I-CISK

HUMAN CENTRED CLIMATE SERVICES

Deliverable D1.3

A critical reflection on the co-creation process for the next generation of climate services: the I-CISK experience with the living labs and multi-actor platforms

August 2025

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I-CISK

Innovating CS through Integrating Scientific and local Knowledge

Deliverable Title:	A critical reflection on the co-creation process for the next generation of CS: the I-CISK experience with the living labs and multi-actor platforms
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Executive Summary

This report presents a critical reflection on the work carried out under work package 1 of I-CISK, which aims to provide a collaborative learning and innovative environment to facilitate co-creation and demonstration of next generation of Climate Services (CS) tailored to the users' needs for improved decision-making at a different spatial and temporal scales across a variety of geographical, climatic and sectoral conditions in the selected EU regions and beyond. The analysis and discussion are mainly focused on tasks undertaken within the work package relating to the establishing, functioning and sustainability of I-CISK the living labs (LLs) and their associated Multi-Actor Platform (MAPs). The key achievements, challenges and lessons are discussed in detail, mainly underpinned by the co-creation experience with the seven LLs and MAPs established in Netherlands, Spain, Italy, Hungary, Greece, Georgia and Lesotho that provided significant contributions to achieve project objectives and impacts alongside of generating valuable lessons and recommendations to guide future work on co-creation of user centred CS together with MAPs.

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Glossary

Acronym	Definition
API	Application Programming Interface
C3S	Copernicus Climate Change Service
CDS	Climate Data Store
CEMS	Copernicus Emergency Management Services
CMIP	World Climate Research Programme's Coupled Model Intercomparison Project
CORDEX	Coordinated Regional Climate Downscaling Experiment
CS	Climate Services
CSIS	Climate Services Information Systems
DRR	Disaster Risk Reduction
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GUI	Graphical User Interface
IPCC	Intergovernmental Panel on Climate Change
LL	Climate Services Living Labs
NHMS	National Hydro-meteorological Service
MOOC	Massive Open Online Course
OGC	Open Geospatial Consortium
S2S	Sub-seasonal to Seasonal
TRL	Technology Readiness Level
UNCCD	United Nations Convention to Combat Desertification
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Programme
WFD	Water Framework Directive
WMO	World Meteorological Organization

1 Introduction

Climate and water related hazards such as floods, droughts and heatwaves are growing globally and in Europe. These hazards coupled with other non-climatic factors such as social, economic and ecological vulnerabilities put societies, economies and ecosystems at risk. Climate change is expected to increase these risks (IPCC, 2021 and 2022, EEA, 2024). Therefore, addressing climate and water related risks is a major challenge in Europe and globally. Provision and use of climate services[1] (CS) is widely recommended to address these challenges (Hewitt et al., 2012 and 2020; UNDRR 2015; EEA, 2024). Over the last few decades, several CS have been developed to guide the transition towards climate smart and resilient societies and economies. For example, the EU Copernicus[2] programme provides several CS that help in monitoring, predicting and projecting climate extremes at sub-seasonal to seasonal and decadal time scales, with services provided catering to sector specific needs such as for agriculture and energy. Despite progress on CS generation, their use in policy and decision making is still limited owing to various factors such as lack of involvement of the end users in development and unavailability of or lack of access to sector specific information at the spatial and temporal scales relevant to user needs (I-CISK, 2021).

The European Commission funded I-CISK[3] (Innovating CS through Integrating Scientific and Local Knowledge) project aims to bridge some of these gaps by innovating how CS are developed, through co-creating these with and involving all actors of the climate service value chain including users (I-CISK, 2021). The CS value chain depicts the movement and transformation of climate-related data and information from one actor to another into a tailored and context specific CS (Hewitt and Stone, 2021; Dasgupta et al., 2025) (Figure 1). Co-creation approaches are widely recommended to involve users in the development of CS that are salient, legitimate, and credible (Bojovic et al., 2021; Chiputwa et al., 2020; I-CISK MS10, 2021; Boon et al., 2025; Wens et al., 2025). These approaches have gained popularity among practitioners to effectively bridge the current usability gap in CS. Thus, co-creation is central to the work carried out under I-CISK. A co-creation framework has been developed under I-CISK to guide the development of user centred CS (I-CISK MS10, 2022). The framework is composed of a number of phases, from building continuous engagement, to co-delivering pre-operational CS innovation systems (Figure 2). In the I-CISK project, this framework was applied in a flexible, iterative, and context sensitive manner involving various actors across the CS value chain (Wens et al., 2025). The I-CISK work on innovating user centred CS is embedded in seven living labs[4] (LLs), representing diverse geographical

[1] In this report, climate services are understood as described by European Commission (2015): "the transformation of climate-related data — together with other relevant information into customised products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use for the society at large. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management."

[2] https://www.copernicus.eu/en

[3] https://icisk.eu/

[4] Living Labs are defined as "places for innovation - multidisciplinary ecosystems in which the I-CISK co-creation process will take place. They are an experimental setting and a safe space for stakeholder involvement (Fuglsang et al., 2019); real-life environments in which multiple heterogeneous stakeholders are connected through public-private-people partnerships and in which innovation-development activities can be conducted (Hossain et al., 2019)" (I-CISK MS10, 2022). These definitions are quite generic and are applicable to the living labs with focus on water and climate, and also captures the key elements included in the Water Europe's definition of water oriented living labs (WoLLs) " WoLLs are real-life, water oriented and demo-type and platform-type environments with a cross-sector nexus approach, which have the involvement and commitment of multi-stakeholders (including water authorities) and a certain continuity (good chance to continue to their existence), and provide a "field lab" to develop, test, and validate a combination of solutions as defined in the SIRA, which include technologies, their integration as well as combination with new business models and innovative policies based on the value of water." (Water Europe, 2019).

and climate change hotspots regions (semi-arid, deltas and snowpack dependent river basins) in Europe (Netherlands, Spain, Italy, Hungary, Greece, Georgia) and Africa (Lesotho). In these diverse LLs, seven Multi-Actor Platforms (MAPs) were successfully established and made operational during the first year of the project (Masih et al., 2022). These platforms bring together key actors from science to practice working alongside of the project partners in the co-creation process. I-CISK followed Responsible Research and Innovation (RRI) principles[5] (Stahl et al., 2017; Thapa et al., 2019) and Multi Actor Approach (MAA) (EIP-AGRI, 2017[6]; Fieldsend et al., 2021) in stakeholder identification and engagement processes. The RRI approach recommends the inclusion of multiple actors representing policy makers, research community, education community, business and industry, and civil society organizations in the research and innovation process. While the MAA aims to bring the right people together from science, practice, or anyone who can help achieve the project objectives. The approach aims to integrate transdisciplinary knowledge and experience to analyse issues and find solutions to address real problems. The I-CISK MAPs, established following the RRI and MAA approaches, were expected to be the main drivers of the co-creation process from the LLs perspective. Their role was also foreseen in defining the core climate risks and CS needs to be focused on in case of each LLs besides contributing to the co-creation of CS to address the identified issues and needs.

The main objective of this report is to critically reflect on the contribution of the I-CISK LLs and MAPs in co-creating user centred CS to serve the needs of users within each of these labs. The report focuses on the establishing, functioning and sustainability of the MAPs. First, the establishment and key characteristics of the I-CISK LLs and MAPs are presented. Second, the contribution and functioning of the MAPs in co-creating the user centred CS and achieving I-CISK objectives and impacts are thoroughly discussed. Then, a critical discussion is presented on some of the key principles contributing to a successful co-creation process. Finally, the key lessons and conclusions are drawn from the I-CISK experience on the establishment, functionality and sustainability of the MAPs.

[5] RRI Tools, 2023 - https://rri-tools.eu/
[6] EIP-AGRI - https://ec.europa.eu/eip/agriculture/en;

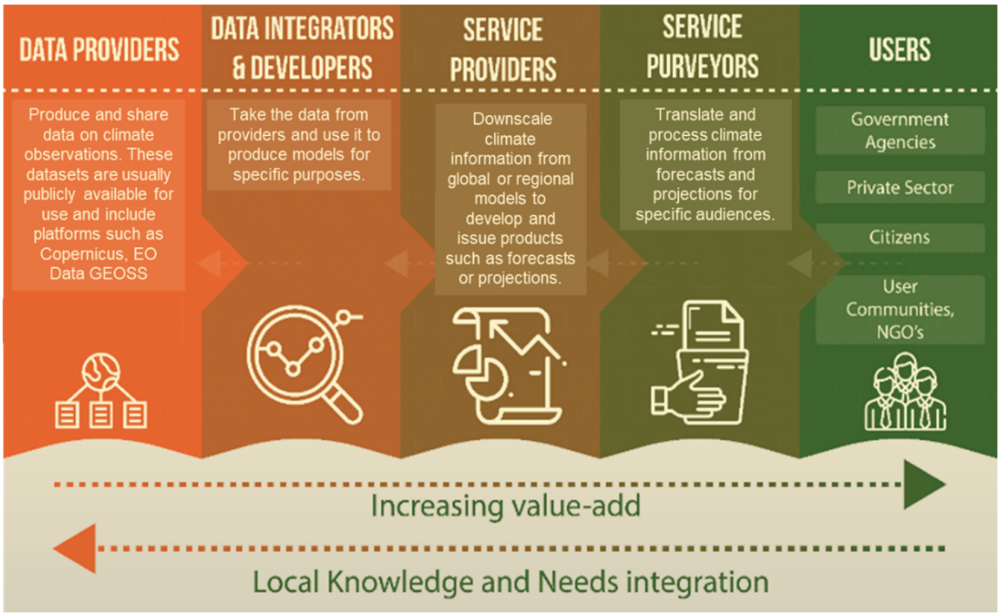


Figure 1. A schematic representation of key actors in the climate service value chain.

