the following section.

4.1.2. Building and running global, regional and national scenarios using WILIAM

All the concepts presented in section 2 - Toolbox of concepts 2are logically related to each other, conforming an internally consistent scenario methodology that allows to simulate scenarios in the WILIAM model that can help to systematically communicate results and strategically support policymaking. Above, a fundamental distinction is done between baseline and policy-scenarios. As explained in the beginning of this deliverable, van Vuuren et al. (2012) differentiates between exploratory and normative scenarios. These two types of scenarios match very well with our distinction. In explorative or baseline scenarios, there are not explicitly implemented policies, whereas in normative or policy action scenarios there are. Variations in hypotheses will lead to new baseline scenarios, whereas application and variation of policy measures and targets will lead to new policy-action scenarios. Policy-action scenarios are applied on top of baseline scenarios, so that every scenario starts as a baseline and gradually becomes a policy-action one. Differentiating between

[2] Also the WILIAM hand-book, which is currently under development, will be distributed once it is ready.

hypotheses and other scenario parameters such as policy or behavioural change measures and targets is key to guarantee the coherence and transparency in scenario building. In this manner, we can attribute results across scenarios to specific assumptions.

With regards to policy-action storylines, it is worth highlighting the relationship between policy-related concepts. Figure 12 shows the hierarchy that exists among overall goals, policy objectives, policy targets and policy measures. The size of each box is related to the possible number of options available. This means that: more measures can be associated to one target, more targets to one objective and more objectives to a single goal. There exists a many-to-many relationship among the different boxes.

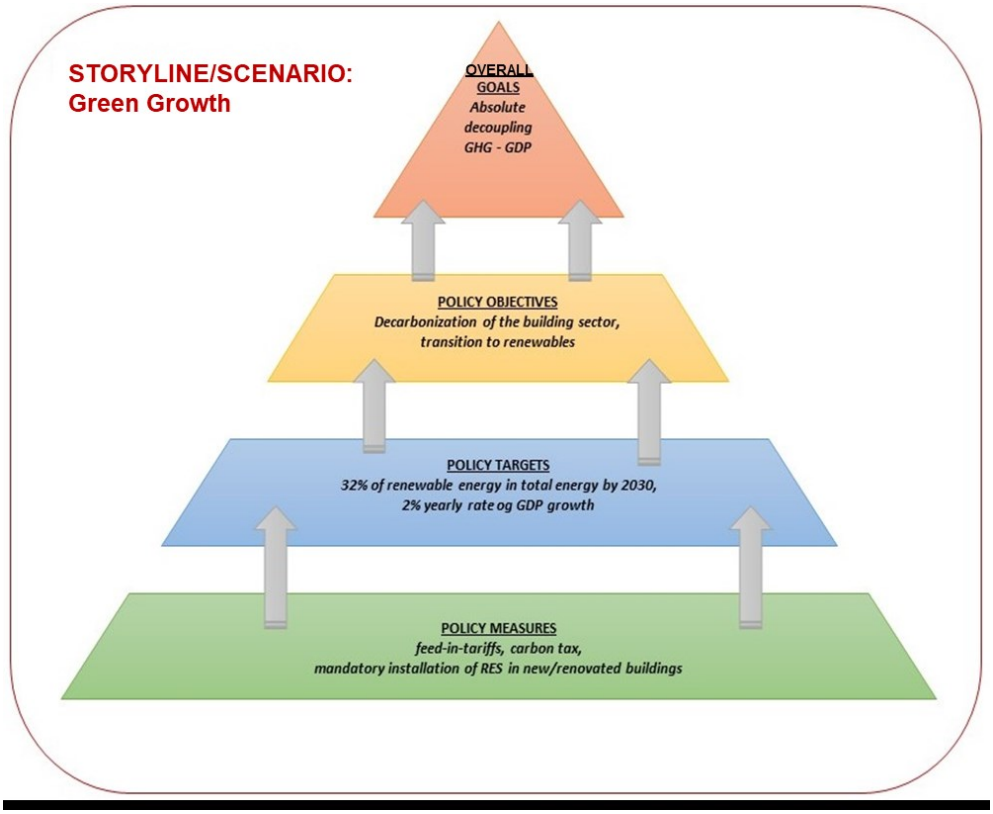


Figure 12. Schematic example of the hierarchy of the policy concepts. Source: (Luzzati, T et al., 2021)

To build a scenario to be implemented in WILIAM, it is necessary to follow a series of steps. First, we qualitatively define the storylines and identify the exogenous variables of the model, which will be those that we will use for implementing scenarios. Usually, these two tasks are conducted in parallel, since storyline definition is to a certain extent conditioned by the model structure, but also the model can suffer changes in the structure to introduce variables that are needed for implementing a scenario. Second, we conduct the 'qualification of storylines'. Qualification refers to assigning qualitative dimensions to the storylines, which will serve afterwards to guide future scenario quantification. For this step we use tools such as the overall goals (go to section 2 for a definition) and qualitative attribute tables (Table 6). Third, we link those pre-defined qualitative attributes to specific targets and measures, and we set quantitative values. This is how we go from a storyline to a scenario. All these steps are synthesised in Figure 13.

Section 5 shows how we have practically carried out the steps to build different storylines and scenarios.

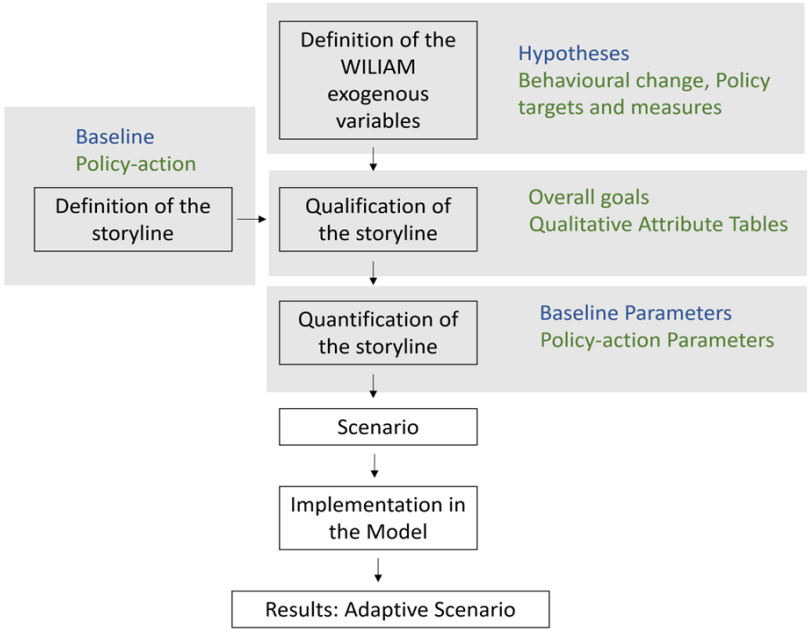


Figure 13. Workflow for developing WILIAM global, regional/EU and national scenarios

Table 6. Example of a qualitative attribute table

Dimension/Sector	Attributes	Scenario 1	Scenario 2	Scenario 3
Demography	Fertility Hypotheses / Policies	High	Medium	Medium
Economy	Government Hypotheses / Policies	High	Medium	Low
	Firms Hypotheses / Policies	Low	Medium	High
Energy	RES Hypotheses / Policies	Low	Low-medium	Medium-High
…	…	…	…	…

In addition, in Figure 14 and Figure 15 are represented the different steps required to simulate a scenario (baseline and policy-action, respectively) by using WILIAM.

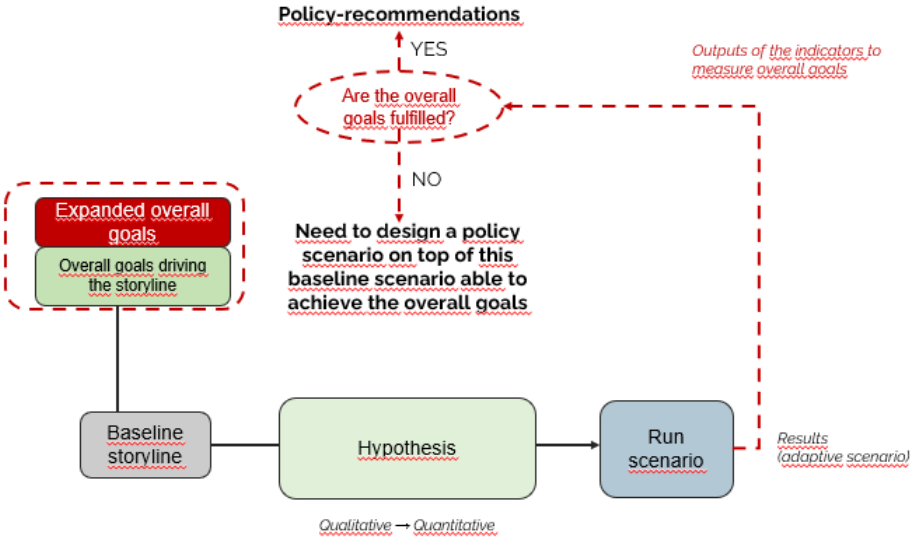


Figure 14. Conceptual representation of the steps required to simulate a baseline scenario with the WILIAM model

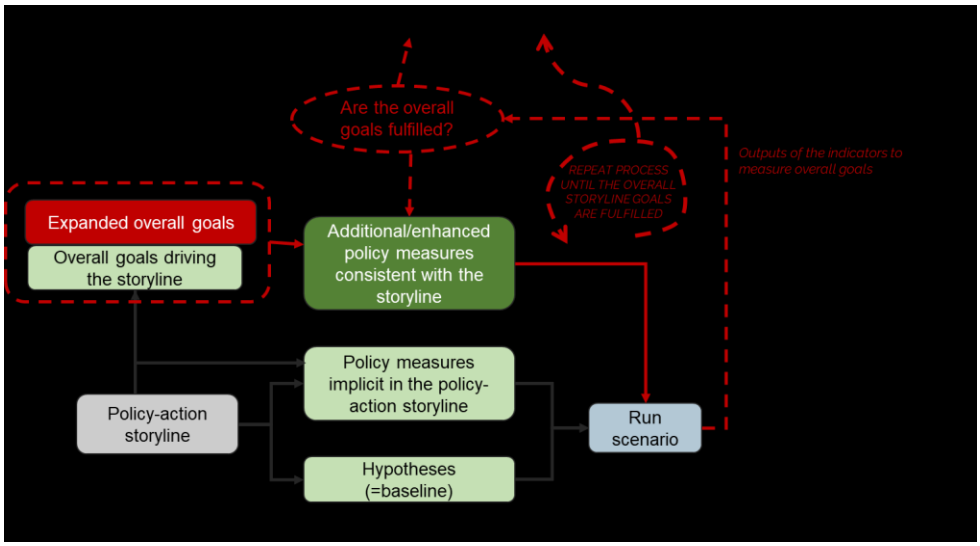


Figure 15. Conceptual representation of the steps required to simulate a policy-action scenario with the WILIAM model

The processes behind running a baseline scenario and a policy-action scenario are different since the nature of each kind of scenario is also different. A baseline scenario is an explorative scenario in which most of the exogenous model parameters are hypotheses calibrated to represent a concrete pathway, typically being current/historical trends, but it does not explicitly include policy measures. As mentioned above, policy-action scenarios are modelled on top of the baseline one, with the same hypothesis but different policies, to make it comparable.

