



CLIMAS

CLIMATE change citizens engagement
toolbox for dealing with Societal resilience

Deliverable No. 3.4 - Tool for scenario prioritisation based on citizen and expert values

Issue date: 07/2024

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Acknowledgement: We would especially like to thank two Living Labs of Vilnius, Aukštamiestis and Chios, who actively participated in organising the future scenario-building workshops. We would also like to extend our thanks to Dr. Jorre Vannieuwenhuyze for his help and guidance in developing the software architecture and implementing the tool.

Information Table










Project Acronym	CLIMAS
Grant Number	101094021
Deliverable Number	D3.4
Deliverable Title	Tool for scenario prioritisation based on citizen and expert values.
Responsible Partner	VUB
Contractual Date of Delivery	31/07/2024
Actual Date of Delivery	22/07/2024
Type	Report
Dissemination Level	PU - Public

Disclosure Statement

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Version Control Sheet

Version	Date	Main modifications	Organisation
v0.1	01/03/2024	First draft	VUB
v0.2	03/06/2024	Final draft submitted for review	VUB
v0.3	05/06/2024	Internal review by consortium partners	David Laniado Monika Mačiulienė Anna Maria Kotrikla Mohammad Azizur Rahman
v0.4	18/06/2024	Internal quality check and consolidation of feedback	VUB (Havva Ebrahimi Pour, Carina Veeckman)
v1.0	25/06/2024	Final check and revisions by the Project Coordinator	VILNIUS TECH
v1.0	22/07/2024	Final version for submission	VILNIUS TECH

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List of Acronyms

Acronym	Definition
MCDM	Multi-Criteria Decision Making
AHP	Analytic Hierarchy Process
CA	Climate Assembly
LL	Living Lab
D3.1	Deliverable 3.1 -- Methodology for citizen-collaborative future scenario building for a climate-resilient society
SWOT	Strengths, Weaknesses, Opportunities, Threats
VUB	Vrije Universiteit Brussel
ANP	Analytic Network Process
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluations

CLIMAS Project Overview

Climate change is one of the most critical issues to tackle today as it is foreseen to have detrimental social, environmental, and economic impacts in the near future. The last climate change events, such as flooding in Germany and Belgium in both Continental and Atlantic regions, heat waves and lack of water in both Mediterranean and Boreal regions, show that the policymakers, experts, and stakeholders' actions are not enough, and a 360° citizens engagement is urgently needed. Therefore, we must learn from the good experience in citizens' engagement in climate change action and build up citizens' supporting infrastructure for climate adaptation measures to help the 150 European regions and local communities resist. Climate assemblies and Living labs are considered sustainable and reasonable tools to stimulate deliberative democracy in climate policymaking.

The ambition of the CLIMAS project is to support a transformation to climate resilience by offering an innovative problem-oriented climate adoption Toolbox, co-designed together with stakeholders by applying a values-based approach, design thinking methods and citizen science mechanisms. All that will be carried out with a gender and diversity approach. The Toolbox is expected to anticipate possible tensions, points of controversy and dilemmas vis-a-vis the adaptation to resilience. Therefore, the Toolbox aims at enabling empowerment and engagement strategies that produce a society "resilient by design". In addition, CLIMAS will include the empirical component for testing this Toolbox and formulating scientific-based guidelines for policymakers on how to shift Climate Assemblies from technically based deliberations that belong to climate change experts to multi-stakeholder deliberations based on solving the dilemmas from a bottom-up, more societal, and value-based perspective. CLIMAS outcomes will positively influence policy development and awareness-raising processes and offer sustainable strategies to enhance the acceptance of citizens' led decisions by policymakers.

Executive Summary

Deliverable 3.4 of the CLIMAS project presents the developed decision-making tool for prioritising the scenarios generated during the citizen-collaborative future scenario-building workshops. This deliverable is the follow-up of deliverable 3.1 (D3.1), which concentrates on citizen-collaborative methodologies for constructing future scenarios in a climate-resilient society. A comprehensive report on applying the developed future scenario-building methodologies in two living labs is reported in D3.1. To analyse the outcomes of these future workshops and systematically prioritise the generated scenarios based on the collective opinions of different stakeholders, a software implementation of a robust analytical model is provided in task 3.4. Deliverable 3.4 details the implementation of this decision-making tool developed based on a quantitative Multi-Criteria Decision Making (MCDM) model. The tool uses the Analytic Hierarchy Process (AHP) as an MCDM technique to evaluate the scenarios developed during future scenario-building workshops, and it is being used as a supporting tool for selecting and prioritising future scenarios and corresponding criteria established in task 3.1.

Before applying the AHP model for the quantitative evaluation of scenarios, two surveys are designed and distributed to workshop attendees to gather their views on the significance of the scenarios and evaluation criteria. Subsequently, the survey results are utilised in the developed tool to analyse and prioritise the scenarios, incorporating the consolidated preferences of the participants about the most significant scenarios across various evaluation criteria. This deliverable first outlines the preparation of the evaluation surveys and then introduces each step of the AHP-based MCDM technique. Finally, the report explains the quantitative analysis of the scenarios developed in the 2 future scenario-building workshops organised in Vilnius Aukštamiestis and Chios Living Labs.

As the following steps, a customisable web application will be provided to assist this prioritisation process, help citizens participate in the decision-making process, and assess the social support for (future) scenarios subject to policymaking. Partner TVS will support the web application development and integrate the tool in Task 3.7.



1. Introduction

This deliverable presents a scenario-prioritization tool developed in Task 3.4, aiming to provide an analytical framework for evaluating and prioritising the scenarios – generated in future scenario-building workshops (of Task 3.1, lead VUB) – based on the values of citizens and experts. The tool is designed to facilitate citizens in exploring and expressing their attitudes towards various climate resilience scenarios through a simplified and accessible interface. The goal is to support users in creating value-based scenarios, identifying key values, and prioritising different elements by applying a multi-criteria decision-making (MCDM) approach, allowing for analysing uncertainties in prioritisation. The developed techniques described in this deliverable will be thoroughly evaluated, and a customisable web application (in Task 3.7, lead TVS) will be provided to assist this process.

The scenario prioritisation tool is a key part of the complex decision-making process and helps in the "scenario evaluation" and the "recommendation generation" phase, making the setting more realistic and improving decision-making. Higher-ranked scenarios are likely to be in the final proposals and policy recommendations. The scenario-building methodology and the associated workshops for scenario and criteria generation are elaborated in D3.1. The workshop outcomes serve the subsequent analytical steps to capture the multifaceted aspects of scenarios and understand their importance through a structured analysis of the participants' opinions. The next step after future workshops is delivering surveys to the participants, which assess the consensus on the priority of the scenarios. The final step will analyse the survey outcomes using an MCDM tool for scenario prioritisation. The three steps proposed from scenario building to scenario prioritisation are summarised in Figure 1. The first stage (workshop) is performed in task 3.1. In this deliverable, the two forthcoming steps after the workshops will be explained in detail, including the survey structures to collect the participant's opinions on the priority of the scenarios, followed by the developed MCDM tool based on the Analytic Hierarchy Process (AHP) model for scenario prioritisation.



Figure 1. Steps from scenario building to scenario prioritisation.

The tool development of this task is in alignment with the main objectives of Work Package 3 to (a) facilitate the inclusion of diverse societal perspectives in climate policy deliberations and (b) to provide Living Labs (LLs) and Climate Assemblies (CAs) with innovative tools for co-creating and co-designing solutions for climate-resilient society. The deliverable is closely connected with Task 3.1, in which future scenarios generated and reported in D3.1 are evaluated using the tool developed in

Task 3.4. Moreover, this task closely supports the activities in task 3.7, which is to design a web application for this tool. The developed tool will be further tested in CAs and Living Labs (LLs) in Task 4.3 (Testing phase 2), and the final toolbox will be calibrated and adapted to CAs needs in Tasks 4.4 (Toolbox calibration and adaption to CAs) and Task 4.5 (Toolbox evaluation and validation).

This deliverable is structured into several sections: First, we provide background about the concepts and techniques, such as MCDM and AHP, deployed in developing the scenario prioritisation tool. Next, the methodology sections outline the research design, data collection process, and the developed analytical methods. The subsequent section details the tool's deployment in analysing the outcomes of two future workshops organised in task 3.1. Finally, the conclusion summarises the main findings, implications, and potential future research directions.



2. Background

2.1 What is the multi-criteria decision-making

Multi-criteria decision-making (MCDM) is a process that involves considering multiple criteria or factors when evaluating and selecting among different alternatives or options. In real-world decision-making scenarios, decisions are often complex, involving trade-offs among various conflicting objectives or criteria. Therefore, using MCDM to consider the impact of different aspects and criteria provides a more inclusive decision by selecting the optimal alternative based on multiple criteria (Mateo, 2012; Majumder, 2016). MCDM models can provide a valuable alternative to decision-making about optimal strategies and scenario focus.

Decision processes are often based on intuition in “anarchic environments” (McFarland & Gomez, 2013); however, such intuitive decisions typically stem from linear thinking, which examines and evaluates the consequences of decision alternatives altogether rather than using balanced comparisons. Decision-makers must make a balanced, structured assessment of different factors to make firm conclusions. Previous research has shown that structured rather than intuitive methods enhance the quality of decision-making (Covin et al., 2001; Dane et al., 2012; Nygren & White, 2002). Such structured methods may adopt MCDM models, which try to decompose the linear decision process into small, simpler, and manageable steps. This allows better evaluation of the relative impact of various conflicting factors (Canco et al., 2021).