(Source: adapted by Nyamakura et al., 2025, from Dasgupta et al., 2025)

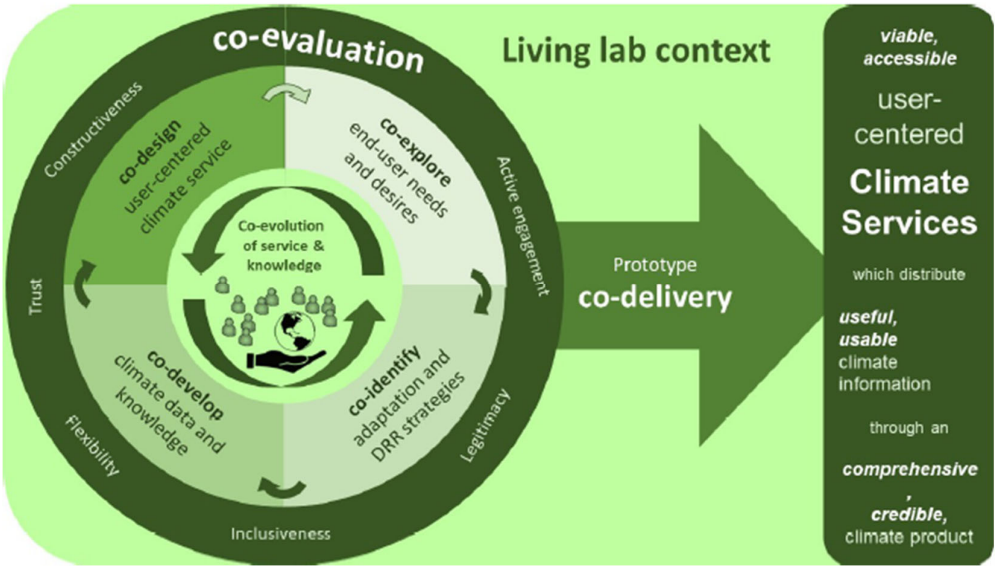


Figure 2: The protype I-CISK co-creation framework. (Source: I-CISK MS10, 2022)

2 Task objectives and context within I-CISK

The main objective of the I-CISK project is to develop next-generation CS that follow a social and behaviourally informed approach for co-producing CS that meet the climate information needs of citizens, decision makers and stakeholders at the spatial and temporal scale relevant to them (Box 1). One of the six specific objectives of I-CISK (objective # 4, see Box 1 and https://icisk.eu/about-icisk/) is to work with citizens, decision makers and stakeholders to demonstrate the value-proposition of human-centred CS through pre-operational CS information systems that have been co-produced to meet end-user needs in LLs established in climate change hotspots in Europe and beyond, and that address the multiple sectors sensitive to climate change and extreme events. This objective is mainly linked to the work carried out under work package 1 (WP1). WP1 aims to provide a collaborative learning and innovative environment through LLs to facilitate co-creation and demonstration of next generation CS tailored to the users' needs for improved decision-making at different spatial and temporal scales across a variety of geographical, climatic and sectoral conditions in the selected EU regions and beyond. The work in WP1 was organised under three tasks: establishing and operationalizing the LLs and associated MAPs (Task 1.1); contributing to the co-creation process (Task 1.2); and monitoring and evaluating impacts (Task 1.3). The work carried out under WP1, including the contribution of the MAPs is pivotal to achieve overall objectives of the I-CISK project, as well as the specific objectives and tasks associated with WP1 and the many other objectives of various I-CISK WPs. This central role of WP1 is schematised in the PERT chart (Figure 3). This report reflects on the role of the LLs and their associated MAPs (WP1 tasks 1.1 and 1.2) in the work carried out under WP1 and other WPs to achieve the objectives and impacts I-CISK, particularly those related to working with and empowering of citizens, decision makers and stakeholders.

Main objective: The main objective of the I-CISK project is to develop next-generation CS that follow a social and behaviourally informed approach for co-producing CS that meet the climate information needs of citizens, decision makers and stakeholders at the spatial and temporal scale relevant to them. Six specific objectives have been formulated:

Objective #1: To develop a framework for co-producing next-generation, human-centred climate services by co-exploring user needs, incorporating social and behavioural factors and integrating local knowledge with scientific data, tailoring climate information based on the adaptation options.

Objective #2: To advance the scientific and technological frontiers of integrating and visualising scientific data from Copernicus and GEOSS, local data sources, citizen science and local knowledge; providing actionable information at a spatial and temporal scale pertinent to user needs, seamlessly bridging from sub-seasonal to seasonal, to decadal and to end-century future time horizons.

Objective #3: To foster the access and use of climate information through insight into the feedbacks, causal mechanisms and cross-sectoral influences between climate change and adaptation actions across timescales and hazard types.

Objective #4: To work with citizens, decision makers and stakeholders to demonstrate the value-proposition of human-centred climate services through pre-operational climate services information systems that have been co-produced to meet end-user needs in living labs established in climate change hotspots in Europe and beyond, and that address the multiple sectors sensitive to climate change and extreme events.

Objective #5: To upscale the use of climate information in risk management and planning across sectors and through provision of tools and capacities for next-generation climate services to catalyse the public and private entities in the European services sector.

Objective #6: To multiply the stories from the demonstrator climate services beyond the living labs to citizens, sectoral organisations, public authorities, climate service providers, and European and international policy, to consolidate the position of climate information in supporting climate adaptation solutions and increasing resilience to climatic extremes.

Box 1. Main and specific objectives of the I-CISK project. (Source: I-CISK, 2021).

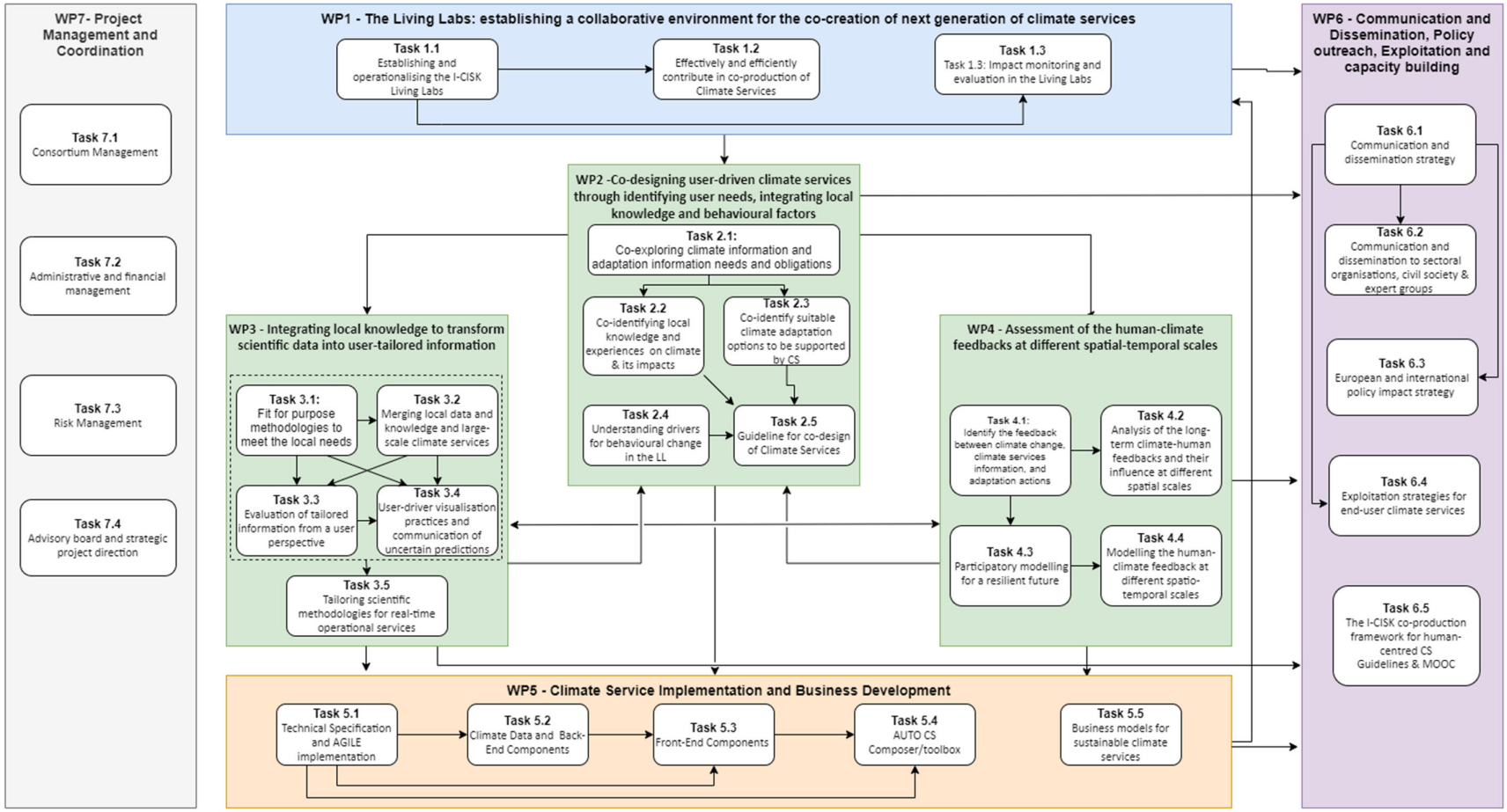


Figure 3: The I-CISK PERT diagram showing I-CISK work structured around six work packages including their interlinkages.