It is important to remark that the final scenario is the adaptive scenario. We assume over some exogenous variables, but the model complements it with results on the endogenous variables. In turn, we cannot know a priori what the quantitative trends are on some variables. We can make pre-assumptions following common sense but not specific trends, and some of our pre-assumptions can be debunked by obtaining counterintuitive results in some cases because we cannot realise some feedback loops. In this sense, the use of the model also helps to check the feasibility of a storyline.

All the steps that compound the process of building and running scenarios in WILIAM can be used in the same way for global, regional/EU and national scenarios. As explained above, WILIAM is a global model in which the world is disaggregated into 9 (or 35, depending on the module/variable) regions. This means that we can make a wide variety of regionalized scenarios.

If we want to simulate a global scenario, we just have to parametrize the scenario parameters in the same way for all the regions. But if we want to simulate regional and national scenarios, we can parametrize by differentiating across the different WILIAM regions. Table 7 synthesises these two ways of implementing a scenario in WILIAM.

Table 7. Scenario implementation in the WILIAM model differentiating (or not) by regions

Scenario	EU-27	UK	USMCA	China	Russia	LATAM	EASOC	India	LROW
Global Scenario	S1	S1	S1	S1	S1	S1	S1	S1	S1
Regional/ National Scenario	S1/S2*[3]	S1	S2	S2	S1	S2	S1	S2	S2

[3] In some modules/variables, EU-27 is disaggregated for each country, which allows to implement national scenarios.

All regions will start simulations following a business as usual or baseline storyline and will move towards a policy action scenario progressively in the specified period (Figure 16).

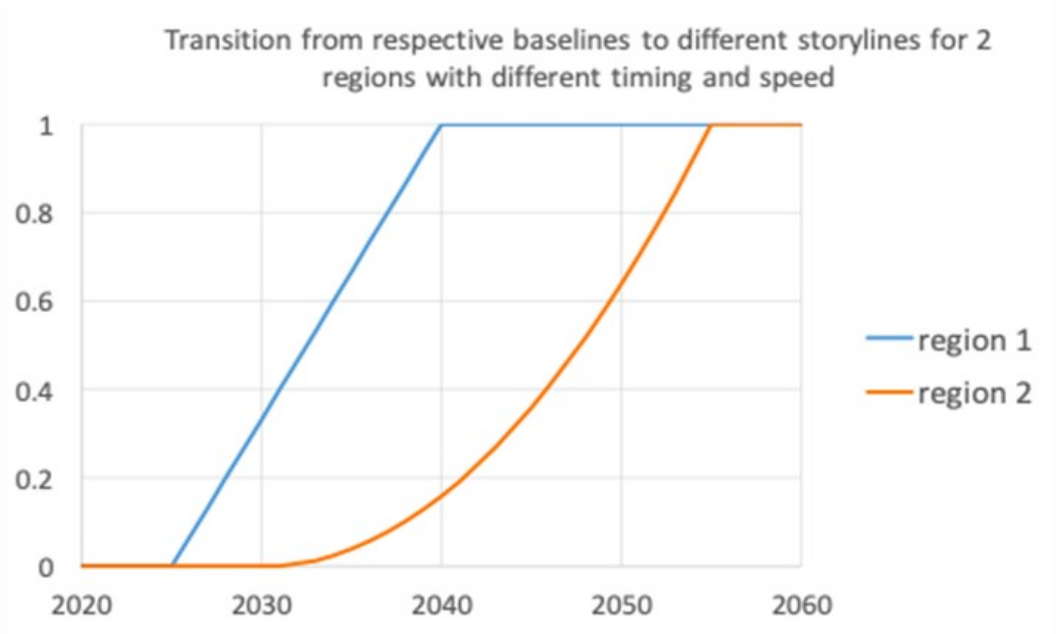


Figure 16. Transition from respective baselines to different storylines for 2 regions with different timing and speed. Source: (Markovska et al., 2021)

It is also important to highlight that some storylines (and their consequent scenario) could imply a specific regionalization to reach internal coherence. An example could be the Post-Growth scenario (explained in the section 5.1.) which is featured by regional justice. Even though we would like to implement this scenario globally, we may fix some parameters by differentiating across regions to capture these regional differences that are implicit in the storyline. Also, the baseline scenario is calibrated to follow current trends considering the regional differences.

4.2. The development of local scenarios

It is worthwhile to dedicate a specific section to the methodology developed to build local scenarios, since they have different nature and different purposes than global to national scenarios. First, as explained in section 3.2, local scenarios usually -respond to specific challenges, so the stakeholder's participation takes on increased importance. In addition, these scenarios will feed the local models, which are radically different to WILIAM (main differences will be shown in the deliverable 4.2). In turn, although the methodology (and its constituent concepts) used to build and simulate global, regional/EU and national scenarios will be taken as a basis, we consider it necessary to develop a specific approach that matches local scenario needs.

In sub-section 4.2.1, the methodology of the local modelling is explained. In sub-section 4.2.2, we provide some preliminary ideas to align in a top-down way the WILIAM scenarios with the local models and finally , in the subsection 4.2.3 we explain a bottom-up methodology to develop local-specific storylines that could be used in the to generate new specific policy-action scenarios.

4.2.1. Local Models

The first step is the definition of specific key concepts to understand the local methodology and common nomenclature to ensure coherence between different modelling scales:

- **Hazard**: the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. This is normally quantified through a probability of occurrence.
- **Exposure:** the presence of people, livelihoods, species, ecosystems, environmental functions, services, infrastructures, economic, social, or cultural assets in places and settings that could be adversely affected.
- **Vulnerability**: the propensity or predisposition of the asset to be adversely affected for a specified type of hazard. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
- **Impacts:** the total effects (e.g., economic losses) of a hazardous event. The term includes economic, human and environmental impacts, and may include death, injuries, disease and other negative effects on human physical, mental and social well-being.
- **Risk**: the combination of the consequences of an event or hazard and the associated likelihood of its occurrence, considering in the analysis also the asset vulnerability.
- **Probabilistic Risk Approach**: The consideration of all possible events, their likelihood, and associated impacts. This method contains the idea of uncertainty because it incorporates the concept of randomness. The probabilistic risk is quantified from a series of historical or synthetic events spanning a time period long enough to be statistically representative of all possible disastrous events that can occur in a territory.
- **Deterministic Risk Approach**: the scenario is determined based on historic events or corresponding to most likely and/or worst possible consequence events.
- **Current Scenario**: A hazard or risk scenario using the historical baseline or current data, for the current conditions.
- **Future Scenario**: A hazard or risk scenario using the historical baseline or current data, and/or modelled climate change metrics presented in the future (after present day), for example for 2050 or 2080.
- **Adaptation Pathways**: A series of adaptation choices involving trade-offs between short-term and long-term goals and values. These are processes of deliberation to identify solutions that are meaningful to people in the context of their daily lives and to avoid potential maladaptation (IPCC, 2022).

Due to the flexibility that this methodology demands in order to be feasible for implementation to various assets and against various hazards, the methodology is setting some standard steps toward the risk assessment. The procedure is being described in the Figure 17.

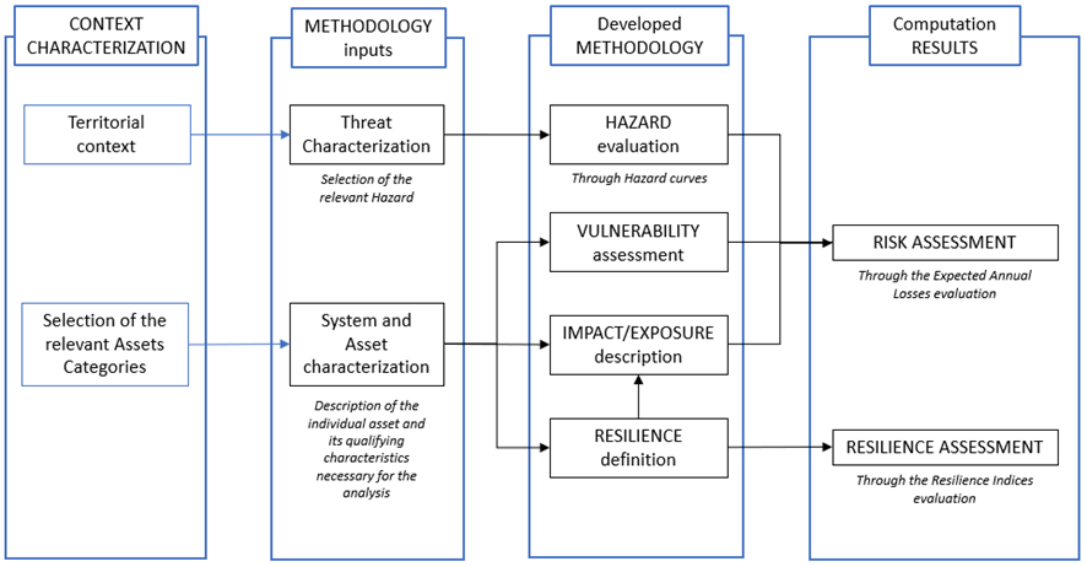


Figure 17. Schematic representation of the methodology at local scale

The three basic components of a risk model are: hazard, exposure and vulnerability. First, the identification of potential threats and hazards is carried out, after the evaluation of the disruptive event's magnitude and criticality, and the definition of relevant hazard scenarios is taking place. Briefly, the hazard component estimates the probability that the parameters that define the hazard will exceed various levels. Next, the model characterizes the inventory of properties at risk as accurately as possible. One of the most important parameters used to characterize the assets is the location of each property at risk. A process called geocoding is normally used to assign geographic coordinates such as latitude and longitude to each asset. With a property's location in spatial terms, other factors that could aid in estimating the vulnerability of a property are added to its characterization. For a building, these parameters include such features as its construction type, the number of stories and its age. Lastly, the vulnerability of the asset shall be determined as well using a structural assessment. In essence, this step in the model quantifies the physical impact of the natural hazard phenomenon on the property at risk. How this vulnerability is quantified differs from model to model. For instance, the HAZUS model (FEMA, 2013) classifies a structure as being in a Slight, Moderate, Extensive, or Complete damage state.

The impact could be evaluated for different assets as well as for different kinds of targets. The impact is defined as the presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected by a hazard. Therefore, it can be seen as the scale of the consequences of a hazard. The impact is normally quantified in the determination of damages and losses caused to stakeholders, the environment and human life. In this study case, the analysis of the impact is based on the analysis of three different categories, according to Poljansek et al. (2019) Sousa et al.: impacts on People (fatalities/injuries); impacts on the Physical System/Infrastructure (damages on the structures); impacts on Service continuity (interruptions/downtime). The evaluation of each component is provided in economic terms; in such a way that the combination of them provides a unique impact value.