MCDM compares alternatives to estimate their priority value, ultimately identifying the optimal alternative (Mateo, 2012; Majumder, 2016). The method is frequently used to solve complex and ambiguous real-life decision problems that incorporate multiple, conflicting, and incommensurate criteria, such as those encountered in military operations, environmental management, public policy, and healthcare (Temuçin, 2021; Bonissone et al., 2009). It helps decision-makers make informed and systematic choices in situations with multiple conflicting objectives.

Standard methods used in MCDM include **Analytic Hierarchy Process (AHP)** (Saaty, 1980), Analytic Network Process (ANP) (Saaty, 1996), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) (Hwang, C. L., & Yoon, K., 1981), and PROMETHEE (Preference et al. Method for Enrichment Evaluations) (Brans, J. P., & Vincke, P., 1985), among others. The choice of method depends on the specific characteristics of the decision problem and the decision-maker's preferences. We decided to use the AHP model for scenario prioritisation due to the advantages discussed in the following subsection.

2.2 What is the Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), introduced by Saaty (Saaty, 1987), is an MCDM model facilitating a difficult choice between various alternatives, e.g. A, B, C,... This choice is built upon the determination of the importance of the alternatives. The main result of the AHP is the assignment

of importance weights and the ranking of the alternatives from least to most important, e.g. $A > B > C > \dots$. Subsequently, the highest ranked alternative may be chosen as the final decision.

The ranking of the alternatives is based on a set of distinct evaluation criteria a, b, c, \dots . Such ranking, however, may soon become a complex process to perform thoroughly when solely based on intuition. Indeed, the decision-maker is often confronted with an overwhelming number of possible alternatives and evaluation criteria. This may increase the risk of overlooking several aspects and leading to sub-optimal decisions, especially when decisions are made in groups and depend on specific group dynamics. The central idea behind the AHP (and other MCDM models) is to disentangle the complex decision process into simple evaluation steps. To do so, the decision process is depicted as a hierarchical model with the choice alternatives at the bottom level and the evaluation criteria at the levels above (see Figure 2). The final goal of the AHP model is considered the top level of the decision process.

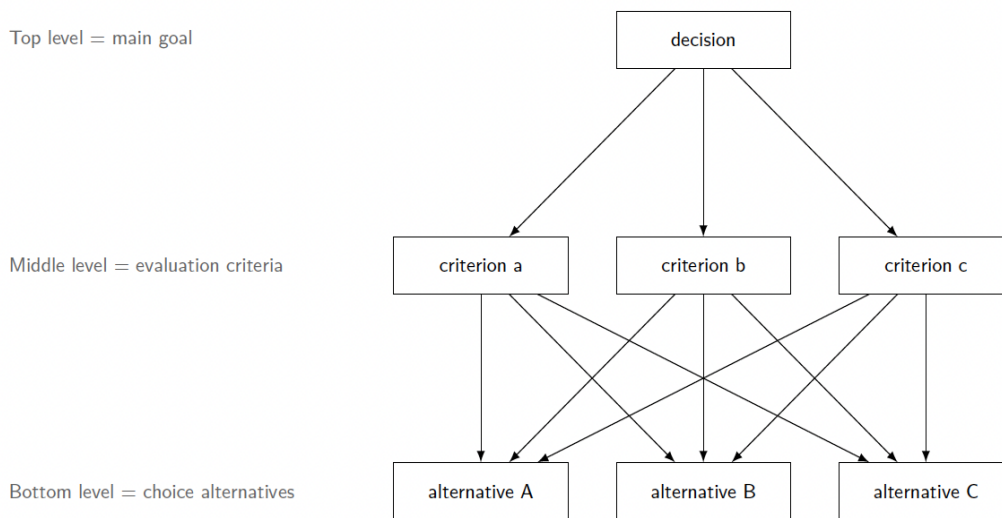


Figure 2. The Analytic Hierarchy Process (AHP) decomposes a decision process in a hierarchy of evaluations.

The AHP now evaluates opposing attributes at different levels (blocks) of the decision process, where attributes refer to the different alternatives (i.e. scenarios) and criteria. To do so, the AHP proposes to compare each possible pair of attributes against each other. These evaluations are subsequently used to assign weights to the different attributes. In the next step, the weights of the single attributes are used to calculate the total weights for the choice alternatives at the bottom of the model. These weights imply the importance ranking of the alternatives and allow the selection of the optimal alternative.

As shown in Figure 2, the bottom level of the decision-making framework consists of a list of alternatives (scenarios) to be evaluated and prioritised. The middle levels of the framework contain the evaluation criteria used to prioritise the alternatives. The experts will rate the importance of each alternative when considering each criterion at the middle level. Additionally, the experts will

rate the importance of the defined evaluation criteria when compared to each other. Finally, the evaluations will be converted to weight vectors that indicate the importance of the alternatives based on the defined criteria.

The AHP has several advantages, making it a suitable model for scenario prioritisation:

- Using the AHP can **save time**. Indeed, by using the AHP, decision-makers do not have to discuss decisions together but can complete the decision-making process independently at their own pace. At the end of the process, the results are merged across all decision-makers. Besides, the decision process is not dominated by certain persons or influenced by typical group dynamics.
- The AHP structures and **simplifies the decision process**. It decomposes the entire process into simple and manageable steps by asking the decision-makers to make simple pairwise comparisons of attributes. This restricts the burden on the decision-makers.
- The primary application of the AHP is **straightforward** and does not require advanced analytic training (Canco et al., 2021). Simple techniques exist to translate the pairwise comparisons by the decision-makers into weight vectors for the choice alternatives. This translation may be done in standard spreadsheet programs for simple models, while online tools exist for more complex models (Goepel, 2013).
- The AHP does not require complex data to evaluate the alternatives across the criteria. Many regular MCDM methods start from **objective evaluation scales** (e.g. cost in a currency, energy saving in kwh, etc.). However, information about the values of the choice alternatives on such scales may be hard to retrieve. Moreover, assigning numerical weights to various evaluation scales is often challenging because such scales are typically expressed in different measurement units. In contrast to traditional MCDM approaches, the AHP merely relies on subjective expert evaluation using a standardised measurement scale, improving all criteria integration.

3. Structuring decision goals for AHP tool development

The first step in developing the AHP is to structure the decision problem. This requires three decisions: (a) Definition of the general goal of the study, (b) Selection of choice alternatives (scenarios) and (c) Selection of the evaluation criteria. These decisions are made as a part of the future scenario-building workshops on climate-resilient society elaborated in D3.1. Here, we briefly summarise the decision outcomes of these future scenario-building workshops, which are used as inputs to the AHP framework.

3.1 Definition of the general goals

The first decision is to determine the general goal of the decision. This determination may involve different exercises like stakeholder mapping or investigating cultural readiness for change. For the application of this project, however, we focus on helping citizens explore their attitudes and values towards different climate-resilient scenarios in a simplified and accessible way. For this aim, we provided a workflow that supports citizens to (1) create value-based scenarios, (2) identify key values, and (3) prioritise different elements (i.e. future scenarios).

3.2 Selection of Choice Alternatives (Future Scenarios)

After determining the focus, the next step of the AHP process is to select different choice alternatives (i.e. scenarios) at the bottom level of the AHP hierarchy. Ideally, this determination occurs using qualitative techniques like expert interviews, focus groups, or workshops. These techniques should provide an answer to the following question:

What are the most critical scenarios that require further investigation?

To determine the scenarios in the CLIMAS project, methodologies for future scenario-building were developed, and two future workshops were organised by inviting various participants and stakeholders in the Living labs of Vilnius Aukštamiestis, Lithuania (08/10/2023) and Chios, Greece (29/11/2023). During these workshops, the participants were asked to think about how they envision the future of their society to be more resilient against climate change. To ensure that the participatory future workshops achieve the desired outcomes, optimal techniques and guidelines have been prepared to guide the process, as reported in D3.1. The outcomes of each workshop consist of a list of scenarios (choice alternatives) and a set of evaluation criteria on which the scenarios will be compared.

In the following, the list of scenarios and their descriptions, developed by participants during the **Vilnius workshop**, is presented:

Scenario 1: Innovation (in communication)

In this scenario, The Ministry of the Environment develops content focused on climate change; other institutions integrate it. The revision of core content is done by scientific institutions. The focus is on developing new/non-traditional tools; the development of a customisation toolkit is being established. Communication innovation also focuses on citizen

engagement by organising Citizens' Assemblies. Citizens cannot act independently; coordinating institutions should organise citizen engagement. Effective communication is essential for security reasons - citizens should get responsive information about dangerous situations connected to climate change (floods, strong winds and so on). Mobile communication should be implemented, and consistent, periodic information should be guaranteed. The role of organisations is essential – students and the Rifle Union can be included in dealing with different climate change-connected situations (shovelling snow, etc.). This is how citizens can adapt more quickly to climate change.

Scenario 2: Local campaigns

In this scenario, local campaigns are focused on communities of citizens. Municipalities act as organisers of community meetings and analyse questions. Identification and demonstration of good examples are applicable. Wide dissemination plays an important role. Green Citizens can be the positioning message of community initiatives. Clear action initiatives are the most important because local campaigns should be implemented, not just discussions and meetings without actual results.

Scenario 3: Climate-friendly Lithuania

This scenario focuses on building a nationwide identity for Lithuania as a climate-neutral country. The Government's Strategic Communication Department shapes the identity of Lithuania and publicises it, implementing UN and EU requirements. The scenario is linked to political decisions on the mandatory creation of green areas in new building complexes and other areas. Also, it is linked to urban infrastructure improvement and citizen activation. All actions are focused on small community initiatives - bottom-up initiatives - the communities themselves initiate ideas. Communities prioritise goals, identify what is essential and allocate available resources (for example, a school buys its bus and solves infrastructure problems). Mandatory greening of areas involves citizens deciding which parts of the area should be greened and which areas should be developed. At the same time, the choice of plantings should also be made according to the needs of society.