(Source: I-CISK 2021)

3 Methodology

The methodology used in developing this report is schematised in Figure 4. The report builds on the data and information collected using multiple methods including review of the I-CISK deliverables, minutes of the relevant project meetings and an online survey. The survey covers the main elements for a successful co-creation outlined in the I-CISK co-creation guiding framework, which include legitimacy, inclusivity, active engagement, constructive interaction, flexibility and trust (I-CISK MS10, 2022; Wens et al., 2025). Additionally, the survey included questions about the sustainability of the MAPs beyond the lifetime of the I-CISK project. The survey was completed by each of the LL leads who are also part of the project and members of their respective MAP. Overall, ten responses were collected, one per LL (total seven), with three additional responses were provided from MAP members in the Spanish LL. These additional responses were later merged into one response to report consistently across each LL. The results of this survey contribute to this report as well as to WP2 Deliverable D2.8 related to task 2.5 on co-creation guidelines (Wens et al., 2025).

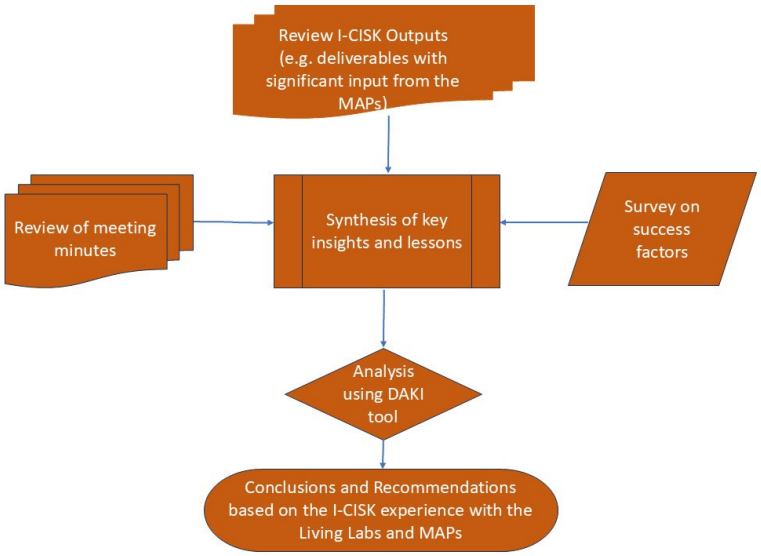


Figure 4: Methodological framework used for the reflection on I-CISK experience with the living labs and associated Multi-Actor Platforms.

For this report, the review and analysis of information were mainly focused on the role of I-CISK LLs and associated MAPs in co-creating user centred CS. Specific attention was given to the thematic areas related to the establishing, functioning and sustainability of the LLs and MAPs. Key points were synthesised in terms of approach, contribution to the project outputs and impacts, success factors, challenges and how these were addressed. Then a critical reflection was made on selected principles of successful co-creation, focusing on inclusion, value representation and flexibility. These principles were selected because of their pivotal role in the establishing and functioning of the MAPs. Additionally, sustainability of the MAPs beyond the lifespan of the I-CISK project was examined. Finally, key lessons and insights emerging from the I-CISK experience with the LLs and MAPs were analysed. Future directions and recommendations were summarized using the DAKI[7] (Drop; Add; Keep; Improve) retrospective tool, with the aim to plan and where possible improve stakeholder contribution in the co-creation of CS.

[7] https://www.teamretro.com/retrospectives/daki-retrospective

4 Establishment of the I-CISK living labs and Multi-Actor Platforms

This section provides a reflection on the I-CISK experience on establishing and operationalising the LL and associated MAPs. The reflection is mainly based on the data and information available through the I-CISK deliverable 1.1 related to WP1 Task 1.1 (Masih et al., 2022), periodic review reports of the project submitted to the European Commission (Werner et al., 2023 and 2024) and analysis of the deliberations involving WP1 teams in project meetings, in particular WP1 meetings and I-CISK annual general assembly meetings.

4.1 Approach developed and applied

To establish and operationalise the LLs, a dedicated LL lead team was set up alongside the central coordination for WP1. This lead team was constituted by a LL lead partner for each of the seven LLs. The LL leading partner (also an I-CISK consortium member) was responsible for delivering fully functional LL environments to facilitate co-creation of innovative CS. The overall coordination from the work package responsible for coherent guidance on methodological approaches, linkages to various WPs, coordination across the LL, cross-learning and jointly addressing any emerging issues.

The main framework developed and used in establishing the I-CISK LL and MAPs is schematised in Figure 5. This framework was developed building on the best practices available within and beyond the field of CS development including LL approaches to involve stakeholders in participatory planning and co-creation processes (e.g. Loucks and Van Beek, 2017; EIP-AGRI, 2017, Stahl et al., 2017; Carter et al. 2019, Thapa et al., 2019; Fieldsend et al., 2021, I-CISK MS10, 2022). The framework was mainly based on the principles of responsible research and innovation, Multi-Actor Approach, and best practices available from different projects such as the EU funded European Innovative Programme (EIP-AGRI). Moreover, the framework was closely aligned with the CS co-creation framework developed under I-CISK WP2, which provides key principles for successfully establishing and continuously engaging with the LL stakeholders.

This tailor-made approach was found suitable to achieve the objectives of the WP1 task 1.1. The approach was found to be very helpful to provide a coherent set of concepts, tools and methods to the LL lead teams, which they then used in a context sensitive and flexible manner when establishing the seven LLs and their associated MAPs. Many meetings were held within WP1 team and LL lead teams, and with stakeholders during this process. Most of these meetings happened online in part to COVID 19 related restrictions, which brought some additional challenges and delays in communication with the stakeholders. Meetings were also held online following the lapse of COVID-19 restrictions to reduce travel as well as to benefit from efficiency of online meetings. With the dedicated efforts of the WP1 team, and, especially, the commendable work done by the LL lead teams, all seven I-CISK LL and their associated MAPs were established and operationalised during the first year of the project.

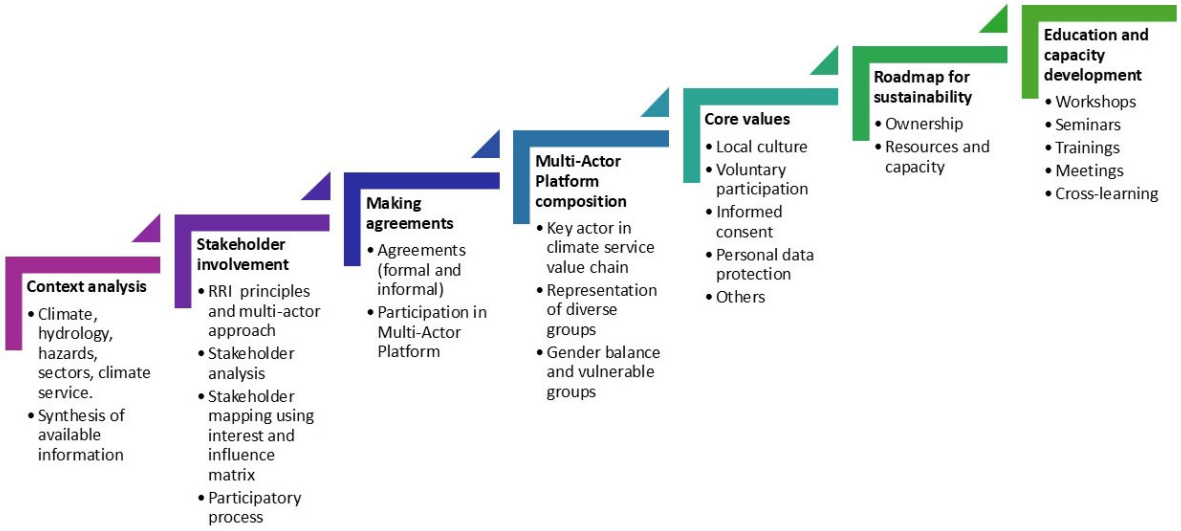


Figure 5. The salient features of the approach developed and used in establishing and operationalising the I-CISK living labs and Multi-Actor Platforms. (Source: Adapted from I-CISK, 2021)

4.2 Major achievements in establishing and operationalising the Living labs

Seven LLs and their associated MAPs were successfully established in geographically diverse landscapes in the EU region and beyond (Figure 6; Table 1). The MAPs established in these LLs brought together about 50 organizations and over 100 key actors representing policy makers, academia and research, industry and business community, NGOs and citizens (Figure 7). The key actors included in the MAPs well represented the CS value chain together with the I-CISK consortium partners (e.g. providers, purveyors and end-users). This successfully demonstrated responsible research and innovation as well as multi-actor approaches in action. This novel work advanced the state of the art by bringing together all the CS value chain actors (CS providers, purveyors and users) in the CS co-creation process.

Table 1: Summary of selected characteristics of the I-CISK Living Labs. (Source: Adapted from Moschini et al., 2022; Masih et al., 2022; Egan et al., 2025).