Finally, the loss module translates damage into monetary loss and estimates the probability of exceeding various levels of loss thorough the risk curve. Risk is calculated as the convolution of the damage caused by all events, considering their associated likelihood. Each point on a risk curve connects the probability of exceedance of an event (e.g., a flood) with the expected losses from that event. Further, by calculating the area under a risk curve, the corresponding EAL (expected annual

loss) can be obtained. The EAL represents the losses expected on average each year. It accounts for all return periods and is, therefore, a better point of comparison between different risks.

The local model will analyse the current scenario that is obtained using the historical baseline or current data, for the current conditions. Moreover, future projections of climate and development variables will be considered to run future scenarios.

The magnitude of economic losses from natural disasters raises various questions: Who are the individuals affected by these events? What options are available to them to assess their risk? What factors influence their choices for dealing with these risks and actively managing their risk? By examining the perspectives of these individuals and groups, one can develop more effective risk management strategies for reducing potential losses from such disasters.

To handle the deep uncertainty associated with future projections of climate and development variables, climate risk management studies commonly implement the "states of the world" (SOWs) approach to describe possible trajectories of the future (Doss-Gollin & Keller, 2022; Hinkel et al., 2019). These trajectories can be defined in terms of future climate, socioeconomic, population, or other key parameters (e.g., energy pathways, land use) projections relevant to the analysis. The SOWs concept embraces the idea that the future may unfold in different ways (especially on increasing timescales) and attempts to broadly capture these different plausible futures to provide a representative "sample" of the future. The selection of plausible future trajectories using the SOWs concept will ultimately depend on the type of questions to be answered, such as: "what would happen if…", "how could we get to…", "what are the response options we could take to…", "what are the major sources of uncertainty in…".

4.2.2. Preliminary Link with WILIAM (ideas to link WILIAM and local scenarios)

On the one hand, it is true that the case studies have specific characteristics that need to be explored in a focused way. Therefore, in the next section, we will develop a methodology for building policy-action storylines adapted to local case studies. But we must not forget that local scenarios are also embedded on global, European and national contexts. In this sense, although the links between WILIAM and the local models still need to be defined, we consider that it is worth it to mention some ideas on how WILIAM global, regional and national scenarios could feed local scenarios.

The basic idea is that WILIAM results/outputs at global, EU and national scales can be used as inputs of the local models, setting the boundary conditions of them. The WILIAM model is a dynamic model, whereas local models are fixed. However, by varying the values of some exogenous variables of the local models, we could make adaptations to make the local models adapt to WILIAM results, according to different adaptive scenarios.

Some of the exogenous variables of the local models that could vary according to WILIAM outputs are:

- Climate variables. In order to provide a set of climate information, the CMIP6 projections and models will be utilized for each solution step of IAM model, as a possibility to expand outputs/results of WILIAM. As such, climate variables like precipitation, wind and temperature, in daily or monthly resolution and with regional information that will provide information for local differentiations of climate projections, will give a robust climate dataset to calculate hazards, extreme events, perform impact assessment, risk and provide the necessary information for adaptation planning in different climate scenarios generated through WILIAM.
- Exposure variables. Examples are 'Population' or 'Assets', for the different regions and sectors. Future exposure could be driven by increases in population (such as urbanization, i.e., the

movement of people from rural to urban areas), socioeconomic growth as well as choices on land use.

- Vulnerability variables. Examples are 'Fragility Curves', for the different regions and sectors. Risk assessment methods account for the future vulnerability of physical infrastructure to natural hazards from two main perspectives. The first one assumes that vulnerability will increase in time because of unplanned/informal modifications or maintenance/degradation challenges. This is important, given that rising carbon dioxide levels associated with global warming will increase the likelihood of carbonation-induced corrosion (Stewart et al., 2011). In contrast, the second focuses on the reduction in vulnerability that can be achieved by adapting infrastructure to future conditions.

In the modelling-related tasks of WP4 and WP6, more work will be done with regards to specifically define WILIAM & local models' linkages, which will help to define scenario linkages at the different scales. Challenges regarding the alignment between methodologies (e.g., different modelling languages, different time and scale, etc.) are expected.

4.2.3. The local storylines building processes

Here we present an approach to develop local policy-action storylines through a participatory process. The purpose of this methodology is to explore in a bottom-up way storyline adapted to the local concerns that can complement the top-down generated storylines for global to national levels. The approach incorporates participatory processes with stakeholders for purposes of guaranteeing consistency, richness, creativity, salience and legitimacy of scenarios (Table 5).

Following the classification of van Vuuren et al. (2012), our approach is also both product-oriented and process-oriented: it is clear that we use participatory processes to obtain local-adapted storylines that afterwards can be converted into scenarios by being quantified and implemented in the local models; but another objective of the consultation processes is to make the local leaders and stakeholder familiar with scenario thinking. Therefore, the consultations will be useful in helping targeted users of the models better understand their use.

We are aware of the difficulties we may face in trying to extract useful information on the storylines since it can be a complex concept for some stakeholders. This is why we need tools that allow us to communicate and obtain information about scenarios in a way that is understandable and not too technical. In that sense we have developed a method based on what-if questions and the Scope-Actions-Actors-Sectors (SAAS) framework, a new framework based on the FAS framework from (Absar & Preston, 2015).

The method facilitates the brainstorming and the generation of insightful ideas that can help to generate interesting and grounded pathways. It consists of selecting challenges that each case study is concerned about and start thinking on "what-if" questions that actually are hypothetical solutions. After, the "what-if" questions are analysed and used to identify and generate local-adapted and storylines. This method has been created in collaboration to the WP2 to ensure that the participatory process is understandable and easy to conduct for stakeholders not very familiarised with scenario thinking. The three steps carried out to complete the process are synthetised in Table 8.

Table 8. Steps needed to carry out the bottom-up method to generate local adapted storylines.

Step	Partners involved	Content	Objective
01	All partners involved in T4.1.	Plenary Session explaining the proc ess and key concepts.	Make the process, objectives, and outputs clear.

02	Local supporters + local leaders.	What-if questions generation.	To imagine and identify interesting, desirable, and grounded solutions to climate change challenges adapted to local features.
03	UVa	Storylines suggestions based on the what-if questions.	To coherently create storylines, through extracting information from the what-if questions.

During the Step 01, the Plenary Session, we explained the whole method to develop the what-if questions. Figure 18, Figure 19 and Figure 20 show the slides that were used to explain the method.

Table 9 shows the SAAS framework that was proposed. This method is useful to sort all the information we need from stakeholders in a systematic and structured manner that helps to address the complexity of a socioeconomic system and to decide on all the relevant aspects. The stakeholders were told to use the SAAS framework to generate combinations for each what-if question, just like the Table 10 shows. The consultation was carried out between 18th April and 30th April.

Scope	Actions	Actors	Sectors
Mitigation	Consumption	Public authorities / Local government	Agriculture, Forestry and Fishing
Adaptation	Production	Citizenship	Mining and Quarrying
Mitigation & Adaptation	Investment	Private companies	Energy (incl. Energy production and distribution-infrastructures)
	Regulation	NGOs	Industry and commerce (incl. refinery, chemicals, metals, other manufacturers)
	Protection		Transport (incl. transport infrastructure)
	Prevention		Water and waste (incl. Water treatment and distribution-infrastructures)
	Prices		Cities, urban planning and construction
	Taxes		Tourism/Leisure /cultural heritage
	Subsidies		Technology, Information and Communication
	Sharing Economy		Finance
	Collective Action		Society (incl. Human health, wellbeing, migration and Education)
			Biodiversity and natural heritage
Add new Scopes if necessary	Add new Actions if necessary	Add new Actors if necessary	Be more specific (including sub-sectors) if necessary

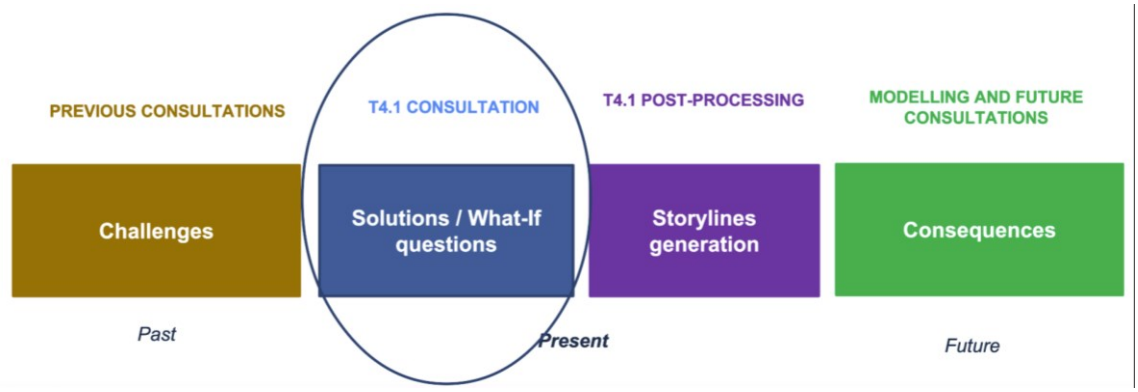
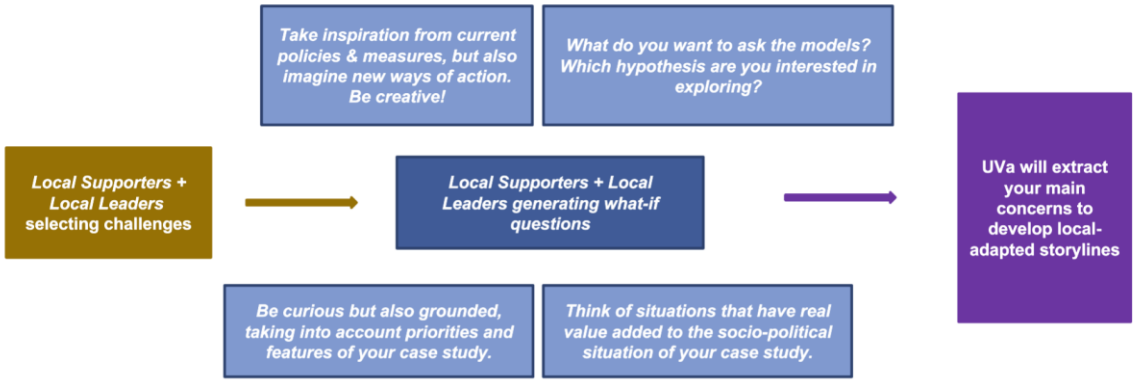


Figure 18. Slide 1 used in the Plenary Session to explain the what-if question exercise



What-if questions should be motivated by challenges but also by *desirability*, *curiosity*, *feasibility* and *local knowledge*. This means that a what-if question could make sense for a local case study but not for another one, depending on local features or interests. They can be more or less concrete.