Scenario 4: Green Vilnius

Green Vilnius is a specific case in this scenario, a smart city in the climate-neutral sense. A monitoring system is implemented for pollution, sound and climate forecasting through digital systems. Innovative communication tools (such as smart monitors) are used to expose information. Action plans to manage climate phenomena, if they occur (e.g. fires, drought, water bags near trees in Vilnius), are being created. Prevention plays a vital role through communicating directly with citizens and creating action plans and commitments. Special attention is focused on initiatives to stimulate actions from education departments (for example, top-down parallel initiatives to motivate schools to buy their green transport by giving funding). Dissemination of good practices should be guaranteed. Encouraging the renewal of the transport fleet also receives special attention - some measures focus on the middle or upper class (those who can afford electric cars, etc.). Those with old cars should be encouraged to buy newer ones. All social levels should be reached.

A similar workshop was organised in **Chios, Greece**, and the following list of scenarios was developed by participants:

Scenario 1: High level of response to climate change at global and local scale.

A high level of global cooperation among states and measures for curbing GHG emissions are being effectively implemented. As a result, the temperature rise is kept at moderate levels (1,5 – 2,0°C), and the sea level rise is also moderate. Concentrated effort is placed on maintaining the ecosystems intact and protecting water resources. For the pine tree forests, which are common in the Mediterranean ecosystems and are especially vulnerable to forest fires, traditional techniques such as controlled burning and innovative ones such as surveillance with drones and satellites are implemented. Reforestation programs with fire-resistant plants indigenous to the ecosystems are organised (e.g., carob trees in Chios). Forest preservation has multiple benefits, such as carbon sequestration (an important climate change mitigation method), soil preservation, flood prevention, aquifer recharge, and surface and air temperature control



(strengthening climate change adaptation). The management of water resources is also a priority, and actions such as freshwater saving campaigns, maintenance of the leakages in the water supply systems, and reuse of treated wastewater for irrigation and desalination with renewable electricity are employed. The **traditional technique of the “fountanas”** used in the detached houses of Chios to collect and reuse rainwater revives. The sea-level rise is moderate, and drawing from the example of the Netherlands, technical projects are implemented in advance to protect critical infrastructures such as ports and airports, coastal cities, key industries, hotels and beaches, important ecosystems, etc.

Scenario 2: Digitation and artificial intelligence in agriculture.

Technological innovations have been developed to a large extent till 2050. The agricultural lands have been digitised in high-resolution maps. Sensors are used to monitor the soil properties, the atmospheric or weather conditions and the growth of the plants, and the findings are displayed on high-resolution maps. In this way, tailored and informed interventions are made regarding irrigation, the use of fertilisers and pesticides and the protection of the crops from extreme weather events (e.g. the crops could be covered in case of hail). Plant growth is optimised with efficient energy use, irrigation water and chemicals. Thus, the environmental footprint of agriculture is reduced.

Scenario 3: Sustainable tourism in the climate change era.

Climate change in the Mediterranean Sea area results in increased temperatures, increased frequency of extreme weather events (droughts, floods, and fires), coastal erosion or coastal flooding and salinisation of freshwater resources. There are severe adverse effects on tourism, and the Mediterranean Sea area gradually becomes an unattractive destination for the summer. To face the problems that arise, long-term planning is being made to extend the tourist period and prioritise sustainability in the tourism industry. The hotel units embrace technological innovations to decrease their environmental footprint: energy-efficient cooling devices (air conditioners) and washing machines are used. Actions such as installing heat pumps and roof photovoltaics are employed while increasing the visitors' awareness of reducing their personal footprint. There is control over the water used for personal hygiene, and the amount of waste produced using single-use items, such as plastic bottles, is reduced. Moreover, fishing tourism (“blue tourism”, meaning that the visitors can rent a boat to take a tour and watch a demonstration of the fishing methods) is promoted in coastal areas, so the fishermen are given an alternative form of income. In that way, they only fish the quantities the sea can replenish. As a result, tourism becomes a sustainable activity with limited adverse effects on the local and global environment.

Scenario 4: Top-down policies and new technologies.

The focus is on pro-environmental policies developed and enforced from the top (the governments) and the invention of innovative technologies to address the climate crisis. There is no fight against overconsumption; instead, the products have a long lifetime, and there are alternatives to choose from with a low carbon footprint and high potential for reusing and recycling, reducing waste production. In transport, technological solutions such as drones for last-mile delivery and electric and autonomous cars help to keep the carbon footprint low.

Scenario 5. A society on the path of sustainability.

The values and lifestyles of people are aligned with the sustainability principles. This is achieved through education, lifelong training, and environmental campaigns. Consumption is reduced, and recycling and circular economy solutions are promoted. There is a bottom-up social revolutionary movement that informs people and inspires them to change their values and lifestyles towards sustainability. Politicians are forced by the society movement to adopt environmentally friendly legislation tailored to society's needs. In transport, innovative or more traditional solutions are adopted, such as active transport (cycling and walking), micro-mobility, sharing mobility, demand-responsive transportation, autonomous vehicles, and drones, which offer an overall reduction of fossil fuel use and carbon dioxide emissions, resulting in the improvement of environmental conditions.

3.3 Selection of evaluation criteria

Once the scenarios are generated, they should be reviewed, analysed, and prioritised. This requires determining a number of key criteria that are crucial in evaluating the scenarios. These criteria are important for assessing the scenarios in any situation, even if the goals, strategies, or management change. The criteria should match the goals, objectives, and context of the scenario-building exercise. A list of essential criteria for ranking the scenarios will give a clear and objective way to evaluate and compare them, ensuring that the analysis and decision-making process is based on relevant factors and considerations.

The main technique used by the participants during the workshops was **brainstorming** and **group discussions** to define the criteria. The criteria help assess and rank the scenarios according to the scenario-building exercise's objectives, goals, and strategic priorities. The criteria should cover aspects such as feasibility, desirability, alignment with goals, potential impacts, risks, resource requirements, stakeholder acceptance, or any other relevant factors for decision-making. Overall, this phase of the workshop aims to address the following questions:

What critical evaluation criteria can be used to assess and compare the scenarios?

Table 1 summarises the list of **12 evaluation criteria** selected in two future workshops; eight were selected in Vilnius, and nine were chosen in the Chios workshop.

Table 1. List of the evaluation criteria selected in the workshops of Vilnius Aukštamiestis and Chios living labs.

Criteria	Vilnius	Chios
<i>Relevant</i> – reflecting objectives that fit the local context and reflecting the future needs.	✓	
<i>Sustainable</i> – reflecting elements of transformations toward sustainability.	✓	
<i>They are shared</i> , reflecting agreement between key stakeholders and the community.	✓	
<i>Adaptive</i> – reflecting the possibility to adjust to changing situations, resources, systems, infrastructures and other conditions.	✓	✓
<i>Engaging</i> – reflecting the engagement of institutions, local authorities, small communities and citizens.	✓	✓
<i>Inclusive</i> – reflecting on ensuring the benefit of all members, especially vulnerable populations.	✓	✓
<i>Motivational</i> – reflecting the inspiration for change.	✓	✓
<i>Tangible</i> – reflecting clearly described objectives.	✓	✓
<i>Comprehensiveness</i> – scenarios must consider all the relevant factors and projections		✓
<i>Cost/ benefit ratio</i> – The ultimate cost of the future scenario that the society would have to pay (sum of economic, environmental, and social costs) divided (normalised) by its probable/potential benefit.		✓
<i>Environmental effect</i> – Reflecting the environmental effect of a scenario (probably has greater importance compared to the social and economic effects.)		✓

<i>Plausibility</i> – The scenarios that are more reasonable and likely to become future reality must be given priority.		✓
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4. Survey for AHP analysis

Once the focus of the decision process has been determined along a list of scenarios and evaluation criteria, the AHP proceeds by constructing a survey asking respondents for **pairwise evaluations of the different attributes** (i.e. evaluation criteria and scenarios). This questionnaire is subsequently administered to each workshop participant independently.

The questionnaire repeats one standard building block for constructing a so-called comparison matrix, translated to a weight vector in the analyses. This building block is discussed in the first subsection. However, applying this main building block may result in a long and repetitive questionnaire, increasing the burden on experts, even for relatively simple decision models. Therefore, different strategies exist to reduce the questionnaire length, as explained in subsection 4.2.

4.1 Formulation of AHP block

The main building block of an AHP questionnaire consists of all possible pairwise comparisons of attributes stemming from one higher-level attribute in the hierarchical decision model (as shown in Figure 3). In the simplest three-level model, this means that first, all criteria at the middle level are compared to each other since they all stem from the general goal of the decision model at the top level. Subsequently, all choice alternatives (scenarios) at the bottom level are compared for each criterion separately. In total, $n_c + 1$ of such blocks of comparisons need to be administered where n_c denote the number of different criteria in the model.

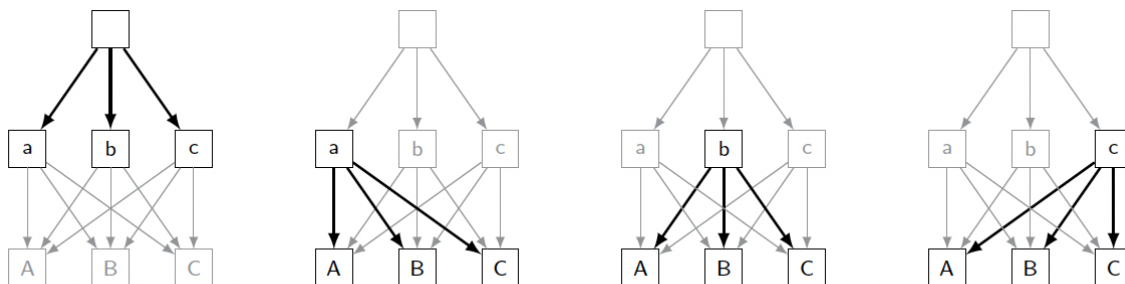


Figure 3. Four evaluation blocks can be distinguished for the simple model in Figure 2..