Living Lab	**Climate information Köppen classification with mean annual precipitation in mm and temperature in °C (and monthly range)**	**Main Hazards in focus under I-CISK**	**Main sectors in focus under I-CISK**	**CSs currently in use**	**CSs needs identified**	**How the new CSs co-created under I-CISK address the identified needs**
Rijnland Delta, the Netherlands	Marine West Coast (Cfb) P: 825 (40-90) T: 11 (4-18	Drought, water scarcity	Water management, Tourism and water recreation, Agriculture,	Drought monitoring system (including medium-range forecasts), streamflow predictions	Longer lead times; stakeholder engagement; user-friendly visualisation	Developed streamflow forecasts with sub-seasonal to seasonal outlooks; thresholds and historical context integrated; simplified interface to aid water management and policy coordination.
Andalucía, Spain	Mediterranean (Csa) P: 485 (2-70) T: 17 (9-26)	Drought, water scarcity, heatwaves, wildfire	Water management, environment including forestry, agriculture, livestock, tourism, and recreation	reservoir management support, seasonal forecasts, climate projections, climate scenarios viewer, drought monitoring, river basin monitoring	Sector-specific forecasts (rainfall, temperature); improved temporal and spatial resolution	Using map-based and interactive visualisations, provided (1) sub-seasonal to seasonal predictions, (2) 10-year projections; and (3) historical P and T data; (4) agroclimatic indicators; and (5) improved hydrogeological characterization. CS tailored to drought response with improved lead time, spatial resolution, and accessibility.
Emilia-Romagna, Italy	Humid subtropical (Cfa) P: 800 (45-100) T: 13 (2-23)	Drought, water scarcity, floods, and highly variable water supply	Water management, agriculture, environment, energy	Regional climate projections, agriculture water demand forecasts	River discharge forecasts; local data integration; intuitive uncertainty displays	Delivered streamflow forecasts at daily and monthly timescales with colour-coded thresholds; local stakeholder sites integrated; visual simplification of probabilistic outputs.
Erzsébetváros, Budapest, Hungary	Humid Continental (Dfb) P: 570 (30-70) T: 11 (-1 to 22)	Heatwaves, Urban heat islands	Tourism and recreation, Health	CLMS Urban Atlas, historical global land surface temperature, meteorological data, air quality monitoring	Urban heat mapping; health-impact forecasting; greening strategy support	Built high-resolution thermal maps and vegetation overlays; enabled identification of heat hotspots and monitoring greening efforts; interface tailored for policy and public communication.

Crete, Greece	Mediterranean (CSa) P: 655 (0-140) T: 18 (11-26)	Drought, water scarcity, floods	Tourism and recreation, water management, energy, agriculture	Weather forecasts, climate change impact assessments and vulnerability analysis, hindcasts, short-term forecast service for reservoirs	Tourism indicators; cross-sector forecasting; clarity and accessibility	Created dashboard of 12 user-defined indicators across water, transport infrastructure, and tourism; scenario-based outputs with spatial interactivity and simplified charts; users helped define layout. Seasonal forecasting supports operational decision making. Indicator values up to end-of-century support long-term planning.
Alazani river basin, Georgia	Humid subtropical (Cfa) P: 730 (30-106) T: 10 (-3 to 22)	Flood, drought, water scarcity	Water management, agriculture, environment, energy, tourism, and recreation	meteorological and hydrological forecasts, extreme event warnings, agrometeorological bulletins, frost early warning, seasonal outlooks, climate projections	Streamflow predictions; early warning; locally adapted services	Designed river forecast portal with probabilistic shading and percentile views; included observed data and educational tools (e.g. serious game); user training and iterative feedback loop included.
Southern Lowlands Districts, Lesotho	Temperate with Alpine influence (Cfb) P: 700 (10-120) T: 14 (8 to 19)	Drought, water scarcity, cold waves, hailstorms	Disaster management, Agriculture and livestock, humanitarian	Seasonal climate outlook, seasonal meteorological outlook, seasonal hydrological outlook, socio-economic outlook, crop monitoring, vulnerability Assessment	District-level forecasts; centralised platform; trigger-based early warning	Developed drought forecast tool with district-level triggers, population impact overlays, and side-by-side forecast comparisons; aligned with Early Action Protocol.

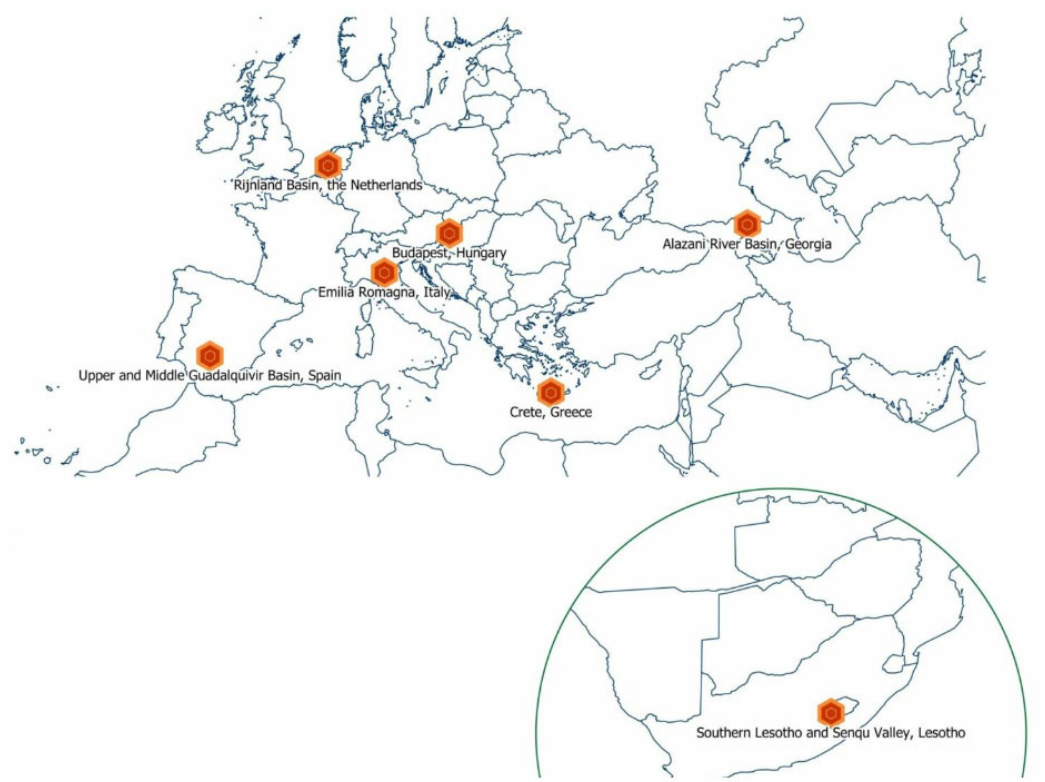


Figure 6. The geographical location of I-CISK's Living Labs in Europe and Africa. (Source: Masih et al., 2022)

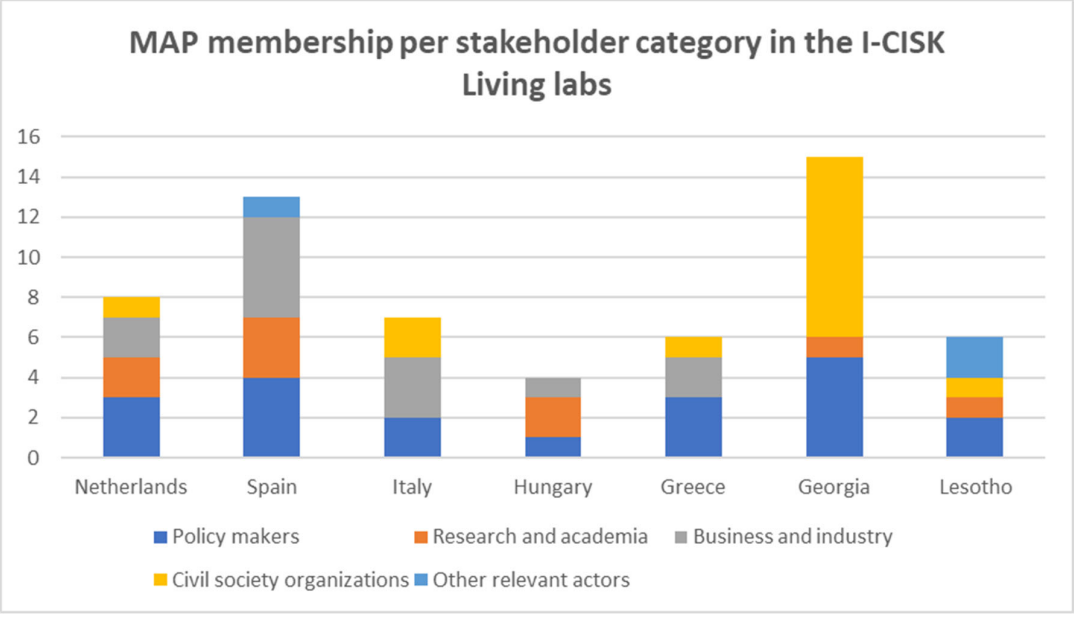


Figure 7. The number of different stakeholder groups participating in the seven MAPs established under I-CISK. (Source: Masih et al., 2022).