Figure 19. Slide 2 used in the Plenary Session to explain the what-if question exercise

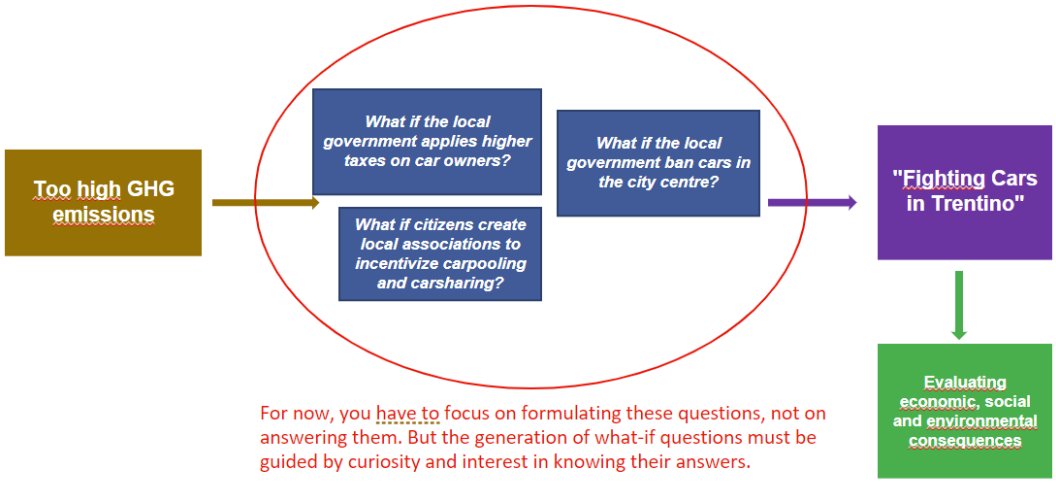


Figure 20. Slide 3 using during the Plenary Session to explain the what-if question exercise

Table 9. The Scope-Actions-Actors-Sectors (SAAS) framework

Scope	Actions	Actors	Sectors
Mitigation	Consumption	Public authorities / Local government	Agriculture, Forestry and Fishing
Adaptation	Production	Citizenship	Mining and Quarrying
Mitigation & Adaptation	Investment	Private companies	Energy (incl. Energy production and distribution-infrastructures)
	Regulation	NGOs	Industry and commerce (incl. refinery, chemicals, metals, other manufacturers)
	Protection		Transport (incl. transport infrastructure)
	Prevention		Water and waste (incl. Water treatment and distribution-infrastructures)
	Prices		Cities, urban planning and construction
	Taxes		Tourism/Leisure /cultural heritage
	Subsidies		Technology, Information and Communication
	Sharing Economy		Finance
	Collective Action		Society (incl. Human health, wellbeing, migration and Education)
			Biodiversity and natural heritage
Add new Scopes if necessary	Add new Actions if necessary	Add new Actors if necessary	Be more specific (including sub-sectors) if necessary

Table 10. Structure to be filled by each case study to generate the what-if questions

Challenge	What-If question	Scope	Action	Actor	Sector
…					
…					

For the time being, the activity has been carried out using the inputs from the local leaders and local supporters. Outputs of the activity are in section 6.1. Later on (outside the scope of this task, but within the NEVERMORE project) it is also planned to carry out the activity with the local council.

5. Scenario Design at Global, Regional and National Scales

In this section we apply the methodology explained in section 4.1 to create scenarios to be applied in WILIAM. Currently, we propose four scenarios (one baseline scenario and three policy-action scenarios) to systematically and coherently group policies and explore socioeconomic pathways. The storylines proposed were preliminary described in the LOCOMOTION H2020 project. Here, we propose them as a basis, and we improve them in several ways.

We are aware that the storylines proposed here can have some limitations. For instance, some policy measures and targets could not match any of them. Also, we can face difficulties to parametrize some policies according to some scenarios due to the lack of literature. Furthermore, the storylines could be too general and NEVERMORE targeted stakeholders (e.g., local councils) could be more interested

in exploring other storylines. Taking this into account, we also propose to take these storylines as a baseline to explore new combined storylines (this is further explained in section 5.1.1).

5.1. Selection of baseline and policy-action storylines

The four socioeconomic storylines that we propose as a basis to systematise the NEVERMORE results are: a Business as Usual or baseline storyline, a Green Growth storyline, a Green Deal storyline, and a Post Growth storyline. The first one is the baseline, and the others are the policy-action storylines, which are modelled on top of the previous one, as explained previously.

- Business As Usual / Baseline.

The baseline storyline represents the continuation of historical/current trends. Inertia is one of the main drivers of this storyline. Our baseline storyline relies on the SSP2 qualitative description:

'The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Most economies are politically stable. Globally connected markets function imperfectly. Global and national institutions work toward but make slow progress in achieving sustainable development goals, including improved living conditions and access to education, safe water, and health care. Technological development proceeds apace, but without fundamental breakthroughs. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Even though fossil fuel dependency decreases slowly, there is no reluctance to use unconventional fossil resources. Global population growth is moderate and levels off in the second half of the century as a consequence of completion of the demographic transition. However, education investments are not high enough to accelerate the transition to low fertility rates in low-income countries and to rapidly slow population growth. This growth, along with income inequality that persists or improves only slowly, continuing societal stratification, and limited social cohesion, maintain challenges to reducing vulnerability to societal and environmental changes and constrain significant advances in sustainable development. These moderate development trends leave the world, on average, facing moderate challenges to mitigation and adaptation, but with significant heterogeneities across and within countries.' (O'Neill et al., 2017).

It is important to remark that, since WILIAM endogenizes many relationships, we cannot use SSPs directly. This means that we are only using SSP2 as a qualitative description of the baseline storyline, which will guide parametrization as much as possible. This also allows a certain degree of comparison between our scenarios and SSPs. Nevertheless, we are not using the quantitative description of SSP2 provided by other IAMs to parametrize WILIAM. Most of the exogenous parameters are parametrized to match historical trends, and this has been a very long work mainly developed in parallel with the development of the WILIAM model.

Mitigation and adaptation policies are not implemented explicitly in the scenario corresponding to this storyline. Nevertheless, we could be implicitly taking into account policies carried out so far since some policy parameters that are calibrated to follow current trends (e.g., energy mix already includes certain development of renewable sources).

This storyline matches the 'Minimum Intervention' scenario from (Suckall et al., 2018) with low public investment and non-significant policy change. Vulnerability reduction is addressed through human capital investment (e.g., basic training to households). Disaster Risk Reduction is provided through basic long-term measures mainly based on training and 'ex-post' actions (e.g. emergency evacuation and basic services for disaster recovery and rehabilitation (e.g. treatment and construction of the most affected houses). Ecosystem resilience is managed through basic provisioning services that sometimes overlap with the previously mentioned training services.

- Policy-action storylines.

The following storylines differ one from another regarding the importance they give to some environmental, social and resilience goals, and regarding the pathway they propose to achieve them.

Table 11. Environmental and socio-economic general goals in the WILIAM storylines. Source: Markovska et al. (2021)

Objective	Green Growth	Green Deal	Post-growth
Environmental goals	Prioritized-through markets and innovation	Prioritized-through markets, innovation, regulation and large public expenditures	Prioritized-through transformation of economy, regulation, production slowdown and behavioural change
Socio-economic goals	Not an objective per se, trickle-down (as in baseline)	Specific inclusion policies	Universal social policies

- Green Growth (GG)

The notion of Green Growth was first introduced in the 5th Ministerial Conference on Environment and Development (MCED) in March 2005 in Seoul. 52 governments and stakeholders from Asia and Pacific adopted 'The Seoul Initiative Network on Green Growth'. Since then, it is the most widely accepted solution to stop environmental degradation and has been largely promoted by international organisations such as the United Nations, the OECD, and the World Bank. Indeed, in 2008, the UN Environmental-led Green Economy initiative was launched, as a platform offered by the United Nations to help its members move toward a green economy. In 2009, the OECD started its 'Green Growth strategy' and in 2010, the Global Green Growth Institute (GGGI) was founded to promote Green Growth as a new model of economic growth. In 2012, the World Bank, UNEP, OECD and the GGGI launched an international knowledge-sharing platform: 'the Green Growth Knowledge Platform'.

According to Green Growth theory, environmental damages are provoked by 'brown growth': an economic growth based on fossil-fuel energies and other environmentally damaging processes. Thus, this paradigm is about the continuation of growth patterns whereas targeting a significant reduction of environmental footprint. The idea of decoupling is the core of this storyline (Haberl et al., 2020) since an absolute decoupling between economic growth and environmental pressures would be needed to keep growing in a 'green' way.

This storyline is very similar to the SSP1 storyline, with a focus on *'resource efficiency, preferences for sustainable production methods and investment in human development'* (van Vuuren et al., 2017). According to Hallegatte et al. (2012), Green Growth '*is about making growth processes resources-efficient, cleaner and more resilient without necessarily slowing them*'.

The Green Growth paradigm aims to reduce GHG emissions by means of innovation and technological solutions. Green Growth is mainly a narrative of a technological transition, whereas low importance is given to lifestyle or social changes. Thus, specific policies to be implemented will be related to improving efficiency and developing new technologies (e.g digitalisation, electrification, etc.). This green economy would be based on the 'economisation' of environmental protection, where environmental protection is seen as an opportunity to create new jobs, technologies and commodities. It can be achieved by green stimulus, environmental policy, and green innovations (Markovska et al., 2021).

Environmental damages are analysed as 'negative externalities' of the economy, so they need to be integrated into prices to be considered by the market. To promote the consideration of GHG as costs (to be included in the prices), the Green Growth paradigm promotes market-based instruments and

regulation, aimed at increasing incentives to low carbon technologies and reducing them to fossil fuels. Examples are carbon taxation and cap-and-trade systems. These tools are seen to achieve climate change mitigation with minimum costs. A cap-and-trade system places a cap on the aggregate emissions of a group of regulated sources, by creating a limited number of tradable emissions allowances for a given period. The system doesn't impose a particular limit on emissions from a given source but requires firms to surrender a quantity of allowances equal to their emissions during this period. Thus, if a firm emits more greenhouse gases emissions than its number of allowances, it needs to buy new allowances on the market, from firms that haven't used all their allowances Initially, the government distributes the allowances for free or sells them at auction (Schmalensee & Stavins, 2017).

Green Growth matches a 'Capacity Expansion' scenario of Suckall et al. (2018) where there is a high level of public investment but aimed at protecting economic growth. There exists a high focus on vulnerability reduction with governmental and NGO actions providing aid to households and private companies (e.g., loans, training, entrepreneurship promotion, etc.). The provision of infrastructures to support economic growth is key. Disaster Risk Reduction is ensured through protective infrastructure deployment and insurance schemes that help to get the economy operating fast after disasters. Ecosystem resilience is provided through investment in provisioning services such as guaranteeing food and water access.

- Green Deal (GD)

Green Deal aims to face environmental challenges simultaneously tackling social inequality. The concept 'Green Deal' is reminiscent of the USA 'New Deal' program characterised by government interventions and welfare state.

The Green Deal narrative is an interventionist approach embracing regulation and government intervention in the economy and markets. It argues for limiting the primacy of market-based environmental policy instruments through public intervention.

It is closely related to the concepts 'Just Transition' and 'do not leave anybody behind' that assume that ecological transition has to be carefully carried out in order to guarantee wellbeing standards.