Following the original AHP, the pairwise comparisons within each block are administered using a 17-point response scale to be completed by the participants (see Figure 4 for comparing criteria and Figure 5 for comparing alternatives within a given criterion). On this response scale, the middle category denotes that both criteria are equally important or that the alternatives perform equally well on a specific criterion. The greater the response category, the more one criterion or the alternative one is preferred relative to the other.

Once a participant has completed all pairwise comparisons within a given block, the scores on the scale are translated to comparison scores a_{ij} for criterion/alternative i versus j (see Figures 4 and

5). A value of $a_{ij} = 1/9$ indicates that the participant considers criterion/alternative i extremely more important than criterion/alternative j , . In contrast,alue $a_{ij} = 9$ means that she or he considers criterion/alternative j extremely more important than criterion/alternative i . A value of $a_{ij} = 1$ indicates equal importance of both criteria/alternatives.

When comparing criterion i to criterion j , how much more or less important do you consider both criteria relative to each other?		a_{ij}
<input type="radio"/> 9 — Criterion i is extremely more important		→ 1/9
<input type="radio"/> 8		→ 1/8
<input type="radio"/> 7 — Criterion i is very much more important		→ 1/7
<input type="radio"/> 6		→ 1/6
<input type="radio"/> 5 — Criterion i is much more important		→ 1/5
<input type="radio"/> 4		→ 1/4
<input type="radio"/> 3 — Criterion i is moderately more important		→ 1/3
<input type="radio"/> 2		→ 1/2
<input type="radio"/> 1 — Criterion i and j are equally important		→ 1
<input type="radio"/> 2		→ 2
<input type="radio"/> 3 — Criterion j is moderately more important		→ 3
<input checked="" type="radio"/> 4		→ 4
<input type="radio"/> 5 — Criterion j is much more important		→ 5
<input type="radio"/> 6		→ 6
<input type="radio"/> 7 — Criterion j is very much more important		→ 7
<input type="radio"/> 8		→ 8
<input type="radio"/> 9 — Criterion j is extremely more important		→ 9

Figure 4. In the AHP model framework, criteria are evaluated against each other using a 17-point response scale. The responses are then mapped to a comparison scale.

When comparing alternative i and alternative j on criteria z , how much better or worse perform both alternatives relative to each other?		a_{ij}
<input type="radio"/> 9 — Alternative i performs extremely better		→ 1/9
<input type="radio"/> 8		→ 1/8
<input type="radio"/> 7 — Alternative i performs very much better		→ 1/7
<input type="radio"/> 6		→ 1/6
<input type="radio"/> 5 — Alternative i performs much better		→ 1/5
<input type="radio"/> 4		→ 1/4
<input type="radio"/> 3 — Alternative i performs moderately better		→ 1/3
<input type="radio"/> 2		→ 1/2
<input type="radio"/> 1 — Alternative i and j perform equally good		→ 1
<input type="radio"/> 2		→ 2
<input type="radio"/> 3 — Alternative j performs moderately better		→ 3
<input checked="" type="radio"/> 4		→ 4
<input type="radio"/> 5 — Alternative j performs much better		→ 5
<input type="radio"/> 6		→ 6
<input type="radio"/> 7 — Alternative j performs very much better		→ 7
<input type="radio"/> 8		→ 8
<input type="radio"/> 9 — Alternative j performs extremely better		→ 9

Figure 5. In the AHP model framework, choice alternatives are evaluated against each other for each criterion using a 17-point response scale. The responses are then mapped to a comparison scale.

All comparison scores are subsequently combined into a $k \times k$ symmetric comparison matrix.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1k} \\ a_{21} & a_{22} & \cdots & a_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ a_{k1} & a_{k2} & \cdots & a_{kk} \end{bmatrix}$$

where $a_{ij} = 1/a_{ji}$, and $a_{ii} = 1$. In the analysis phase, these comparison matrices are translated into a vector of k weights denoting the marginal importance of all criteria, or alternatives given a specific criterion.

4.2 Questionnaire reduction

Note that, within each block, a given set of pairwise comparisons needs to be made. More specifically, if there are k attributes in an evaluation block, $k(k - 1)/2$ comparisons need to be made. The number of pairwise comparisons grows exponentially with the number of attributes, which may result in a very long questionnaire.

Fortunately, solutions are provided to restrict the questionnaire length. Most of these solutions start from the observation that comparison matrix A contains much redundant information. This redundancy arises from the assumption that the relative importance of an attribute i versus another attribute j , as quantified by a_{ij} , can be derived from the comparison scores of both attributes relative to a third attribute (R. W. Saaty, 1987). More specifically, it is assumed that the comparison scores relate to each other as:

$$a_{ij} = a_{kj}/a_{ki} \quad (1)$$

This redundancy is considered valuable within the original AHP because it explicitly allows assessing consistency in the evaluations. Nonetheless, when the AHP is used for group decisions among several participants, inconsistencies can be investigated implicitly by comparing responses across the participants.

In order to lower question redundancy and decrease respondents' burden, Leal (2020) proposes the AHP-express model. This model advises first asking participants about the best or worst scoring alternative. Next, the participants are asked to compare this best or worst alternative with the remaining alternatives. As a result, rather than asking participants to make all $k(k - 1)/2$ possible pairwise comparisons, the AHP-express model reduces the number of questions to k within each block. The k resulting comparisons allow the complete one single row of comparison matrix A , from which the other comparison scores can be derived using equation (1).

A disadvantage of the AHP-express method is its complete lack of redundancy, so inconsistencies within participants cannot be measured anymore. Therefore, we propose adopting an intermediate solution, albeit one that has not yet been reported in the existing literature. Rather than only comparing every attribute to the best-scoring attribute, we propose comparing every attribute to two randomly chosen attributes. For k attributes, this means that $2k$ comparisons need to be made by the participant within each block.

This number of comparisons is still considerably lower than $k(k - 1)/2$ for larger k 's and will thus reduce the questionnaire length substantively compared to the complete assessment of all possible pairs of attributes. Additionally, this strategy allows for investigating inconsistencies because the evaluations include redundancy.

The development of a questionnaire along the proposed strategy of comparing every attribute to two other randomly chosen attributes is implemented in the Qualtrics software. Within each block, a question needs to be included for every attribute, asking to compare this specific attribute with two other randomly chosen attributes. An example of the questionnaire comparing one criterion with two other randomly selected criteria is presented in Figure 6.

Within the columns of this matrix table, the 17-point scale options should be included, starting from 'extremely more important — 9' on the left to 'equally important — 1' in the middle of the scale, and again up to 'extremely less important — 9' on the right-hand side.

Compared to the criterion:

"Relevant: The scenario should address the objectives that fit the local context and reflect future needs."

how much less or more important do you consider the criteria below when evaluating a scenario?

extremely more important	8	very much more important	7	6	much more important	5	4	moderately more important	3	2	equally important	1	2	moderately less important	3	4	much less important	5	6
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Tangible: The scenario should reflect clearly-described objectives.

Shared: The scenario should reflect agreement by key stakeholders and the commur

← →

Figure 6. A survey question comparing a criterion (Relevant) with two other randomly chosen criteria (Tangible and Shared).

The second questionnaire on scenario assessment compares all pairs of scenarios based on each criterion. The two questionnaires on assessing evaluation criteria and scenarios were delivered to the participants of the two workshops, and the outcomes of the surveys were processed in the next step.

5. AHP analysis

Once pairwise comparison scores are retrieved from the participants, the responses must be analysed. This analysis comprises three steps.

- First, the comparison scores and comparison matrices need to be translated to weight vectors for the attributes in each block.
- Second, the responses must be consistently evaluated by exploiting the redundant information in the comparison matrices. If necessary, inconsistent values need to be corrected or weighted down.
- Last, the weight vectors must be combined into a vector with total weights for the choice alternatives.

These total weights combine the information about the given priority weights for the criteria with the given priority weights for the alternatives (scenarios) within each criterion.

5.1 Transformation of the comparison matrix into a weight vector

The first goal of an AHP analysis is to translate the comparison matrix A into a vector of priority weights w_1, \dots, w_k for the k attributes within each block. Within the classical application of the AHP, priority weights are typically calculated for each individual participant separately by calculating the Perron-Frobenius eigenvector on their full individual comparison matrix A (T. L. Saaty, 2003). For incomplete comparison matrices, however, eigenvectors cannot be calculated directly, but stochastic estimation techniques can be used alternatively (Altuzarra et al., 2010; Laininen & Hämäläinen, 2003). Additionally, such stochastic estimation techniques are attractive for group decisions involving a sample of different participants because they immediately provide groupwise average priority weights.