4.3 Contribution to the project outputs, objectives and impacts

The establishing and operationalising of the seven LLs and their corresponding MAPs across Europe and Africa directly contributed to achieving the WP1 objectives and deliverable D1.1 (Masih et al., 2025). These also provided a solid foundation for achieving overall objectives of I-CISK (Box 1), specifically objective # 4 on citizen, decision-maker and stakeholder involvement. Moreover, the MAPs, which include the LL leads, made significant inputs to several of I-CISK tasks and deliverables related to WP2-WP6 (discussed in detail in the next section). That the LL leads also contributed actively to various tasks in WP2-WP6 was intentional in the design of the project, and found to provide an enabling and collaborative environment, and important achieving in the objectives of the I-CISK project. Most of the I-CISK partners and WPs activities were strongly embedded within the LLs, Most importantly, the stakeholders that work closely with the project in establishing pre-operational CS provide a crucial dimension to the research and innovation that is developed from working with MAPs in the I-CISK LLs. The participation of such a diverse and highly relevant group of actors ensures that a transdisciplinary approach is used throughout the process of co-creating innovative and user centred CS. It also ensures that these next generation CS are sustainable and contribute to safeguarding different economic sectors and empowering citizens, decision-makers and stakeholders against multiple climate and water related risks in Europe and beyond.

4.4 Major challenges and how these were addressed

There were two major challenges faced in the process of establishing and operationalizing the I-CISK LLs and MAPs: (1) change of location of one LL, and (2) some delays in establishing the LLs and MAPs. Though with a couple of months of delay, six of the seven originally intended seven LL were established and operational during first six months of the project, though with some differences in stage of establishment (e.g., final commitment from the key actors, and completion of MAP establishment process) and operationalisation (e.g., providing contributions to various WPs tasks. Despite earlier commitment and a few months of work in establishing the LL in Namibia, the Namibia Red Cross Society (NRCS) concluded that they could not host the I-CISK LL anymore due to changes in leadership, capacity constraints and shifting strategic priorities.

The failure to establish a LL in Namibia Africa was addressed by finding an alternative location. The responsible partners RC510 and IHE Delft took alternative measures and evaluated the prospects of establishing the LL in the Southern Africa Region. Establishing a LL in Lesotho was seen as the best alternative due to prospects of building synergies with the ongoing work of RC510 and very positive response of the local stakeholders. The Lesotho Red Cross Society (LRCS) agreed to take over the development of a LL in Lesotho, and the commitment was formalized in September 2021. The LRCS was considered a good alternative partner because they have a strong and committed team working on anticipatory action for drought, and they are the driving force behind a technical working group with different stakeholders on drought in Lesotho.

5 Functioning of MAPs and their contribution to I-CISK

This section provides a reflection on WP1 task 1.2, which focused on effectively and efficiently contributing to the co-creation of CS." To achieve this objective, a roadmap of cooperation with WP2-WP6 was developed at the project level, which was tailored and applied by each LL (Werner et al., 2022, 2023 and 2024). The section mainly reflects on the experience of translating the I-CISK roadmap of cooperation into action. The analysis is mainly based on the review of all the I-CISK deliverables where LLs and MAPs made a major contribution. The selected deliverables either have dedicated sections for the LLs or build on the significant input provided by the LLs. The analysis is complemented by the review of the proceedings of various project meetings (e.g. WP1 join meeting, project coordination and steering committee meetings and general assembly meetings).

5.1 Approach developed and applied for operations of MAPs

The LLs and MAPs play a pivotal role in the action-research approach that is essential to realise the innovation potential of the I-CISK project. This required a close interaction and iterative process with the diverse stakeholders voluntarily contributing to the project. To ensure a continued engagement of the MAPs in the I-CISK co-creation process, a roadmap of collaboration between WP1 and WP2-WP6 was developed (Figure 8), tailored and applied to each LL context (Figure 9). The roadmap also highlights the linkages between the co-creation process steps, the main research themes addressed by the different WP tasks, and the stakeholder engagement process. These roadmaps provided useful guidelines on ensuring effective and efficient contribution of WP1 to the other WPs tasks, especially those needed to be carried out together with or using the input from the LLs and MAPs.

The application of a wide range of tools and methods according to the type and purpose of the project activities was found necessary and fitting to the purpose. Several participatory methods and tools were used to conduct project activities, including, but not limited to, surveys, interviews, focus group discussions, workshops, (online & in-person) meetings, serious gaming, participation in local events, field visits and collaboration with local organisations, tailor-made trainings, and cross-learning from multiple actors within and across case studies (e.g. Rastogi et al., 2025). Figure 10 shows a few impressions from the implementation of these activities. Surveys, interviews, meetings and workshops were the most widely used methods to engage in the co-creation process with the LLs and MAPs. Similarly, meetings and workshops were also used as an important tool in coordinating the WP1 activities. These joint meetings were found very helpful in several ways such as: (1) developing of methodologies for different tasks ; (2) creating a space for interaction within WP1 task teams and across other WPs teams; (3) facilitating cross-learning across different LLs as well as the whole I-CISK team; and (4) discussing emerging issues, risks and formulate actions to address those.

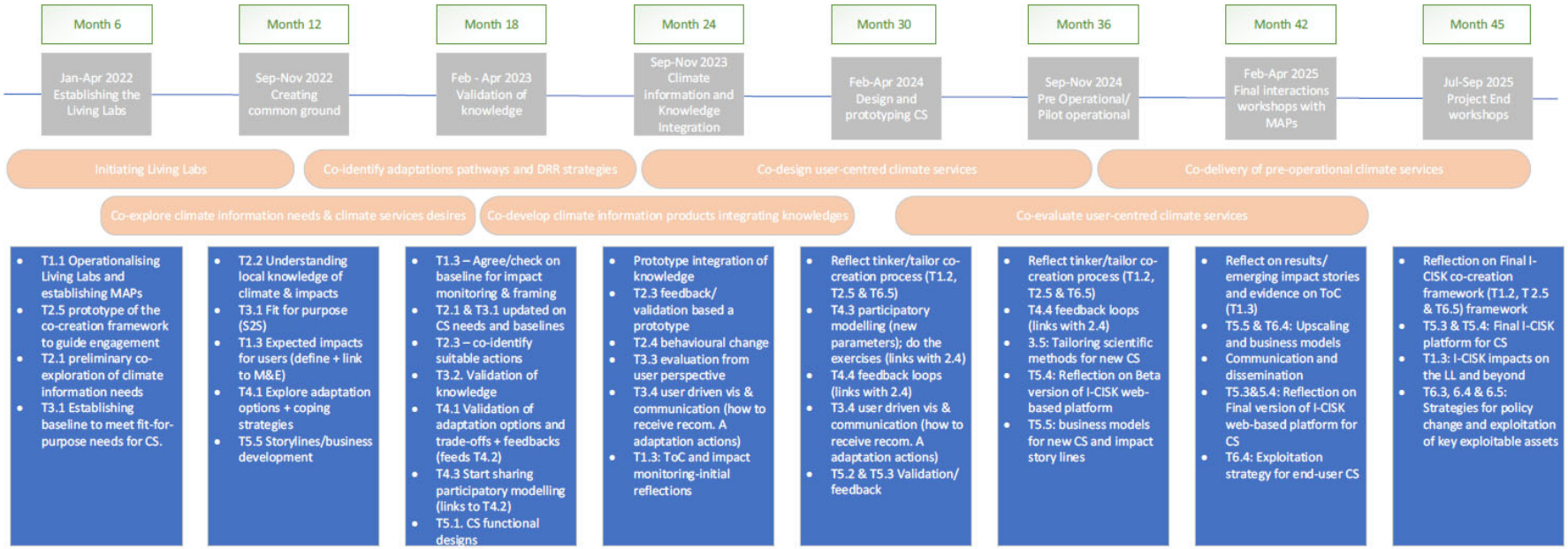
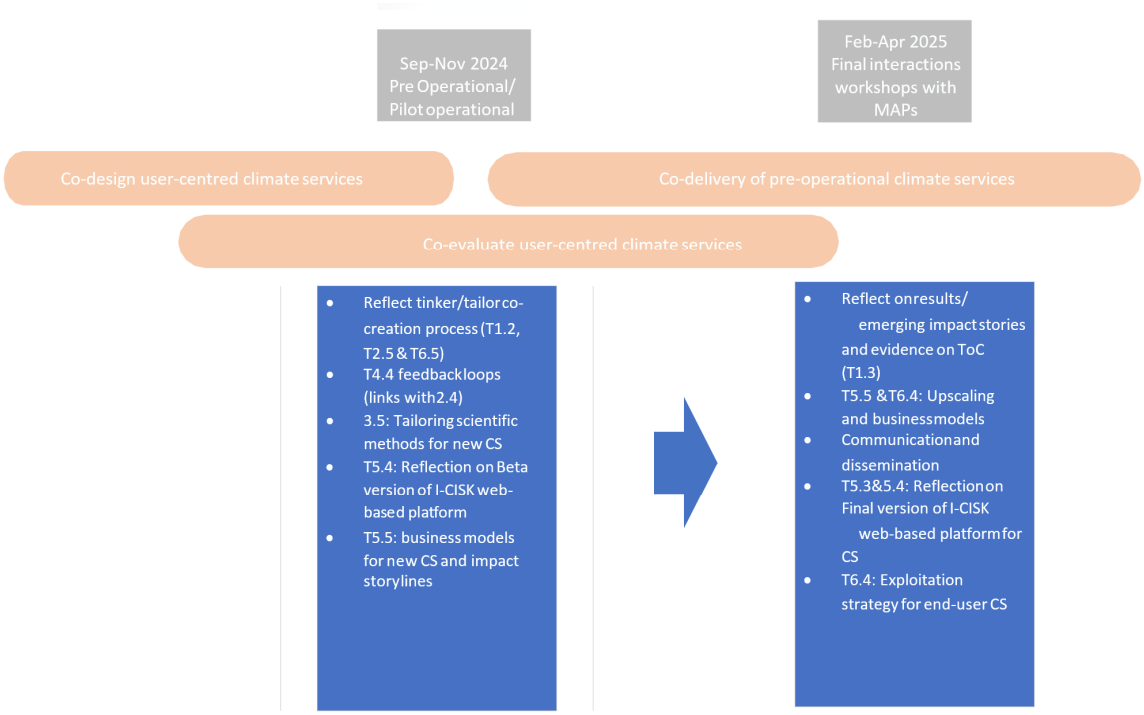


Figure 8. I-CISK roadmap highlighting the interactions with Multi Actor Platforms in the Living labs and linkages to different tasks to be focused on during co creation sessions with the Multi-Actor Platforms. (Source: Werner et al., 2022).