As Green Growth does, Green Deal also considers economic growth as positive and possible. This means that this narrative embraces the idea of decoupling and can also be framed within a 'green capitalism' but with a focus on social and wellbeing issues. It proposes simultaneously addressing environmental challenges, economic stagnation, and inequalities through indicative planning, industrial policies, public investment, and an extensive welfare state with a high level of social protection. The narrative defends that transition must be supported by social measures and the professional formation of workers of the fossil-fuel industry (Pollin, 2019).

Green Deal also matches a 'Capacity Expansion' scenario of Suckall et al. (2018), but with a higher focus on government-led investment and inequalities eradication.

- Post Growth (PG)

Post growth storylines build on the second law of thermodynamics, which imply that - based on physical processes related to entropy - endless growth is impossible on a planet with finite resources and sinks. According to Post-Growth supporters, these biophysical boundaries are not to be overcome by yet-to-be-developed technological solutions as more efficient technologies have not led to lower material throughputs but historically have rather increased them (Alcott, 2005; Kallis, 2011; Parrique et al., 2019). The toll of the current growth reliant capitalist economies is externalised to both the environment and marginalised and discriminated members of societies in the Global North and even more so in the Global South (Brand & Wissen, 2013; Harvey, 2012).

Post growth narratives therefore aim at a profound social ecological transformation of the current system. For conceptualising a specific post growth scenario, the following is based on degrowth as a

specific set of post growth narratives that has emerged in the 1970s and 80's in Southern Europe and spread its ideas and since then in the Global North and the Global South alike (Kallis et al., 2014).

Degrowth can be defined as a gradual and equitable transition based on the reduction of material throughput towards quantitatively smaller and qualitatively different societies that respect planetary boundaries and aim at inter- and intragenerational justice by centering the good life for all rather than GDP/economic growth (Schneider et al., 2010).

In order to achieve such a transformation Serge Latouche suggests the following 'eight 'R's' (Latouche, 2009,): a collective and participatory re-evaluation and a re-conceptualization of what is needed; a restructuration of how this is achieved; a redistribution of wealth, access and resources; a relocalisation of processes (think global, act local); a reduction of societies' negative impact on the environment, as well as increasing the increased reuse and recycling of materials.

The transformation is not to be achieved by top-down policies, but rather flourishing through local, participatory and collective bottom-up processes. Thus, there are many different ways a degrowth future can look like and many different proposals of the specific ways currently dominant institutions and structures could be changed for the sake of a social-ecological transformation.

In the realm of this scenario, the following degrowth proposals are considered:

- The care sector, the education sector and the renewable energy sector are strengthened (Kallis, 2011).
- Employment: working hours are reduced (Dengler & Strunk, 2018; Kallis et al., 2013), a maximum and minimum income are introduced (Kallis et al., 2014). Universal basic income is introduced (Dengler et al., 2022).
- Wealth is redistributed with taxation policies (Kallis et al., 2014).
- Land-use: Soil is de-sealed (Szabo et al., 2022), the built environment is dismantled rather than expanded (Heindl, 2022).
- Housing: communal living is supported (Schmelzer & Vetter, 2020), single-household-construction in the country-side restricted (Heindl, 2022).
- The production of goods is re-localised (Kallis et al., 2014).
- Transport: Individual transport by cars is limited, travelling by aeroplane is limited (Szabo et al., 2022).
- Commons and community structures replace commodified market-organised relations (Dengler et al., 2022).
- Technology: technology is organised for the common good, made accessible and affordable, easily usable and repairable, then knowledge sharing, open-source software, fab labs, digital commons and peer-to-peer production are encouraged (Kerschner et al., 2018).
- Energy: transition to renewable energy sources is needed, collective renewable projects and small-scale production should be promoted. Collective forms of ownership and decision-making is considered (Kunze & Becker, 2015). An overall reduction of energy consumption is needed as these energies won't be able to support a growth-oriented economy (de Blas et al., 2020).
- Consumption: is based on re-evaluated needs and linked to production, advertisement is banned (*Prosperity without Growth*, n.d.).

- Food: food sovereignty is aspired, organic farming, permaculture techniques and communal food provisioning are supported (Plank, 2022), the amount of animal-based proteins is decreased both in production and consumption (Fehlinger, et al., 2022).

The relationship between post-growth and adaptation has been poorly explored in the literature. To add some information on this dimension, we assume that Post-Growth mainly matches the 'Efficiency Enhancement' but also incorporates some features of the 'System-Restructuring - Protect' adaptation direction (Suckall et al., 2018). It is focused on measures taken at community level rather than on big infrastructure projects, although on some occasions high public investment is needed for protecting livelihoods and emplacements.

This storyline reduces vulnerability by means of household and community level strategies such as cooperatives, climate resilient techniques training, permits to manage land, land redistribution to poorer, and green spaces promotion. Disaster Risk Reduction is mainly focused on long-term risk management, with a precautionary and as far as possible, nature-based, pro-regulation and pro-adaptation approach. High-cost investments are a second option, that is why 'Efficiency Enhancement' is prioritised over 'System-Restructuring Protect'. Ecosystem resilience is also a priority to allow traditionally based agricultural livelihoods to keep relying on the ecosystems.

Figure 21 synthesises main differences across Green Growth, Green Deal (focused on EU's strategy) and Degrowth.

	Green Growth	Degrowth	EU Green Deal
Ecology	- nature as a resource - nature as an investment opportunity	- nature as a biosphere - nature as ecological commons	- mainly nature as a resource - notion of an ecosystem - green oath
Economy	- green capitalism - firm-based	- economy embedded in ecology - community-based - commons-based	- green capitalism - acknowledges problematic nature of industry and extractivism
Power structures	- top down elite networks	-bottom up movements	- top down elite networks - inclusive transition - support for democratization
Technology	- technological solutionism - tech-firm-led digital transformation - green tech	- socially embedded tech - low tech	- technological solutionism - tech-firm-led digital transformation - green tech
Sustainability	- decarbonization	- structural transformation of capitalist society	- decarbonization - recognition that green growth will not be sufficient to realize zero emissions by 2050
Lifestyle	- consumerist	- anti-consumerist	- consumerist
Discourse-makers	- capitalist elite networks	- counter-movements	- capitalist elite networks

Figure 21. Overview and main differences of Green Growth, Degrowth and Eu Green Deal. Source: (Ossewaarde & Ossewaarde-Lowtoo, 2020)

5.1.1. Further storylines for exploring specific what-if questions

From our point of view, the four storylines described in the previous section allow us to systematically group plausible and interesting pathways for the world (and specifically for the European Union countries) in a coherent way. However, since (in terms of modelling) a scenario is only a set of hypotheses and policies coherently grouped to try to answer one or several 'what-if' questions and related to a specific narrative (which can be more or less general), we could also set other storylines and consequent scenarios to analyse specific situations. Indeed, WILIAM is prepared to run almost infinite scenarios by varying specific hypotheses and policies.

One of the main objectives of the NEVERMORE Project is to analyse the effects of specific mitigation and adaptation policies. Many of these policies can be grouped to conform to the storylines above, but sometimes the match is not straightforward, either because we do not have information to parametrize a policy across the three scenarios, or because the role of a policy in the previous storylines is not clear. It can happen, on the other hand, that we are more interested in creating new storylines and scenarios to explore other situations (e.g., comparing effects of similar policies grouped

to make up an *ad hoc* scenario). For these situations, it will be worthwhile to create specific scenarios aimed at answering specific 'what-if' questions.

A second important objective of the NEVERMORE Project is to analyse climate change impacts. In this sense, it will be interesting to vary some hypotheses to create different baseline scenarios that allow us to explore different climate uncertainties. This is not related to socioeconomic assumptions, but it is worth mentioning. This will be assessed more in detail in WP3.

These *ad hoc* scenarios could be set up depending on the needs and research interests (identified by researchers and stakeholders) once the models are ready to be used and the policy measures and targets are chosen[4]. *Ad hoc* scenarios can range from baseline to policy action ones. Hereafter we show some examples of specific scenarios we could run in the NEVERMORE Project:

- Scenarios focused on behavioural change, aimed at exploring 'what-if' questions such as 'what are the economic, social and environmental consequences of moving towards different diets (e.g., vegan, vegetarian, flexi-vegetarian) and non-motorized transport use?'. In turn, we could set different policy-intervention scenarios as combinations of different behavioural change measures, without trying to represent Green Growth, Green Deal or Post-Growth discourses.
- Scenarios focused on specific policy instruments. An example could be to create a scenario with only taxes-related policies VS a scenario with only regulation-related policies, with the aim of exploring the 'what-if' question 'which policy instruments are more efficient/effective in terms of reducing GHG emissions (or other objectives), taxes or regulations?'.
- New baseline scenarios apart from the BAU, by making changes on the hypotheses (e.g., varying climatic uncertainties or other physical uncertainties).
- A scenario trying to realistically represent a specific political plan such as the National Determined Contributions (NCDs). In this specific example, the narrative is quite simple and there can be more quantitative information to parametrize some specific policies with a high level of regionalization.
- Local-adapted scenarios identified in section 6.1 can be also used to generate storylines to be modelled at higher scales.

There is also the possibility of exploring policy intervention-specific scenarios within the current storylines, which would be used as scenario families. For instance, we can explore the effect of specific efficiency-related policies in the Green Growth scenarios, which would lead us to new scenarios (e.g., Green Growth only including building efficiency-related policies, Green Growth 2 only including agricultural efficiency-related policies, etc.).

All these *ad hoc* storylines can be applied and tested on top of baselines or policy-action storylines, giving to different situations and combined scenarios. A scenario matrix architecture such as the one shown in Table 12 and Table 13.

Table 12. Example 1 of scenario matrix architecture

	'Neutral' Policy Intervention
Green Growth	
Green Deal	
Post-Growth/Degrowth	

[4] Once these new storylines are identified, these should be translated into scenarios along tasks related to policy quantification and modelling in WP4, WP5 and WP6.

Table 13. Example 2 of scenario matrix architecture

	GG	GD	PG
Climate Scenario 1	S1	S1	S1
Climate Scenario 2	S1/S2*	S1	S2
Climate Scenario 3			

We think this section opens a room for future exploration of situations and we are sure that stakeholders will play a key role in identifying interesting situations they are interested in.

5.2. Qualification of storylines

As explained in Figure 13, once we have generally defined each storyline, we must conduct a process of qualification. Qualification refers to assigning qualitative dimensions to the storylines, which will serve afterwards as a roadmap to guide future scenario quantification.

We can follow different strategies of qualification. In the scope of WILIAM, we mainly use overall goals and qualitative attribute tables.

Here, we first link the different overall goals (as shown in the section 2) to the different storylines. This is very useful for the implementation of the scenarios in the WILIAM model since overall goals should be (as far as possible) quantitatively integrated as indicators that will allow to check the coherence of each storyline (Table 12). As Table 14 shows, an overall goal can drive different storylines. At the same time, storylines are driven by more than one overall goal. Table 14 shows a list of overall goals for the three policy-action storylines, since we assume there are no explicit overall goals linked to the BAU scenario.