A common approach for estimating group priority weights is to adopt a linear regression model, a modelling technique available in many statistical software packages (Altuzarra et al., 2010). The comparison score $a_{ij}^{(r)}$ of participant r between attributes i and j can be modelled as:

$$a_{ij}^{(r)} = \frac{v_i}{v_j} u_{ij}^{(r)} \quad (2)$$

where v_i and v_j represent overall unnormalised priority weights for attributes i and j respectively, and $u_{ij}^{(r)}$ represents participant r 's judgment or measurement error. This judgment or measurement error refers to the inconsistencies in the evaluations. Estimates of the unnormalised weights v_i can straightforwardly be transformed to normalised weights, which sum to one, by:

$$w_i = \frac{v_i}{\sum_{j=1}^k v_j} \quad (3)$$

In many situations, the error term $u_{ij}^{(r)}$ is found to follow a lognormal distribution (Altuzarra et al., 2010). Taking this all into account, a simple regression model is retrieved by taking the log of both sides in (2):

$$y_{ij}^{(r)} = b_i - b_j + e_{ij}^{(r)}, \quad (4)$$

$$e_{ij}^{(r)} \sim N(0, \sigma^2)$$

where $y_{ij}^{(r)} = \log(a_{ij}^{(r)})$, $b_i = \log(v_i)$, $e_{ij}^{(r)} = \log(u_{ij}^{(r)})$ and $N(\mu, \sigma^2)$ represents the normal distribution with an average μ and variance σ^2 . The regression model in (4) is overspecified and will provide different optimal solutions for a single dataset (Laininen & Hämäläinen, 2003). In order to avoid this over-specification, one of the b parameters need to be fixed to a constant. The most straightforward approach is to set $b_1 = 0$.

Many statistical software packages easily fit the regression model (4) to AHP data using simple linear regression procedures, such as the ‘lm’ function in R.

5.2 Correction of inconsistencies

Since humans may not be consistent in their answers (Saaty, 2003), their responses may either be intangibles (e.g. A is preferred to B twice and B to C three times, but A is preferred to C only two times) or even ordinal intransitive (A is preferred to B and B to C but C is preferred to A). Therefore, several consistency measures have been proposed in the literature that rate the extent of inconsistency in participant evaluations.

When these measures are above a specific cut-off, the answers are considered to be inconsistent. Often, such validation is based on single parameters like the consistency ratio (Canco et al., 2021; Jayant, 2018) or the geometric consistency index (Aguarón & Moreno- Jiménez, 2003). Such measures, however, require data for the full comparison matrix. Moreover, the general strategy using these measures is to ask the participants to revise specific evaluations to increase consistency. Such approaches are burdensome and require much effort from the participants themselves.

A less burdensome approach is weighting inconsistent responses in the analyses rather than asking participants to revise them. Such downweighting can be realised using robust regression analysis (Laininen & Hämäläinen, 2003). Robust regression starts from regular linear regression but iteratively gives smaller weights to data points with significant error terms. In the context of the AHP, such significant error terms refer to inconsistent responses. In order to determine the regression weights g_i for response i , Laininen and Hämäläinen (2003) propose to use the function:

$$g_i = \begin{cases} 1 & \text{if } |z_i| \leq b \\ \exp(-a(|z_i| - b)) & \text{if } |z_i| > b \end{cases} \quad (5)$$

where z_i represents the standardised residual for response i retrieved in a previous run of the regression analysis. The parameters a and b can freely be chosen, but Laininen and Hämäläinen (2003) propose using values $a = 1$ and $b = 2$.

In R, robust regression can be fitted using the ‘rlm’ function from the MASS package.

5.3 Analysis of weight vectors

The final step of the AHP data analysis is multiplying the priority weights of the evaluation criteria with the weights given to the scenarios for each criterion. Let n_{crit} represent the number of criteria and n_{scen} the number of scenarios. Let w_{crit} represent the vector of length n_{crit} with the priority weights of the criteria and let W_{scen} represent the $n_{scen} * n_{crit}$ matrix of the priority weights given to the scenarios for each criterion, where each column refers to the priority weights of one particular criterion. The vector with the total weights for the scenarios can then be retrieved by multiplying w_{crit} and W_{scen} :

$$w_{total} = W_{scen} * w_{crit} \quad (6)$$

The resulting weight vector w_{total} the final priority weights for the scenarios are included, taking into account the importance of the different evaluation criteria. Given the AHP process, these weights can be considered holistic evaluations of the scenarios provided by separate step-wise comparisons of the scenarios along each evaluation criterion and proper weighting of the criteria in the entire analysis process.

5.4 Aggregation

The procedures described above provide analysis strategies for each participant's responses separately. Such separate analyses may provide valuable insights into the participants' heterogeneity of opinions. Simultaneously, they present differences in the interpretation of scenarios and criteria. However, interest may also lie in the aggregated opinions of all participants. Aggregation over human ratings can be achieved in different ways, but the most adopted technique involves the calculation of aggregated comparison matrices. These aggregated comparison matrices can be retrieved by calculating the geometric means of all comparison scores a_{ij} over all participants in each block of the AHP process. The geometric mean is obtained by:

$$M = \left(\prod_i x_i \right)^{\frac{1}{n}} \quad (7)$$

This geometric mean can be calculated on the consistent or fitted comparison scores derived from the regression analysis for each participant.

6. Analysis of the CLIMAS future workshop scenarios using the developed AHP tool

The AHP model is a robust framework that enables a systematic analysis of the outcomes of future scenario-building workshops. This tool has been deployed in real-world applications to facilitate decision-making regarding the scenarios produced in future workshops of the CLIMAS project. As mentioned earlier and detailed in D3.1, two future scenario-building workshops were organised in the two pilot cities of Vilnius and Chios to develop scenarios to envision a climate-resilient society collaboratively. Each workshop came up with a suite of scenarios and evaluation criteria that considered the diverse local and global needs of the region and Europe. The next phase involves analysing the outcomes of these workshops using our developed AHP model. This section reports the analysis of scenarios generated during these two future scenario-building workshops, aiming to identify the most critical co-created scenarios and highlight the points of consensus and disagreement between the workshop participants (i.e. citizens/stakeholders).

Based on the analytical outcomes of the AHP tool, a third workshop was organized among experts to provide recommendations for refining the generated scenarios (as outlined in D 3.1), with the ultimate goal of improving consensus and offering more clarity to support decision-making processes.

6.1 Analysis of the scenarios generated in the Vilnius Aukštamiestis LL workshop

During the future scenario-building workshop in Vilnius, four future scenarios envisioning a climate-resilient society were generated, as detailed in subsection 2.2. The scenarios are titled as follows:

- *Scenario 1: Innovation (in communication)*
- *Scenario 2: Local campaigns*
- *Scenario 3: Climate-friendly Lithuania*
- *Scenario 4: Green Vilnius (climate-neutral smart city)*

In addition, eight evaluation criteria were selected to assess the scenarios presented in Table 1 (including: Sustainable, Shared, Engaging, Motivational, Tangible, Inclusive, Relevant, and Adaptive). Two surveys—one for the evaluation criteria and another for scenario assessment—were distributed among the participants, resulting in a total of 12 responses each. The outcomes of these two surveys were analysed using the AHP tool to obtain the priority weights. On average, participants spent 10 minutes completing the first survey on assessing criteria and 20 minutes on the subsequent survey on prioritising scenarios.

Figure 7 presents the priority weights given to the eight criteria. According to the 12 participants, no single criterion stands out as significantly more important than the others. However, criteria ‘Sustainable’, ‘Shared’, and ‘Engaging’ received marginally higher priority, while ‘Adaptive’ and ‘Relevant’ were ranked lower.

Regarding the consistency of the responses, the priority weights indicate general agreement on the lower importance of certain criteria but a lack of consensus on the most important criteria. As shown in the figure, the priority weights given by participants are more closely aligned for criteria deemed less important, whereas there is greater dispersion in the weights for higher-ranked criteria like ‘Sustainable’ and ‘Shared’.

The lack of consensus between the participants could be due to two sources: either the participants hold differing opinions on the most vital aspects for evaluating a scenario or interpret the different criteria differently. These inconsistencies can be further explored in the subsequent phases of the decision-making process.

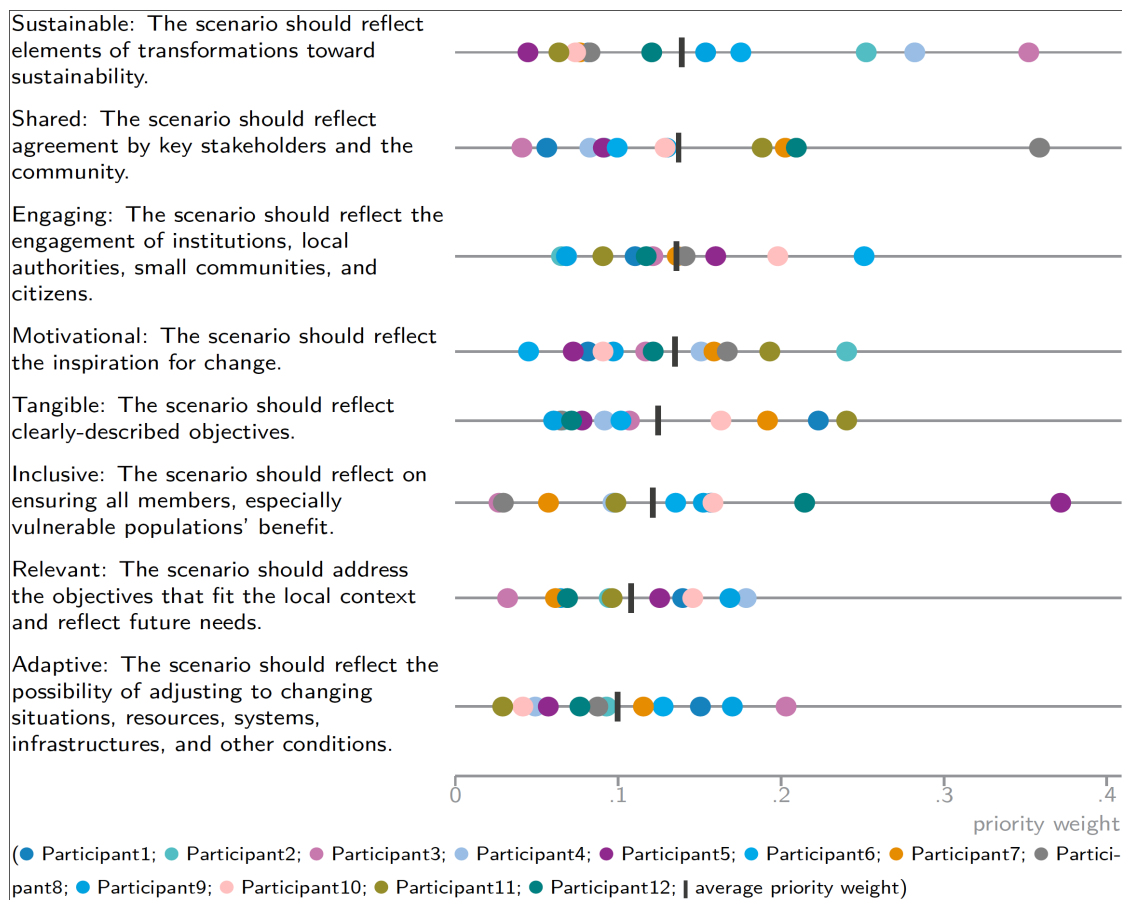


Figure 7. The priority weights are given to the criteria (Vilnius workshop).