The roadmap developed by the living lab in Italy (Source: Mazzoli, 2023)



The roadmap developed by the living lab in Greece (Source: Ziogas, 2022)

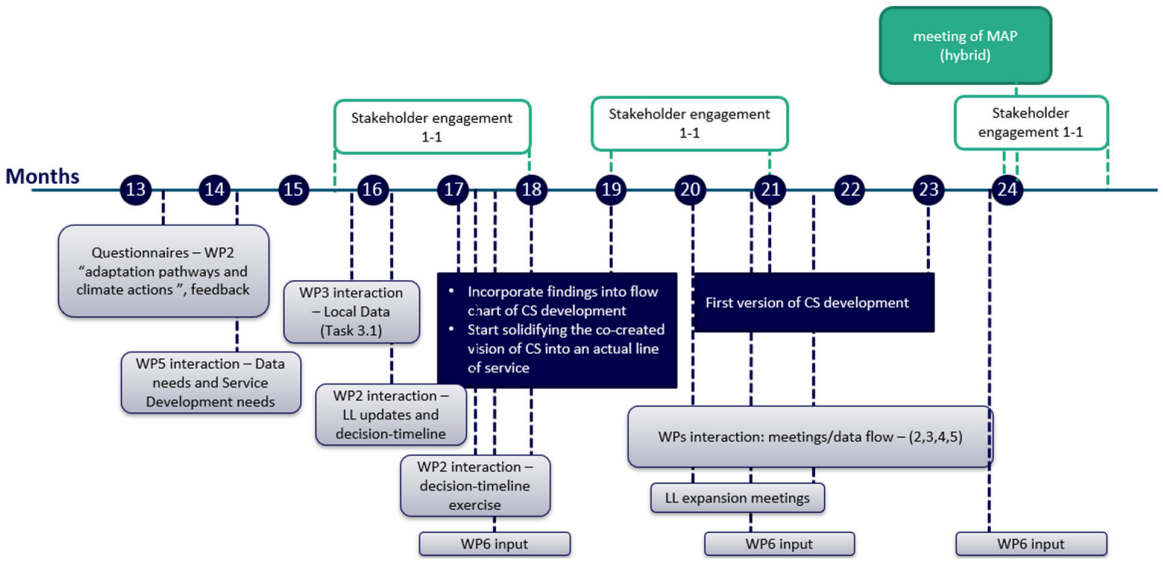


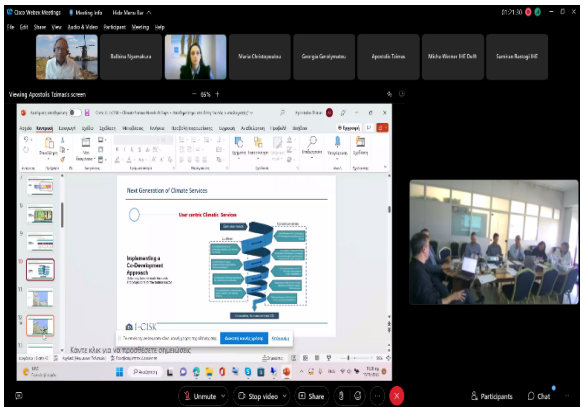
Figure 9. An example of the Italian and Greece living lab roadmaps adapted from the general roadmap.

Georgia (in-person meeting with MAP)

Italy (online meeting with MAP)

Spain (workshop with MAP)

Greece (a hybrid meeting with MAP)



WP1 joint meeting (online)

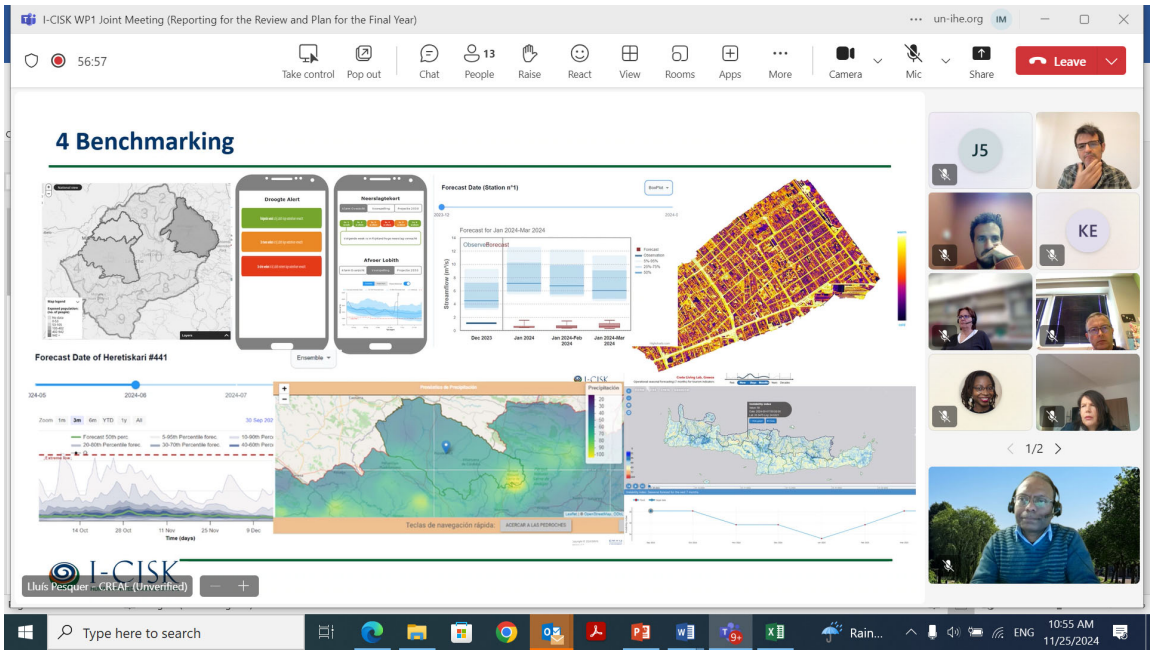


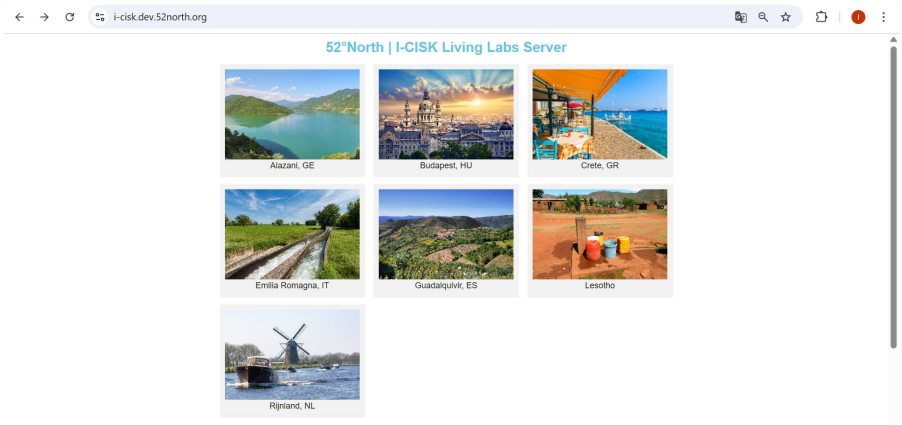
Figure 10. Selected images highlighting the application of various participatory tools and methods during work package 1 activities.

5.2 Major achievements in relation to successful functioning of MAPs

The seven LLs and their associated MAPs that were established within the first six months of the project (with the LL in Lesotho established with a slight delay) were sustained throughout the project period, providing the basis for much of the research and innovation that was carried out in the project. The LL lead teams in each of these have built a strong relationship between the many key actors. The LLs and MAPs functioned well since their inception and were able to effectively and efficiently contribute to the aims and objectives of the I-CISK project including the co-creation of the user centred CS. However, a variable degree of engagement was observed by the different types of stakeholders in each LL. Most of the MAPs members actively contributed to the co-creation process. There were some changes in the composition of MAPs in some LLs during the project. For example, the composition of the MAP for Georgia and Greece were revised. This was done to involve participants from industry who were included in the case of the MAP for the Alazani-Iori basin LL in Georgia, while academic representation was achieved for the MAP for the Crete LL in Greece. These changes were triggered by a critical and constructive review of the project by an external reviewer appointed by the EU to review the progress made during the first eighteen months of the project. In contrast, The MAP for the LL in Lesotho witnessed a drop in participation over time because the stakeholders from the disaster risk reduction sector became only a passive member of the MAP, leaving the Lesotho Red Cross Society and Lesotho Meteorological Services as the main local actors in the co-creation process.