Table 14. Overall goals and storylines

Category	Overall Goal	Driving which storyline?
Mitigation: Sustainability	Prevent exceeding 1.5°C	Green Growth, Green Deal, Post Growth
	Prevent exceeding climate change tipping points	Green Growth, Green Deal, Post Growth
	Use land sustainably	Green Growth, Green Deal, Post Growth
	Use freshwater sustainably	Green Growth, Green Deal, Post Growth
	Manage and use mineral and energy resources sustainably	Green Growth, Green Deal, Post Growth
Social Rights	Universal access to nutritious and sufficient food	Green Deal, Post Growth
	Universal access to public services such as health, education or social security	Green Deal, Post Growth
	Preserve life expectancy	Green Deal, Post Growth
	Full employment	Green Deal, Post Growth
	Equality within regions	Green Deal, Post Growth
	Equality between regions	Green Deal, Post Growth
	Universal wellbeing	Green Deal, Post Growth
Mitigation: Decoupling	Absolute decoupling of environmental pressures from economic growth	Green Growth, Green Deal
Economic	Sustain continuous economic growth	Green Growth, Green Deal
Adaptation: Vulnerability Drivers	Addressing financial vulnerability	Green Growth, Green Deal
	Addressing human vulnerability	Green Growth, Green Deal, Post-Growth

	Addressing social vulnerability	Post-Growth
	Addressing natural vulnerability	Post-Growth
	Addressing physical vulnerability	Green Growth, Green Deal
Adaptation: Disaster Risk Reduction	Managing long term risk	Green Growth, Green Deal, Post-Growth
	Hazard preparedness	Green Deal, Post-Growth
	Disaster response	Green Growth, Green Deal
	Post disaster recovery and rehabilitation	Green Growth, Green Deal
Adaptation: Landscape and Ecosystem Resilience	Provisioning services	Green Growth, Green Deal, Post-Growth
	Regulating services	Green Growth, Green Deal, Post-Growth
	Habitat services	Post-Growth
	Cultural services	Post-Growth

In **Errore. L'origine riferimento non è stata trovata.** we propose some quantitative indicators as overall goals proxies. These will be implemented in the WILIAM model to evaluate coherence and feasibility of the storylines at global, regional, and national level.

Qualitative attribute tables represent properties that describe the development of key storyline features. They are used to guide quantification and modelling; hence they refer to exogenous inputs (hypothesis, policy targets, behavioural change, and policy measures). Here we present a preliminary qualitative attribute table for each policy-action storyline, only including policy parameters, omitting hypotheses that are linked to the baseline scenario, since these are too many (they will be specified in the WILIAM final documentation)[5].

Table 15 is a qualitative attribute table including policy areas for the NEVERMORE sectors. For each policy area across each scenario, we have tried to give a qualitative interpretation including terms such as High, Medium, Low, etc. The objective is to have a general idea for later quantification. For the sake of simplicity, we do not include regional differentiation and we take European Union as a reference. The information needed for filling qualitative attribute tables so far was taken from WILIAM Modelers. It can be enlarged and improved with information from other experts, NEVERMORE partners and literature.

Table 15. Qualitative attribute tables for WILIAM policy-action storylines

NEVERMORE Sectors	Attributes	GG	GD	PG
Economy	Debt Limits	High	High	Low
	Government Expenditures	Slow growth	Medium growth	Low to medium growth
Agriculture	Water use efficiency in agriculture	Medium growth	Medium growth	Low growth
	Agricultural Land Protection	Low	High	High
	Diet change and food waste reduction	Medium	Medium	High
Biodiversity and natural heritage	Natural Land Protection	Low	Medium	High
Cities	Urbanisation	High	High	Low
	Energy efficiency in buildings	High	High	Low

[5] Currently under development in the scope of the LOCOMOTION H2020 project.

Energy	Hydrogen Capacity Expansion	High	High	Medium
	Energy demand	Growth	Stabilisation	Decline
	PV Acceptance	Medium	Medium	High
	Fossil Capacity Expansion	Low	Low	Low
	Nuclear Capacity Expansion	Medium	Low	Low
	RES Capacity Expansion	High	High	High
Transport	Use of public transport	Medium	High	High
	Use of non-motorized transport	Low	Low	High
Society	Environmental Awareness	Medium	Medium	High

As explained before, some policy and behavioural change measures can be difficult to be linked to specific scenarios. In those cases, we can leave it blank, and it can be interesting to propose new storylines and scenarios. Since tasks 5.1 and 2.1, related to behavioural change and policies, are being developed concurrently with this task, we have not managed to have an exact alignment between measures and scenarios. However, work has been done to ensure that there is a general alignment, through several meetings to ensure this.

5.3. Quantification of storylines at global scale, EU and national scales

For quantifying a storyline in WILIAM we basically need to conduct three actions: (i) defining the quantitative expressions of the overall goals (ii) defining the mathematical formulas of hypotheses, policy measures, policy targets, behavioural change parameters and related scenario parameters, and (iii) parametrizing the required variables.

With regards to the action (i): overall goals are not currently included in WILIAM since storyline and scenario feasibility have not been addressed so far. In Tasks 5.2 and 2.2 of the NEVERMORE Project indicators that fit very well with some overall goals are being reviewed and listed. In **Errore. L'origine riferimento non è stata trovata.** we present a preliminary list of indicators that come from other tasks and that can be used for overall goals quantification.

Table 16. WILIAM Overall goals and indicators

Category	Overall Goal	Indicators
Mitigation: Sustainability	Prevent exceeding 1.5°C	Planetary Boundaries Indicators (to be obtained in Task 3.3)
	Prevent exceeding climate change tipping points	
	Use land sustainably	
	Use freshwater sustainably	
	Manage and use mineral and energy resources sustainably	
Social Rights	Universal access to nutritious and sufficient food	Socioeconomic Indicators (T2.2)
	Universal access to public services such as health, education or social security	Social KPIs (T5.2)

	Preserve life expectancy	
	Full employment	
	Equality within regions	
	Equality between regions	
	Universal wellbeing	
Mitigation: Decoupling	Absolute decoupling of environmental pressures from economic growth	Economic-Environmental KPIs (T5.2)
Economic	Sustain continuous economic growth	Economic KPIs (T5.2)
Adaptation: Vulnerability Drivers	Addressing financial vulnerability	Vulnerability Indicators (T2.2).
	Addressing human vulnerability	
	Addressing social vulnerability	
	Addressing natural vulnerability	
	Addressing physical vulnerability	
Adaptation: Disaster Risk Reduction	Managing long term risk	Risk Indicators (T4.3, T4.4)
	Hazard preparedness	
	Disaster response	
	Post disaster recovery and rehabilitation	
Adaptation: Landscape and Ecosystem Resilience	Provisioning services	Resilience Indicators (T2.2).
	Regulating services	
	Habitat services	
	Cultural services	

With regards to (ii) and (iii), it is still very early to quantitatively define the policy parameters for each scenario. These actions will be done within Tasks 5.3 and 4.4. Thus, for the time being, we can only stay in the qualification phase. Quantification of the baseline scenario is currently being done meanwhile the WILIAM model is being finished, but no outputs are available yet.

6. Storylines Design at Local Scale

6.1. Local storylines: Results of the what-if consultations

In this section, we include the information resulting from carrying out the participatory method described in section 4.2.3. The what-if questions generated by the different case studies have been analysed to generate some preliminary ideas on possible policy-action storylines. These storylines will be taken in consideration by the policy modelling exercises in WP5, WP4 and WP6.

6.1.1. What-if questions and preliminary policy-action storylines for Trentino

The Table 17 shows the what-if questions list for the Trentino case study. The partners came up with a list of 20 what-if questions. Among the information that can be gathered from the list, the following can be highlighted:

- The main concerns of the case study leaders are unsustainable over tourism, decreasing water and snow resources, and extreme weather events. The touristic sector has interrelationships with other sectors that can also generate concerns, but tourism usually is the driver (e.g., energy consumption and car-based transport for tourism purposes).
- Both mitigation and adaptation have an important role. It is interesting how adaptation is sometimes used not only to refer to climate change phenomena, but to socio-economic phenomenon like over tourism.
- An important role is given to public authorities: most of the what-if questions start by '*what if the local government…?'.* Public-private cooperation also appears many times.
- The action 'Subsidies' appears many times, whereas it is not used in any other case study. Sometimes, this is used to mean 'Incentives'. Other actions that appear regularly are Investment, Regulation and Protection.

With this information, we suggest a storyline for Trentino in which a high public-private cooperation exists with the objective to transform the touristic sector. This transformation would imply not only making it more sustainable, which would have a knock-on effect on other sectors, but also more respectful with Trentino's inhabitants, adapting to their needs and times.

A big part of the touristic sector is related to snow recreational activities. In this sense, it is also necessary to put an eye on adaptation to extreme weather events, water resource competition and loss of snow precipitation and ground permanence. In this storyline, most of the solutions are efficiency-based, prioritising technological measures both to prevent (e.g., tourism diversification; water & storage management systems) and repair when prevention is not possible (e.g., artificial snow generation).

To sum-up, in this storyline, the tourism sector remains the main source of income for the region (there is no radical break), but a high public-private partnership plan is applied to make it more efficient and sustainable, with innovative measures both in a technological, regulatory, and infrastructural sense.

Table 17. What-if questions for the Trentino case study

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Overtourism	What if the local government applies a closed Number for access to specific hotspots or services?	Adaptation	Regulation, Prevention, Protection	Public authorities	Tourism
Overtourism	What if the local government promotes the development of a tourist offer also in the off-peak seasons?	Adaptation	Regulation, Prevention, Protection, Subsidies, Investment	Public authorities, private companies	Tourism
Overtourism	What if the local government redefines the calendar of school vacations and holidays?	Adaptation	Regulation	Public authorities	Tourism, Education
Overtourism	What if the local government promotes investment in technology infrastructure to encourage forms of workcation?	Adaptation	Investment, Subsidies	Public authorities, private companies	Tourism, Job
Land use	What if the local government limits the allocation of new land use change for the tourism industry?	Mitigation	Regulation, Prevention, Protection	Public authorities	Tourism, Agriculture, Forestry
Agri-food chain and tourism	What if tourism businesses promote the consumption of local products that foster biodiversity and give more value to the local food chains?	Mitigation & Adaptation	Investment, Subsidies, Production	Public authorities, private companies, NGOs	Tourism, Agriculture, Commerce, Biodiversity and natural heritage
Reduced snow cover on the ground	What if enterprises optimize and develop technologies to produce artificial snow at higher temperatures?	Adaptation	Investment	Private companies	Tourism, Industry, Technology, Water&Waste
Reduced snow cover on the ground	What if the local government promotes the implementation	Adaptation	Investment, Subsidies	Public authorities, private companies	Tourism, Agriculture, Energy, Water&Waste