Next to analysing the evaluation criteria, the participants were also asked to compare the scenarios against the eight evaluation criteria separately. Figure 8 illustrates the priority weights given to each of the four scenarios, considering each criterion. In general, Scenario 4 is frequently favoured in most evaluations, while Scenario 1 is considered a low-priority scenario compared to others. The priority weights also lack consensus among participants, which may arise from differing perspectives or interpretations of the scenarios. Nonetheless, some degree of consistency was noted for specific criteria that are interesting for further study. For instance, there is a reasonable agreement on the lower significance of Scenario 1 when considering criteria such as ‘Adaptive’, ‘Inclusive’, and ‘Shared’.

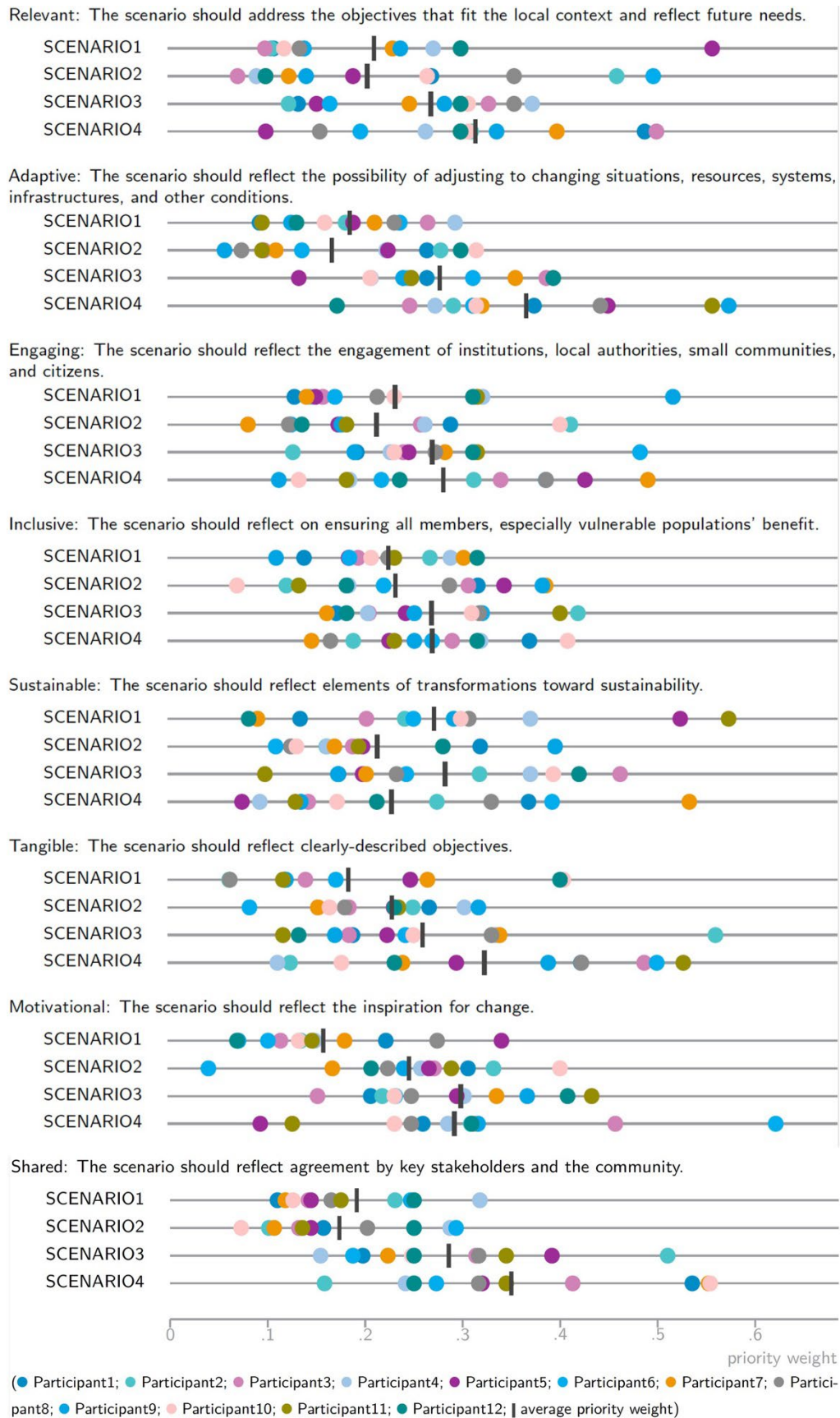


Figure 8. The priority weights are given to the scenarios considering each criterion separately (Vilnius workshop).

In the concluding phase, the priority weights of the evaluation criteria are multiplied by the weights attributed to the scenarios for each respective criterion. Figure 9 depicts the total priority weights for all four scenarios, encompassing all evaluation criteria. The results highlight a pronounced preference for Scenario 4 and Scenario 3, whereas Scenario 1 and Scenario 2 are shown to be of lower significance. It is worth noting that some participants have conflicting opinions that do not conform to the overall trend depicted in the figure. For instance, in contrast to the overall trend, Participants 4 and 5 assigned a lower priority to Scenario 4 and a higher weight to Scenario 1, whereas Participant 1 strongly agreed with the integrated priority trend. These points of disagreement are interesting to further explore in follow-up brainstorming workshops and by considering the recommendations summarised in section 6.

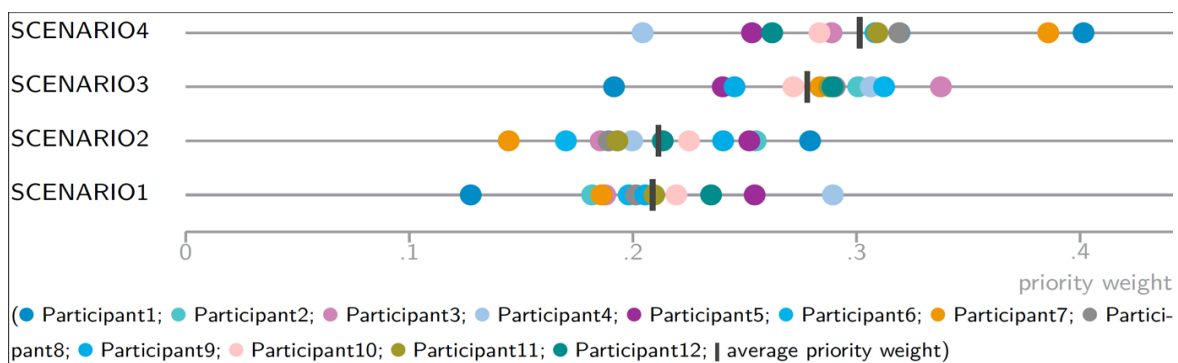


Figure 9. The total priority weights are given to each scenario (Vilnius workshop).

6.2 Analysis of the scenarios generated in the Chios LL workshop

During the future scenario-building workshop in Chios, five scenarios were envisioned, which are described in Section 2.2. The titles of the scenarios are summarised as follows:

- *Scenario 1: High level of response on climate change on global and local scale.*
- *Scenario 2: Digitation and artificial intelligence in agriculture.*
- *Scenario 3: Sustainable tourism in the climate change era.*
- *Scenario 4: Top-down policies and new technologies.*
- *Scenario 5. A society in the path of sustainability.*

In addition, nine evaluation criteria are selected for assessing the scenarios as presented in subsection 2.2 (including Cost-benefit ratio, Plausibility, Engaging, Motivational, Tangible, Inclusive, Comprehensiveness, Adaptive, and Environmental). The two surveys for evaluation criteria and scenario assessment were distributed among the workshop participants, and 12 responses were collected for each survey.

The outcomes of the first survey on evaluation criteria comparison are presented in Figure 10. The participants assigned higher priority weights to the criteria 'Adaptive', 'Comprehensiveness', 'Engaging', and 'Motivational'. The top two criteria, in particular, were ranked with a reasonable degree of agreement regarding their importance. On the other hand, criteria such as 'Plausibility'

and the 'Cost-benefit ratio' were considered less important for evaluating the scenarios. Overall, the weights show good consensus among the participants on the importance of the evaluation criteria in most cases.