Together with the members of the MAP in each LL and researchers in the consortium, I-CISK was able to co-create fifteen CS (Table 1). Most of these are publicly available through the I-CISK web-based platform (https://i-cisk.dev.52north.org/), which was designed with significant inputs from the LLs and MAPs (Figure 11). Other services that are not part of the platform (e.g., databases, models and analysis created during the project) but were reported in various outputs generating from the I-CISK project such as deliverables submitted to EU. The project team brought together researchers and practitioners from across disciplines and sectors. This has resulted in cross-learning between the stakeholders and project partners, many of whom are active participants of the (European) CS community. Targeted outreach activities, including newsletters, policy briefs, conference presentations, activities in the LLs regions, are informing discourses on cocreation of CS and how local and scientific knowledges can be integrated, thus advancing the state-of-the-art of CS.

I-CISK web-based platform hosting CS co-created together with LLs and MAPs. The platform is publicly available at: https://i-cisk.dev.52north.org/



An example showing the CS developed for the I-CISK living labs in Crete, Greece and Emilia-Romagna, Italy

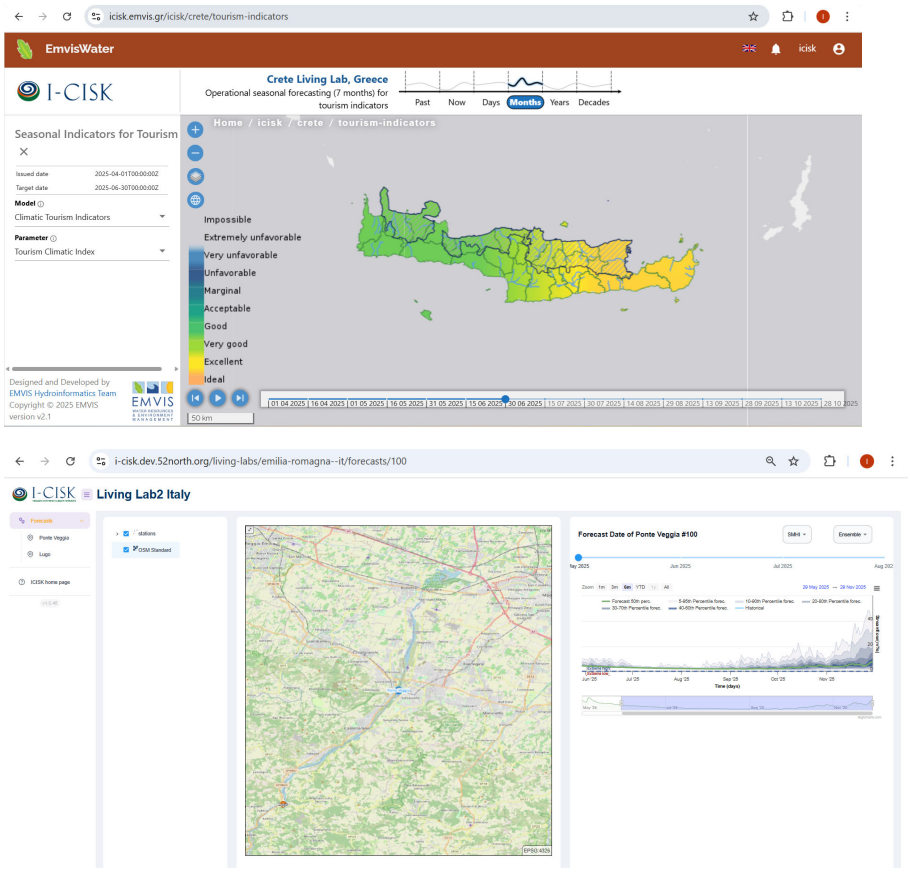


Figure 11. The I-CISK CS and web-based platform co-created together with the living labs and associated MAPs. (Source: I-CISK web-based platform: https://i-cisk.dev.52north.org/; for details, see, Bagli et al., 2024).

5.3 Contribution to the project outputs, objectives and impacts

The LLs lead teams and key stakeholders involved as part of MAPs provided important contributions to various WPs tasks and deliverables while implementing the developed roadmap for collaboration. For example, most of the I-CISK deliverables have dedicated sections for the LLs, which are underpinned by significant inputs from the LL lead teams including MAP members. A few examples of the I-CISK deliverables are provided in Table 2, which indicates the pivotal contribution of WP1 towards WP2-WP6 tasks and outputs. The LLs team members are mostly co-authors of these outputs and in many cases these deliverables have dedicated sections with inputs from each LL.

Table 2: Examples of how LLs and MAPs contributed to selected I-CISK deliverables from WP2-WP6.

I-CISK WP (deliverable reference)	Main focus	Remarks on the contribution from the LLs and MAPs
WP2 (Egan et al., 2025: Information on climate service needs and gaps, I-CISK Deliverable 2.4, available online at www.icisk.eu/resources)	This report provides a detailed overview of the use of existing CS at the start of the I-CISK project in early 2022 in each of the seven participating LLs of I-CISK. It identifies user needs and barriers to the use of these existing services, then demonstrates how new, tailored CS, co-created through the I-CISK project, are addressing them.	This report is mainly based on the questionnaire and interviews completed by MAP members (35 in total). Additionally, LL lead teams also provided input to this process. This work was carried out in an iterative manner, with continuous engagement with the MAP members during 2022-2025.
WP3 (Pesquer et al., 2024: Benchmarking tailored CS for local applications using local knowledge and data, I-CISK Deliverable 3.5, available online at www.icisk.eu/resources	The scientific work conducted in I-CISK aims to explore fit-for-purpose methodologies, tailored to addressing local needs. This document reviews the contribution of the tailored methods, local data, local knowledge and stakeholder feedback to achieve a higher usability of the I-CISK developed CS compared to the global and national ones (benchmarking). This analysis is done for all seven I-CISK LLs, each with their own specific contexts and purposes.	The LLs and MAPs provided local data and knowledge, which was used in CS developed for the purpose of each LL, especially helping in tailoring the service to the user needs and spatial and temporal scales relevant for them. For example, the LLs provided local data related to hydrology (e.g. stream flows) and climate (e.g. precipitation, temperature, wind, thermal heat maps) Whereas, the local knowledge inputs mostly corresponded to the climate and water-related hazards, vulnerability, management decisions including climate change adaptation measures.
WP4 (Rastogi et al., 2025: Participatory modelling for allowing citizens, stakeholders and decision-makers to become active players in climate action, I-CISK Deliverable D4.4, Available online at www.Icisk.eu/resources)	This deliverable demonstrates the key role of participatory methods in the co-creation, learning, and innovation processes required to develop inclusive and actionable CS. The project applied a wide range of participatory tools to involve stakeholders in meaningful ways. The report critically reflects on successes but also highlights persistent challenges.	The report provides a comprehensive synthesis of how and to what extent different stakeholders were engaged in various stages of the co-creation process. The contribution from the LLs and MAPs were discussed for developing the decision timelines, serious games and groundwater modelling across the selected LLs. The report also provides an overview of how the findings contributed to various I-CISK outputs and outcomes.
WP5 (Bagli et al., 2024: Climate Data and Front and Back-End Components of the I-CISK Climate Service Platform. I CISK Deliverable	This deliverable presents an integrated overview of climate data and back-end components as well as front-end components of the I-CISK climate service platform. Each Living Lab has tailored	Following the co-design approach, requirements for CS as well as web-based platform were gathered, discussed, and verified collaboratively among LLs lead teams and their MAPs members, as well as various I-

I-CISK WP (deliverable reference)	Main focus	Remarks on the contribution from the LLs and MAPs
5.2. Available online at https://icisk.eu/resources)	solutions for climate data integration, back-end processing, and front-end visualisation. This deliverable highlights the collaborative efforts in developing CS that are not only scientifically robust but also tailored to local needs, ensuring their relevance, usability and usefulness for stakeholders across different regions.	CISK WP teams, especially WP3 and WP5. These efforts demonstrated co-design of CS with the involvement of all the actors in the climate service value chain (developers, purveyors and users). Dedicated "CS Task Forces" were established, which worked together to define and refine CS and hosting platform for each LL, ensuring co-designed CS meet local needs.
WP6 (Masih et al., 2025): Translating CS Policies into Actions: Recommendations from Seven LLs in Europe and Africa. The I-CISK Project Policy Brief Number 3, Deliverable D6.6, 8 pp. Available at: https://icisk.eu/resources	The policy recommendations presented here stem from the experiences and lessons learned during the co-creation of user centred CS in the I-CISK LLs. Three key policy recommendations relate to: (1) strengthen local hydroclimatic monitoring data and information systems, ; (2) integrate CS informed decisions; and (3). Raise awareness and build capacity of different sectors and decision-makers.	This policy brief was developed by the WP1 team with inputs from other WPs. Besides inputs from the I-CISK partners, a couple of MAP members also contributed and became co-authors of this work. The LL lead teams provided syntheses of policy context, challenges and key recommendations stemming from their work with the MAPs. This formed the basis of this policy brief, which includes generic as well as LLs specific policy recommendations.