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	of multifunctional storage basins?				
Reduced snow cover on the ground	What if the local government promotes a diversification of tourism offer?	Mitigation & Adaptation	Regulation, Prevention, Protection, Subsidies, Investment	Public authorities, private companies	Tourism
Extreme events (e.g. VAIA)	What if the local government, together with other local actors, invests in a real time information system on the possibility of territorial fruition?	Adaptation	Prevention, Investment	Public authorities, private companies	Tourism, Technology
Predominantly car-based tourist transport model	What if the local government incentivizes alternative mobility (e-bikes, public transportation, cable cars, etc.)?	Mitigation & Adaptation	Subsidies, Investment,	Public authorities, private companies, citizenship	Transport (incl. transport infrastructure),
Predominantly car-based tourist transport model	What if the local government invests in public transportation infrastructure?	Mitigation & Adaptation	Subsidies, Investment,	Public authorities, private companies, citizenship	Transport (incl. transport infrastructure)
Decreasing water resources	What if the local government promotes more and more installations and use of water storage systems (es. better spread of rainwater storages)?	Mitigation & Adaptation	Subsidies, Investment,	Public authorities, private companies, citizenship	Water
Decreasing water resources	What if the local government promotes the mapping and digitalization of water management systems for its better monitoring and use?	Adaptation	Investment	Public authorities, private companies	Water
Decreasing water resources	What if local governments create/update water management plans for water storages in order to promote	Adaptation	Investment	Public authorities, private companies	Water, energy, Tourism

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	the coordination and optimization according to needs during different seasons?				
Excessive energy consumption linked to tourism activities	What if businesses promote the implementation of new technologies in energy-consuming tourism activities (es. hydrogen supply for snow grooming, building energy requalification etc.)?	Mitigation & Adaptation	Subsidies, Investment, Regulation	Public authorities, private companies	Tourism, energy
Excessive energy consumption linked to tourism activities	What if the local government, together with businesses, promote the use of only renewable energy in some tourism locations?	Mitigation	Subsidies, Investment	Public authorities, private companies	Tourism, energy
A required behavioral change	What if all businesses and operators involved in tourism take part in accredited trainings on sustainable development of the sector and on climate change?	Mitigation & Adaptation	Investment, Prevention	Public authorities Citizenship Private companies NGOs	Society, Education

6.1.2. What-if questions and preliminary policy-action storylines for Sitia

The Table 18 shows the what-if questions list for the Sitia case study. The partners came up with a list of 20 what-if questions. Among the information that can be gathered from the list, the following can be highlighted:

- There is a high concern on water scarcity and extreme weather events. In line with this, all the what-if questions proposed belong to the 'Adaptation' scope, which unveil a higher interest on adaptation policies than on mitigation.
- There is a predominance of the agriculture sector, but also the water sector, the tourism sector and the technology sector.
- A greater role is given to the agent 'Public authorities', above citizens, and private companies, although the latter also appear on several occasions. Interestingly, the partners have proposed a new agent 'Landowners'.
- Investment, Protection and Prevention are the actions that are used most often.

With this information, we can conclude that Sitia case study could be interested in exploring the consequences of a policy-action storyline focused on adapting to water scarcity and extreme weather events through an interventionist approach.

In this storyline, the main objective is to protect the region from extreme meteorological situations, such as extreme weather events like floods or droughts. In doing so, there is a predominant role of local public authorities. Local government has a role as a regulator (generating regulatory frameworks, providing incentives and disincentives) but also as an active investor, carrying out specific infrastructure construction actions. The actions must be taken in several sectors like agriculture, water, urban planning, and technology, to ensure a complete protection of all possible people, with a focus on vulnerable groups.

The role of private companies is limited to the tourism sector, where they carry out actions related to make it secure and well-adapted to extreme weather situations, and more sustainable, usually incentivised by public authorities. The private sector can also participate in building adaptive infrastructure according to public-private cooperation and planning. The role of citizenship is limited in policymaking: with a certain change of mentality towards new ways of adapting, such as using new farming techniques and the use of technologies.

In this storyline, mitigation is virtually absent. Actions related to making some sectors more sustainable (e.g., renewable energies) are not at the centre of the political agenda, although they sometimes appear to be subordinate to climate change adaptation and protection.

Table 18. What-if questions for the Sitia case study

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Rain/River water ends up in the sea	What if a rainwater harvesting system was built?	Adaptation	Protection, Prevention	Public authorities	Water resources, Agriculture
Water resources	What if there was a system to recycle/reuse wastewater?	Adaptation	Investment	Public authorities	Agriculture
Water resources	What if the local and regional authorities take action to install and use biological wastewater treatment systems?	Adaptation	Investment	Public authorities	Water resources, Agriculture
Drinking water is used for irrigation	What if the waters of rivers and creeks running through Sitia were restored to help with irrigation?	Adaptation	Prevention	Public authorities, private companies	Agriculture
Water resources being mis-managed	What if an agri-economic analysis was performed and resource allocation was done according to resource demand?	Adaptation	Investment	Public authorities, private companies	Agriculture
Droughts affecting water resources	What if water reservoirs were built to collect rainwater?	Adaptation	Prevention	Public authorities, private companies	Water resources
Droughts affecting water resources and agriculture	What if water dams were built to save water resources and supply the irrigation system?	Adaptation	Prevention	Public authorities, private companies	Water resources, Agriculture

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Landslides affect agriculture	What if existing "farming steps" were restored and new ones were built?	Adaptation	Prevention, Investment	Citizenships, Landowners	Agriculture
Wildfires	What if more wildfire buffer zones were created?	Adaptation	Protection, Prevention	Public authorities, Citizenships	Agriculture, Biodiversity, Economy
Wildfires	What if the local authorities provided support to raise awareness on reducing the risk of starting wildfires among the general population e.g. from burning debris or dead vegetation?	Adaptation	Prevention	Public authorities, NGOs	Agriculture, Biodiversity, Economy
Coastal erosion affects coastal areas, infrastructures, and safety	What if breakwaters were placed to reduce the wave momentum on the coasts?	Adaptation	Prevention, Protection, Investment	Public authorities, private companies	Urban planning, Biodiversity, Economy
Floods affect urban areas	What if more strict rules were put in place to prevent uncontrollable construction?	Adaptation	Protection, Prevention	Public authorities, private companies	Urban planning
Floods affect urban areas	What if a rainwater drainage system was constructed in the city of Sitia?	Adaptation	Prevention, Protection, Investment	Public authorities, private companies	Urban planning
Extreme events threaten human lives	What if economic support and funding was provided to acquire new equipment and	Adaptation	Protection	Public authorities	Economy, Agriculture, Biodiversity

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	reinforce civil protection?				
Extreme events threaten human lives	What if a real-time warning system was developed to warn citizens and visitors of extreme events e.g., heatwave, wildfire, floods?	Adaptation	Prevention, Protection	Public authorities, private companies	Technology, Information and Communication
Extreme events threaten human lives	What if the municipality can organize awareness activities, civil protection exercises for vulnerable groups?	Adaptation	Prevention, Protection	Public authorities, NGOs	
Biodiversity/Endangered species	What if the local authorities increased the margins of protected areas so that they remain mostly inaccessible to tourists?	Adaptation	Collective action	Public authorities, Citizenships	Biodiversity and cultural heritage
Tourism affecting energy and water demands	What if the local authorities invested in the digitalization of a management system to better meet increased energy and water demands due to tourism in specific months of the year?	Adaptation	Investment	Public authorities, private companies	Technology, Cities
Extreme events threaten human lives	What if funding was allocated to build new hotel units using the most modern materials	Adaptation	Investment, Protection	Private companies	Tourism, Urban planning, Economy

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	and complying with the latest safety standards regarding natural disasters?				
Green tourism	What if local authorities provided incentives to promote "greener tourism" e.g., sustainable hotel units, agro-tourism, endangered species, and reforestation volunteering activities, etc.?	Adaptation	Investment, Prevention	Public authorities, Private companies, Citizenships	Tourism, Economy

6.1.3. What-if questions and preliminary policy-action storylines for Tulcea

The Table 19 shows the what-if questions list of the Tulcea case study. The partners came up with a list of 16 what-if questions. Among the information that can be gathered from the list, the following can be highlighted:

- Main concerns are unsustainable and inefficient energy consumption in the transport sector and agricultural practices, and climate change hazards such as heatwaves, desertification, and water scarcity. From a socioeconomic point of view, there is also a concern on depopulation and unemployment.
- Due to the high level of interrelationship between problems and the complexity perceived by the local case study leaders, the what-if questions are very comprehensive and cover many sectors and types of actions, both in the mitigation and adaptation scope.
- A greater role is given to the agent 'Public authorities', but generally by 'supporting' or 'incentivising' the private market.
- 'Collective action' is used very often meaning that a high level of public-private cooperation is necessary, not to refer to political citizenship mobilisation.

With this information, we suggest a storyline for Tulcea where both mitigation and adaptation actions are carried out by means of efficiency, innovation, and technological related policy actions. In this situation, the role of the government is strong, but limited to support and create incentives (or to disincentive) the private companies. A green economic growth is pursued not only to mitigate and fight climate change, but also to revitalise the region's economy, which is badly affected by depopulation and unemployment.

Mitigation is of great importance in the transport and energy generation sectors, and in agriculture. Economic revitalisation must be focused on tourism, which seems to be very deteriorated. Adaptation is essential to protect Tulcea from water scarcity and desertification, and to protect biodiversity.

Given that the storyline proposed here is very generic, we also suggest that it might be of interest to break it out to create sector-specific or scope-specific storylines. This can help to analyse specific isolate issues and to compare one with each other and assess which one is better in terms of social, environmental and economic consequences. Examples of specific storylines can be: focusing on mitigation through green energy use and consumption; focusing on infrastructural adaptation to protect the Danube Delta; focusing on adaptation and mitigation regarding water and agricultural resources; or focusing the water-energy-land nexus. It would be also interesting to specifically explore if mitigation related policies could tackle on their own the depopulation and unemployment problems, or, if it is completely necessary to boost the tourism sector (which may be not a very sustainable sector). This could be done by comparing the economic performance through a storyline focusing on mitigation policies and through another one only focusing on economically revitalising tourism.