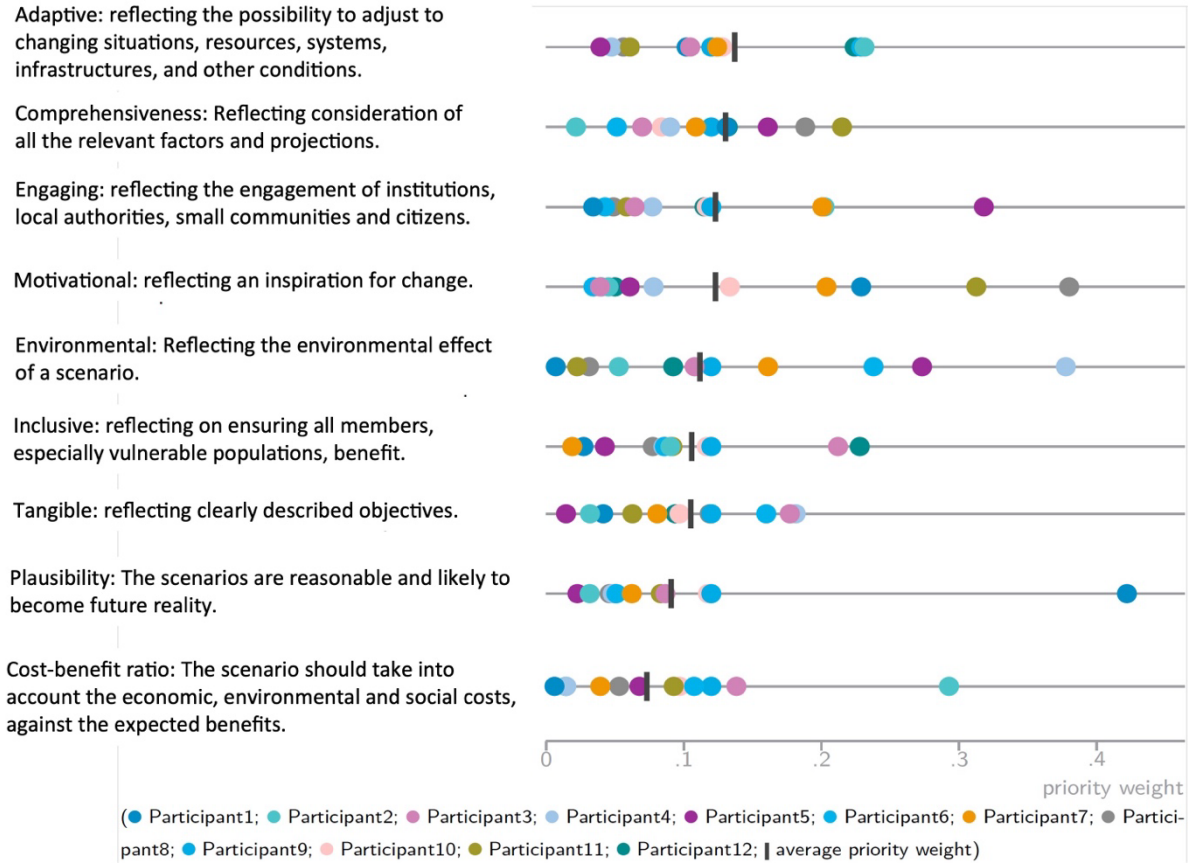


Figure 10. The priority weights are given to the criteria (Chios workshop).

After the first survey, the participants were asked to complete a second survey on scenario prioritisation, considering each evaluation criterion independently. The priority weights analysed from the second survey are presented in Figure 11. The results show some inconsistencies among the participants regarding the most critical scenarios across the different criteria. These inconsistencies may stem from natural variations in opinions or from differing interpretations of the scenarios. In either case, further brainstorming and discussions could refine the outcomes and clarify the sources of these inconsistencies.

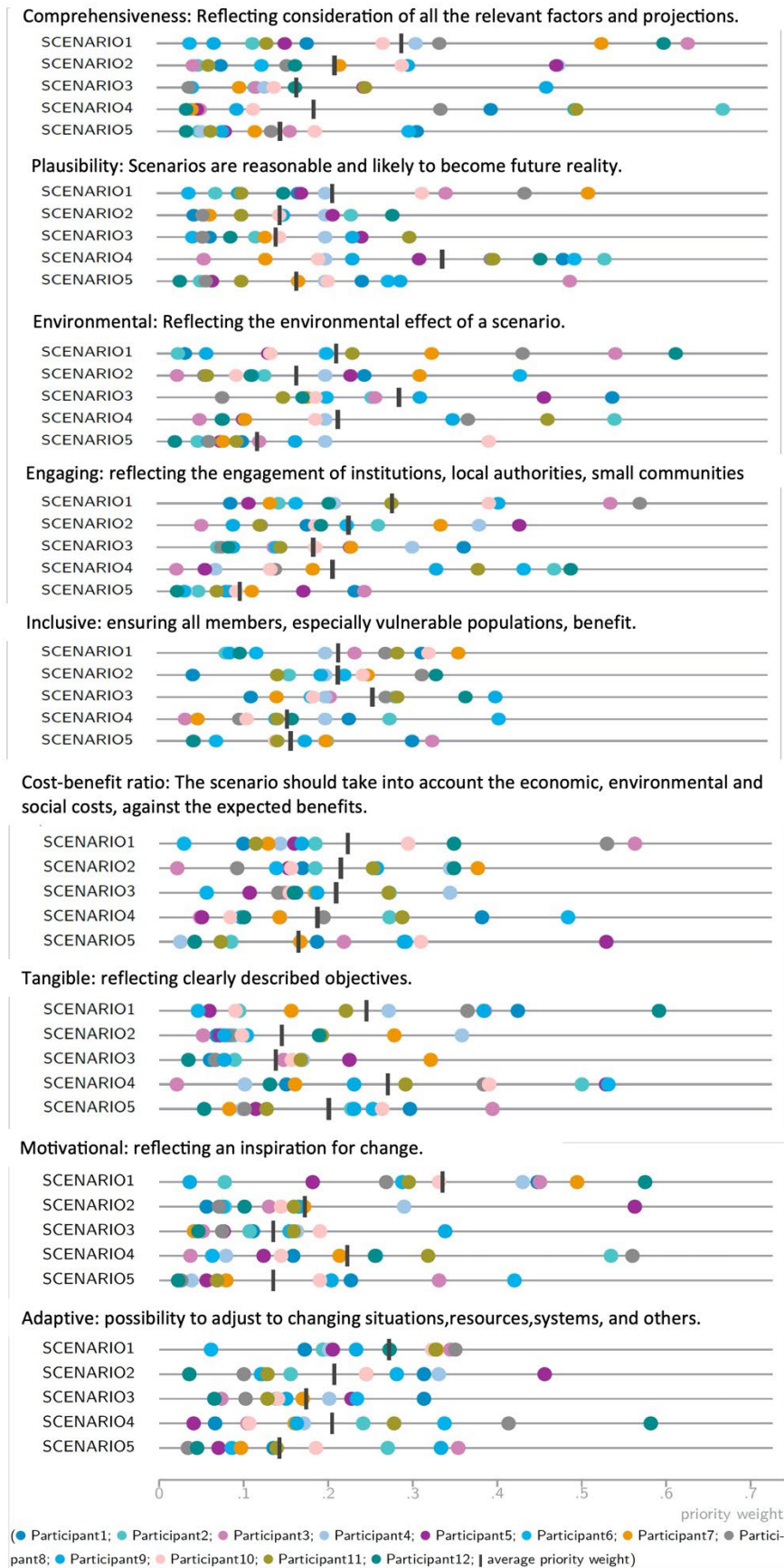


Figure 11. The priority weights are given to the scenarios considering each criterion separately (Chios workshop).

The overall priority analysis across all criteria is presented in Figure 12. The findings indicate that Scenario 1 is the most favoured, with Scenario 4 closely following in second place. Scenario 5 is the least prioritised scenario based on the overall weights. The priority weights have uncovered variances in the participants’ preferences for the scenarios. These differences again could arise from the varied perspectives and backgrounds of the stakeholders or distinct interpretations of the scenarios’ objectives. Some participants align closely with the general trend, while others hold contrasting views. For instance, Participant 3 strongly supports Scenario 1 and Scenario 5 (despite being deemed the least important). Conversely, Participant 5 gives the lowest priority to Scenario 1, preferring Scenarios 2 and 3 instead. Despite these disagreements, the weights reasonably indicate the scenarios’ priority from highest to lowest.

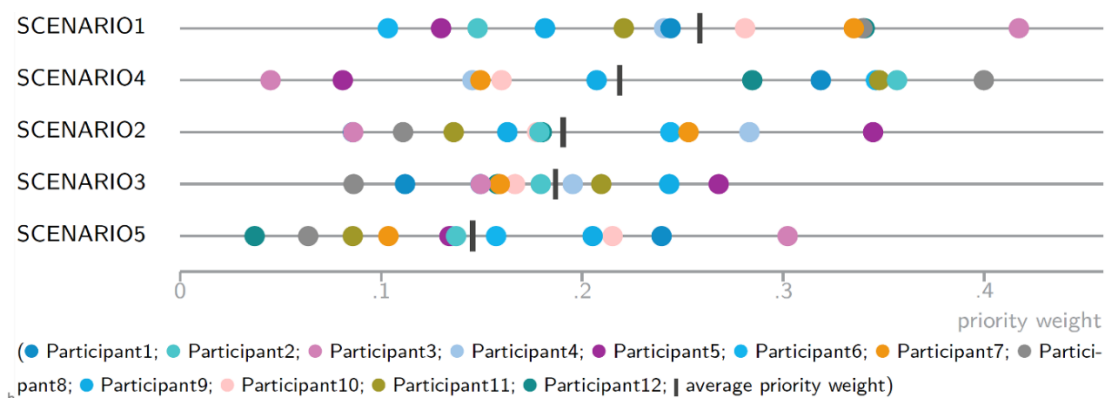


Figure 12. The total priority weights are given to each scenario (Vilnius workshop).

7. Conclusions and Future Steps

The AHP (Analytic Hierarchy Process) model, as an MCDA tool, offers a powerful mechanism to capture the complexity of real-world problems and the nuances of stakeholder preferences. In the context of future scenario-building workshops, AHP allows for a systematic comparison of different scenarios, considering a range of criteria that reflect the diverse values and objectives of the stakeholders. The outcomes reveal the reasoning behind each preference, making identifying where consensus or divergence exists easier.

While the AHP tool provides a procedure to prioritise scenarios, inconsistencies in participants' opinions have been observed because the method relies heavily on the participants' judgments, which can be subjective and vary significantly among individuals. These discrepancies could arise from differing viewpoints, stakeholder interests and sociodemographic backgrounds or varying interpretations of the evaluation criteria and scenarios by different citizens/stakeholders. Therefore, it is crucial to ensure that all participants have a clear and shared understanding of the criteria and the scenarios being evaluated, and it is recommended to take complementary steps to identify the sources of inconsistencies and enhance consensus among participants. The inconsistency can also arise from the limited number of participants, which can be improved by involving a more significant number of participants.

Improving consistency and refining decisions in scenario-building workshops can be challenging. However, several strategies can be employed:

Shared Understanding and Alignment:

Ensuring that all workshop participants share a common understanding of the workshop's purpose, the co-created scenarios, and the evaluation criteria is crucial. To achieve this, a skilled facilitator with experience in future scenario-building workshops plays a vital role. The facilitator guides discussions effectively, manages time, and ensures that every participant's voice is heard.

It is also essential to ensure diverse viewpoints are covered by inviting participants from different backgrounds, roles, and expertise levels. Participants should feel comfortable expressing their views and confident that their input is valued. This can be facilitated by establishing clear rules for engagement and providing opportunities for all voices to be heard. When there are disagreements, they should be addressed through discussion, focusing on the underlying interests and concerns rather than positions. These steps facilitate the active contribution of all participants in generating scenarios and help to foster a shared understanding. To enhance understanding, pre-workshop education sessions can explain the purpose of scenario building, the message conveyed by each scenario, and the rationale behind selecting specific evaluation criteria. Visual aids such as graphs and charts can also clarify complex information.

Stakeholders' brainstorming for scenario clarification and refinement

While careful consideration is needed during the workshop to maintain a common understanding, it is not always possible to ensure that all participants have the same interpretations of the scenarios, especially in complex scenarios. Thus, further refinements will help to have more precise



scenarios with more transparent and understandable goals. Therefore, outcomes of the scenario prioritisation tool can be used for a consistency check to understand the sources of disagreement and then employ an iterative approach to refine scenarios. In the following steps, the inconsistency can be presented in a brainstorming workshop by inviting the participants who contributed to generating the scenarios. The survey and AHP analysis can then be repeated to refine the scenarios iteratively. The iterative nature of this process allows for the gradual refinement of scenarios, making them more precise and understandable. Utilising the AHP tool highlights areas of disagreement and aids in achieving consistency through iterative refinement.

Expert workshops for scenario refinement

Expert workshops offer another avenue for refining scenarios, leveraging the knowledge and experience of specialists in the field. Scenario refinement using strategic planning techniques such as the SWOT matrix (Hill, T., & Westbrook, R., 1997) provides a structured approach to evaluate each scenario, identifying potential strengths, weaknesses, opportunities, and threats related to each scenario. This comprehensive analysis ensures that each scenario is straightforward and considers a wide range of factors. Expert recommendations are then provided on each scenario and to the living labs that organised the previous scenario-building workshops. The recommendations can be later shared with the workshop participants to improve the generated scenarios and increase consensus among them. This process can also be iterative by repeating the surveys and AHP analysis after the expert recommendations and refinement.

The expert workshop methodology was implemented in the context of the CLIMAS project to refine scenarios obtained from two workshops held in Vilnius Aukštamiestis and Chios LLs. To this end, using the SWOT technique, VUB organised a third expert workshop to understand the benefits, disadvantages, and points of uncertainty for each scenario. This workshop took place after analysing the outcomes of the two future scenario workshops, where points of disagreement and consensus on different scenarios were identified. As a result, expert recommendations were provided for each scenario and shared with the two living labs as organisers of the scenario-building workshops. These recommendations can later be disseminated among the workshop participants to improve the generated scenarios and enhance consensus. The outcomes of the scenario refinement workshop are reflected in D3.1.

The goal of the AHP model as a scenario prioritisation tool in scenario-building workshops is to arrive at a decision that reflects a balanced consideration of all relevant factors and the collective opinions of different stakeholders. Combining the power of this analytical tool in an iterative scenario refinement makes it possible to enhance the consistency of the results and refine the decisions made. This leads to more robust and sustainable outcomes that are better aligned with the collective vision and ambitions of the community. Through such a comprehensive and participatory process, AHP not only aids in decision-making but also contributes to building a shared commitment to the chosen path forward. The iterative process provides an opportunity for continuous learning and adaptation, which is necessary in the face of future uncertainties. Using this dynamic approach, organisations can effectively navigate the complexities of the future, making informed decisions resilient to change and uncertainty. The iterative scenario development and refinement process is



a methodological approach and a strategic tool that empowers organisations to create a shared vision for the future and a roadmap to achieve it.

Under the scope of CLIMAS activities, an open-access web-based MCDA tool will also be developed. The tool will allow end-users to implement the prioritisation techniques elaborated in D3.4 using an online platform. TVS has been handed over the scenario prioritisation methodology, and it has started to develop the tool.



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9. Annexes

9.1 Annex A. Example of the Criteria Evaluation Survey

Page 1




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CLIMAS

CLIMAtE change citizens engagement toolbox for dealing with societal resilience

Survey 1: Criteria Evaluation





Page 2



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Please enter your email address:

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Page3



Instructions

Future scenario-building workshop participants were asked to define the evaluation criteria for the defined scenarios. As a result of the workshop, the following criteria were expressed by participants:

Relevant: *The scenario should address the objectives that fit the local context and reflect future needs.*

Adaptive: *The scenario should reflect the possibility of adjusting to changing situations, resources, systems, infrastructures, and other conditions.*

Engaging: *The scenario should reflect the engagement of institutions, local authorities, small communities, and citizens.*

Inclusive: *The scenario should reflect on ensuring all members, especially vulnerable populations' benefit.*

Sustainable: *The scenario should reflect elements of transformations toward sustainability.*

Tangible: *The scenario should reflect clearly-described objectives.*

Motivational: *The scenario should reflect the inspiration for change.*

Shared: *The scenario should reflect agreement by key stakeholders and the community.*

Now, Participants are asked to use a 17-point response scale to determine the pairwise comparison between the given criteria. The 17-point scale is ranging from 'extremely more important — 9' on the left, to 'equally important — 1' in the middle of the scale, and again up to 'extremely less important— 9' on the right-hand side. Generally, the more extreme a response category, the more one criterion is important compared to the other. Even-value scores (2,4,6,8) can also be selected as intermediate levels between the following defined levels.



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Please enter your email address:

Please provide your affiliation:



Page 3



Instructions

Future scenario-building workshop participants were asked to envision and generate possible scenarios that can adapt to climate change. It is crucial for stimulating innovation, facilitating dialogue, and building a shared future vision. As a result of the workshop, the following scenarios were generated by participants during the workshop.

You are now asked to do a pairwise comparison of scenarios considering the given criteria based on a 17-point rating scale ranging from an extreme vote of 9 on the left in favor of one scenario, to 'equally good — 1' in the middle of the scale, and again up to an extreme vote of 9 on the right-hand side in favor of the comparing scenario. Even-value scores (2,4,6,8) can also be selected as intermediate levels between the following defined levels.

score 9 : Scenario *i* addresses the criterion extremely better than Scenario *j*

score 7 : Scenario *i* addresses the criterion very much better than Scenario *j*

score 5 : Scenario *i* addresses the criterion much better than Scenario *j*

score 3 : Scenario *i* addresses the criterion moderately better than Scenario *j*

score 1 : Scenario *i* and Scenario *j* address the criterion equally good

score 3 : Scenario *j* addresses the criterion moderately better than Scenario *i*

score 5 : Scenario *j* addresses the criterion much better than Scenario *i*

score 7 : Scenario *j* addresses the criterion very much better than Scenario *i*

score 9 : Scenario *j* addresses the criterion extremely better than Scenario *i*

Page 4



CRIT1

When comparing Scenario *i* (left) vs. Scenario *j* (on right) based on the criterion:

"Relevant: *The scenario should address the objectives that fit the local context and reflect future needs.*",

how much better or worse two scenarios can address the criterion compared to each other?

9 - <i>i</i> address extremely better than <i>j</i>	8	7 - <i>i</i> address very much better than <i>j</i>	6	5 - <i>i</i> address much better than <i>j</i>	4	3 - <i>i</i> address moderately better than <i>j</i>	2	1 - <i>i</i> and <i>j</i> address equally good	2	3 - <i>j</i> address moderately better than <i>i</i>	4	5 - <i>j</i> address much better than <i>i</i>	6	ac , n b tl
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Scenario 1: Innovation (in communication) vs. Scenario 2: Local campaigns

Scenario 1: Innovation (in communication) vs. Scenario 3: Climate-friendly Lithuania

Scenario 1: Innovation (in communication) vs. Scenario 4: Green Vilnius

Scenario 2: Local campaigns vs. Scenario 3: Climate-friendly Lithuania

Scenario 2: Local campaigns vs. Scenario 4: Green Vilnius

Scenario 3: Climate-friendly Lithuania vs. Scenario 4: Green Vilnius



The survey will continue with pair-wise comparisons of all scenarios considering each criterion.