Table 19. What-if questions for the Tulcea case study

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Biodiversity risk	What if Danube Delta water level would be stable?	Mitigation	Collective action	Public authorities, private companies, NGOs	Biodiversity and natural heritage
Inefficient and expensive energy use	What if energy efficiency was increased by 20 % in Tulcea region?	Mitigation	Collective action	Public authorities, private companies, NGOs	Energy (incl. Energy production and distribution-infrastructures)
Unsustainable energy production	What if renewable energy plants would be increased in Tulcea region by 30%?	Mitigation	Investment, legislation & technological development	Public authorities, private companies, NGOs	Energy (incl. Energy production and distribution-infrastructures)
Inefficient energy use (transport)	What if 50% of cars in Tulcea region were electric cars?	Mitigation	Investment, legislation & technological development	Public authorities, private companies, citizens	Transport (incl. transport infrastructure)
Energy use (transport)	What if the government provided free public transport for everyone in Tulcea region?	Mitigation	Investment, legislation & technological development	Public authorities	Transport (incl. transport infrastructure)
Deforestation by pests (more aggressive in the area caused by climate change)	What if the state increased incentives in sustainable solution research?	Mitigation & Adaptation	Legislation, Investment	Public authorities	Forestry, Biodiversity and natural heritage and agriculture
Illegal fishing and overfishing	What if fish poaching was reduced by 70%?	Mitigation & Adaptation	Legislation	Public authorities	Agriculture, Forestry and Fishing
Lack of investment in sustainable irrigation systems in agriculture	What if sustainable energy was involved in irrigation system development?	Mitigation	Investment	Public authorities, private companies, NGOs, other landowners	Energy (incl. Energy production and distribution-infrastructures) and Agriculture
Unsustainable farming, carbon storage	What if farmers transitioned into regenerative agriculture?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs	Agriculture, Forestry and Fishing

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Depopulation caused by unemployment in the Danube Delta	What if the local government promoted the development of a tourist offer also in the off-peak seasons?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs, other land owners	Tourism; traditional occupations in the Danube Delta
Decreasing water resources	What if the local government promoted more and more installations and use of water storage systems (es. better spread of rainwater storages)?	Mitigation & Adaptation	Regulation	Public authorities	Water and waste (incl. Water treatment and distribution-infrastructures)
Decreasing water resources	What if the local government promoted the mapping and digitalization of water management systems for its better monitoring and use?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs, other land owners	Water and waste (incl. Water treatment and distribution-infrastructures)
Decreasing water resources	What if local governments supported the construction of green infrastructure (particualarly based on nature-based solutions) for water harvesting?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs	Water and waste (incl. Water treatment and distribution-infrastructures)
Heat waves	What if green areas in urban settlements were particularly designed to foster biodiverisity and to protect from heath waves?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs	Cities, urban planning and construction
Carbon print	what if the local government applied incentives for using building with low carbon emmisions materials?	Mitigation	Legislation, Investment	Public authorities, private companies, NGOs	Cities, urban planning and construction

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Desertification	What if local governments sanctioned owners of abandoned/uncultivated lands?	Mitigation	Collective action	Public authorities, private companies, NGOs, other land owners	Agriculture, Forestry and Fishing

6.1.4. What-if questions and preliminary policy-action storylines for Norrbotten

The Table 20 shows the what-if questions list of the Norrbotten case study. The partners came up with a list of 25 what-if questions.

Among the information that can be gathered from the list, the following can be highlighted:

- Nature-based economic activities are given a higher importance, with examples in sectors like forestry, fishing, agriculture, and the local specific sector of reindeer herding.
- The main concerns are related to the lack of public transport system, which seems to be deteriorated, and the lack of fossil free energy.
- Investment and legislation are the actions that appear the most.
- The role of behavioural change and citizenship adopting sustainable lifestyles appears for the first time, since the other case studies did not include it. Climate mobilisation facing large exploitation projects and adoption of sustainable diets are mentioned.

Given the information gathered from the what-if questions, we consider that a local adapted storyline that could be interesting for Norrbotten is one focused on nature-based solutions and natural resources protection.

Natural resources are a very important part of Norrbotten, in different ways. On the one hand, the local government should strongly work for their protection; and, on the other hand, these have a big potential to be used for mitigation and adaptation. In this last sense, it is very important the role of landowners, who can contribute a lot to mitigation and adaptation through innovative forest management practices.

Natural resources are not only considered a priority by the local government, but also by citizens. In this storyline, citizens (who have a strong and direct connection with nature in the region) increase their awareness level and start participating in the fight against climate change in several ways. Examples are people considering new diets and facing exploitation projects, and landowners developing innovative forest management practices.

Nature-based solutions are also carried out by the private sector, mainly in the tourism and energy sectors. The role of the government is very strong in protecting nature.

An alternative storyline could be based on more mainstream, efficiency-based mitigation measures in the energy and transport sectors. It could be very interesting to compare this storyline with a one relying on nature-based solutions.

Table 20. What-if questions for the Norrbotten case study

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Reindeer husbandry land use	What if reindeer husbandry always could be protected when areas av land are selected for wind power?	Adaptation	legislation	Public authorities	Reindeer herding
Reindeer husbandry / biodiversity and land use	What if we could use recycled metals only (no new mines allowed)?	Mitigation	Collective action, legislation, investments & technological development	Public authorities, private companies	Reindeer herding
Biodiversity	What if important areas of forest always could be protected?	Adaptation	Collective action	Public authorities, private companies, NGOs, other land owners	Biodiversity and natural heritage
Energy use	What if energy efficiency was increased by 50 % in Norrbotten?	Mitigation	Collective action	Private companies	Energy (incl. Energy production and distribution-infrastructures)
Energy use (transport)	What if there was renewable fuels or electric airplanes for domestic flights in Sweden?	Mitigation	Investment, legislation & technological development	Private companies	Transport (incl. transport infrastructure)
Energy use (transport)	What if all cars in Norrbotten were electric cars?	Mitigation	Investment	Public authorities, private companies, citizens	Transport (incl. transport infrastructure)
Energy use (transport)	What if the government provided free public transport for everyone in Norrbotten?	Mitigation	Investment	Public authorities	Transport (incl. transport infrastructure)
lack of public transport	What if the Norrbottniabanan was built?	Mitigation	Investment	Public authorities	Transport (incl. transport infrastructure)
lack of fossil free fuels	What if the were more incentives for bio-gas production?	Mitigation	Investment	Public authorities	Agriculture

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
deforestation	What if all state owned forests in Norrbotten were protected from clear cuts?	Mitigation & Adaptation	legislation	Public authorities	Forestry
overfishing	What if more areas of the sea were protected from fishing?	Mitigation & Adaptation	legislation	Public authorities	Fishing
lack of local influence over transition	What if local citizens/organisations/land owners/companies had much more influence over large exploitation projects like mines, wind power, roads etc?	Mitigation	legislation	Public authorities	Reindeer herding
loss of good enough grazing land for reindeer	What if authorites subsidised feed for reindeers if grazing lands were lost due to climate change or climate mitigation (mines, wind power, unsustainable forestry)?	Adaption	Investment	Public authorities	Reindeer herding
lack of fossil free energy	What if there was more sea based wind power?	Mitigation	Investment	Public authorities	Energy (incl. Energy production and distribution-infrastructures)
lack of migration routes for species	What if all hydropower dams had to be adapted so that fish can pass?	Adaption	legislation	Public authorities	Energy (incl. Energy production and distribution-infrastructures)
lack of undisturbed areas for species	What if there were more species management areas, where wildlife is left alone for parts of the year?	Adaption	legislation	Public authorities	Tourism/Leisure /cultural heritage
lack of migration routes for species	What if the were more incentives for increasing the	Adaption	Investment	Public authorities	Biodiversity and natural heritage

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	connectedness of the landscape, so that species could migrate?				
unsustainable farming, carbon storage	What if farmers transitioned into regenerative agriculture?	Mitigation & Adaptation	Collective action	Private companies	Agriculture
lack of fossil free energy	What if forest fertilisation was increased, to increase tree growth for bio fuel och increased carbon capture?	Mitigation	Investment	Land owners	Forestry
the landscapes wetlands and water (and carbon) holding capacities have been decreased due to draining activities	What if draining ditches were removed from forest land and wetlands restored or recreated?	Mitigation & Adaptation	Collective action	Land owners	Forestry
carbon storage, biodiversity	What if planted forest stands were made up of several tree species, not mostly spruce or pine, leading to higher diversity, lessening risks of forest die offs because of pests?	Mitigation & Adaptation	Collective action	Land owners	Forestry
lack of fossil free energy	What if more hydropower was constructed?	Mitigation	Investment	Private companies	Energy (incl. Energy production and distribution-infrastructures)
Biodiversity, carbon storage	What if there were more large grazing animals, enhancing biodiversity on open land and carbon storage in soils?	Mitigation	Collective action	Land owners	Biodiversity and natural heritage, Agriculture
Biodiversity	What if rewilding strategies were followed? (https://rewilding-	Adaption	Collective action	Land owners	Biodiversity and natural heritage

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	sweden.com/swedish-lapland/)				
Unsustainable farming	What if people change diets to more sustainable diets?	Mitigation	Collective action	Citizens	

6.1.5. What-if questions and preliminary policy-action storylines for Murcia

Due to special characteristics and format of the Murcia case study, they developed a different list of what-if questions more focused on facing technical challenges in the NEVERMORE Project context. The list of the 18 what-if questions is presented in Table 21.

Table 21. What-if questions for the Murcia case study

WHAT-IF QUESTIONS
What if 2030 objectives of Covenant of Majors are somehow modified over the Nevermore Case Study 4?
What if SECAP methodology is subject of improvement over the Nevermore Case Study 4?
What if local municipalities failed to engage SECAP preparation under Nevermore Case Study 4?
What if local municipalities under Nevermore Case Study 4 failed to collect energy consumptions data as necessary for the preparation of SECAPs?
What if the conclusions of climate scenarios proposed by Nevermore project are not in line with the orientations emerging from Nevermore Case Study 4?
What if the implementation of Nevermore Case Study 4 is having some conflictual situation with respect to the methodological patterns & tools of the Nevermore project?
What if the participatory process of civil &economic players in each municipality is failed under Nevermore Case Study 4?
What if the results of Nevermore Case Study 4 are not properly communicated to the civil society in the participating municipalities?
What if local NGOs or civil associations are reluctant of the SECAP priorities proposed by local municipalities under Nevermore Case Study 4?
What if the participating municipalities under Nevermore Case Study 4 do not achieve to produce its climate neutrality path 2050?
What if the participating municipalities under Nevermore Case Study 4 do not achieve to implement 2 concrete mitigation-adaptation to climate change measures per municipality?
What if the SECAP procedure is consuming more than 2 years under Nevermore Case Study 4?
What if the results of SECAPs preparation-approval are not marketed as good practice to other municipalities in the Murcia region and overseas?
What if other municipalities in the Murcia region are joining the Nevermore Case Study 4 as observers?
What if the results of the Nevermore Case Study 4 are presented to the annual awards of climate change of the Murcia region?
What if the poor participation of municipalities under Nevermore Case Study 4 is taking the Local Council into risk?
What if experts in the transnational council nominated by Nevermore Case Study 4 eventually fail?

The what-if questions here developed cannot be used for the development of storylines. Nevertheless, these are useful for identifying project related concerns that case study leaders have.

7. Conclusions

We consider this deliverable to be a key document and a roadmap towards modelling at different scales. The literature review in section 2 has served as a starting point for the development of a new approach of scenario modelling at global to national level that is consistent with the WILIAM modelling framework. On one hand, we have improved several scenarios that had already been defined in the previous LOCOMOTION project, extending and enriching them with further literature review. On the other hand, we have ensured that the scenario methodology developed is flexible enough to allow different scenarios to be modelled, which can be interesting in the scope of the NEVERMORE project, which is still at an early phase.

In addition, the literature review (section 2) also allowed us to identify what is the state-of-the-art regarding the downscaling of scenarios, and, by identifying needs and challenges that we specifically have in this project, we developed an adapted bottom-up methodology to explore local-adapted storylines. The obtained local-adapted storylines are preliminary but allow us to understand how different the challenges faced by the different case studies can be, as well as the solutions they propose. This accepts the hypothesis that participatory processes are important to involve specificities and individualities in local scenario development.

We conclude here that both top-down and bottom-up approaches are necessary and combinable in scenario development, and we highlight the importance to moving towards such combined approaches. We also want to point out that a lot of alignment work is necessary during the remainder of the project to meet the challenges that arise in terms of heterogeneity of modelling techniques.

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