In general, WP1, especially the LL leads and teams, and the MAPs have made pivotal contributions (directly or indirectly) towards achieving the expected impacts of the I-CISK project. A detailed assessment on I-CISK impacts is provided by Werner et al. (2024) and Castellana et al. (2025). In this section, a reflection is provided on how the work carried out under I-CISK together with MAPs contributes to enable citizens, stakeholders and decision-makers to factor climate change and climate action into the decisions that will affect their lives for decades to come.

An important dimension of the MAPs in the seven LLs is that these bring together citizens, stakeholders and decision makers, who have participated actively in the I-CISK project. These actors have committed their voluntary participation alongside the consortium partners in the I-CISK co-creation process, and have been actively engaged in the co-creation process through various activities. Together with all CS value chain actors (providers, purveyors, users), the work carried out under I-CISK has generated highly relevant outputs, for example, related to co-exploring CS needs, mapping adaptation decision space and options, conceptualizations of human-climate system feedbacks, identification of the specific CS to be developed under I-CISK project, studying CS use in decision-making and adaptation behaviours, co-design of user centred CS, advancing prediction of hydrological extremes across regional and LL scales, developing I-CISK climate service platform. This work has significantly contributed to empower citizens, stakeholders and decision makers to factor climate change and climate action into the decisions that will affect our lives for decades to come. The contribution towards this objective is also demonstrated by the achievement of related key performance indicators, impact stories and specific impacts for each of the seven LLs (Table 3 and Box 2).

Table 3: The status of key performance indicators related to empowering citizens, stakeholders and decision makers. (Source: Adapted from Castellana et al., 2025)

KPI	Target	Status (July 2025)	Means of verification
Number of decision processes requiring tailored climate information identified within the specific contexts of the LL (at least 2 decision processes per LL)	>14	The seven LLs of I-CISK have at least 2 decision making processes requiring tailored climate information identified within their specific contexts.	Masih et al. (2022); Moschini et al. (2022); Van den Homberg et al. (2024); Egan et al. (2025)
Number of tailored climate service variables and indicators evaluated from a user oriented perspective	>5	As part of co-creation process user centred evaluations were conducted for the pre-operational CS co-designed under I-CISK. The target is fully met, as each of the seven living lab has more than one variable and indicator used in the evaluations.	Baugh et al. (2025); Egan et al. (2025); Van Andel et al. (2025)
Number of participatory modelling and serious gaming actions carried out with climate service end-users (at least 2 per LL)	>14	A number of participatory modelling activities (e.g., co-development of system archetypes and decision-tree timelines) and two serious games have been used to engage end users within I-CISK but also more broadly beyond the project.	Muller et al. (2023); Biella et al. (2024); Bela et al. (2025); Rastogi et al. (2025); I-CISK social media (website and LinkedIn)
Number of the Living Lab CS co-design roadmaps defined	7	A generic roadmap document was developed for all LL labs. All LL tailored it for their use. The roadmaps are living documents and are being implemented and revised as needed.	Werner et al., (2022); Living lab roadmaps
Gender Balance in stakeholder representation and participatory research in LL (Percentage Women)	~50%	Reasonably good gender balance is achieved across the LLs, except one where MAP members from the stakeholder groups are mostly represented by males due to lower proportion of women representatives in general.	Masih et al. (2022)
Number of decision making processes of stakeholders demonstrably changed due to the outcomes and improved capacities on climate information from the project	>5	The decision making processes are identified. The assessment shows that CS prototypes hold substantial promise in supporting both immediate operational choices (e.g. responding to imminent drought or heatwaves) and longer-term adaptation strategies (like urban greening or integrated water-resource planning).	Masih et al. (2022); Moschini et al. (2022); Van den Homberg et al. (2024); Egan et al. (2025)

Transforming drought management in Emilia-Romagna, Italy

Situation: what was the status quo?

Water allocation decisions by relevant players such as irrigation consortia hydropower producers in Emilia-Romagna relied primarily on historical records and real-time monitoring of river flows. Operational restrictions to protect minimum ecological flows were reactive, often implemented only after critical thresholds were breached, creating between environmental protection and legitimate users' needs during droughts.

Complication: what changed or created a problem?

With the increasing frequency and severity of drought events, stakeholders recognised that reactive measures were no longer sufficient to ensure water availability for agriculture while safeguarding river ecosystems. The severe drought in 2022 highlighted the limitations of current planning approaches, as decisions could not be anticipated in time and shared in terms of responsibility among users and the regulating authorities, to reduce economic and environmental impacts.

Question: what question or need arose?

How can water managers anticipate drought impacts earlier to plan storage, optimise distribution, and implement operational restrictions and mitigation measures proactively, ensuring both environmental protection and water availability for relevant usages?

Answer: what happened to address the situation?

Through the I-CISK LL, regional authorities and agencies together with main users co-designed a CS providing sub-seasonal and seasonal hydrological forecasts for strategic hydraulic nodes like Castellarano. This service enables users to explore “what-if” scenarios, communicate early warnings to final users like farmers, and adjust withdrawals before reaching critical thresholds. The approach promotes a shift from reactive control-based decisions to anticipatory and collaborative drought management. Discussions with the Region are ongoing to integrate forecast-based operational rules into Water Protection Plans and Resilience Plans, fostering governance innovations that reduce bureaucratic delays during emergencies and enhance society’s resilience to climate change.

Box 2. An impact story of transition from reaction to anticipation in drought management in the Emilia-Romagna, Italy (Source: Castellana et al., 2025; more impact stories from the LLs are provided in this document)

5.4 Major challenges and how these were addressed

The major challenge for WP1, as well as for other WPs of I-CISK, was the slower than planned progress in relation to the expective contribution in the co-creation process, which was mainly attributed to more time needed than anticipated for the engagements with the MAP members and completing the tasks and outputs related to WP1-WP6. These issues were documented in reporting the delayed or partial achievement of various project milestones and deliverables (e.g. Werner et al., 2024; personal communications with the EU project officer). Other notable challenges included stakeholder fatigue and overlapping WP tasks and activities. Many of the tasks in I-CISK were directly dependent on contributions from the LLs and MAPs. This was often overwhelming for the LL lead teams who played a central role in coordination between MAPs and

I-CISK project teams (e.g., WP teams, CS Task Forces and overall project management teams). The LL teams cautiously worked to manage incoming requests for inputs to reduce (where possible) the burden on MAP members and avoid stakeholder fatigue. Thus, LLs leads acted as intermediaries between MAP members and I-CISK project teams from various WPs. This caused stress and fatigue for the LL lead teams, and the stakeholders volunteering in the MAPs could not fully avoid this, as they were burdened too. Furthermore, there were several project tasks with considerable overlaps, or tasks that due to their nature had to be performed in an iterative manner. This caused an additional burden on the LLs and MAPs, besides impacting other I-CISK teams. These issues were further aggravated, in some cases, due to lack of time, financial resources and capacity. These challenges were addressed (to a large extent, though not fully) through various actions listed below.

- Regular meetings planned under WP1 (including a joint meeting series involving WP2-WP6), among other regular WPs and project management meetings were found very helpful in discussing the issues and options to address them. The annual general assembly meetings provided an opportunity to discuss the progress, challenges and future planning.
- A flexible approach was adopted towards the engagement of the MAP members in the co-creation process. For example, the LL lead teams were given the option to select the most suitable methods to solicit contributions from the MAP members. This could include individual meetings, workshops, focus group discussions, surveys and interviews etc., depending on the context, the preference of the MAP members themselves as well as already established modes of interaction. In some cases, LL lead teams provided contribution to various tasks on behalf of the MAP, where engagement with MAP members were not necessary or possible.
- Enhanced coordination and joint planning within and across the various WP teams as well as project management teams greatly helped in reducing (if not fully eliminating) overlapping activities.
- In some cases, changes were made in time and budget allocation across various WPs as well as within the different budget categories for some project partners.
- Regular communication and discussions within I-CISK team as well as with the EU project officer were instrumental in understanding the challenges and finding jointly agreed solutions.
- Flexibility to allow changes to time and financial resources allocation across WPs and tasks (within the project limits) were found helpful.

The high degree of motivation and unwavering dedication of the I-CISK team and MAPs were instrumental in addressing the issues.

6 Critical reflection on stakeholder engagement in co-creation process

This section discusses selected key elements considered important to the successful co-creation process: inclusion and value representation that requires fairness and equitability; flexibility which should allow openness and adaptability and sustainability that aims to sustain the functions and benefits within and beyond the lifespan of a project. Detailed evaluation on each phase of the co-creation process including principles of successful co-creation is provided in Wens et al. (2025). This section is mainly based on the results of the survey on co-creation experience in the LLs and is complemented by insights from the literature. The responses and discussion presented here are the self-reflections from the LL lead teams, WP1 coordination team as well as the other authors involved in the writing of this report. Therefore, the information presented in this section should be interpreted knowing that the opinions may vary across the LLs given the inherently different ways of doing self-reflections with some displaying a more critical tone while others more appreciative of the achievements within their LL. It is important to note that the section does not intend to make a comparison across the LLs due to the high degree of variability in the context, purpose and self-reflection style.

6.1 Inclusion

Inclusion is regarded as a key component to co-creation processes specifically in MAPs where actors from differing backgrounds, and contexts are meant to diverge and co-create a climate service (Vincent et al., 2018; Caperon et al., 2023). Inclusion may be assessed with different components from diversity of stakeholder groups representing various sectors of economy, their ages, perspectives, through to different climate risks. According to Bojovic et al. (2021), the way in which the MAPs are established and who gets involved is a critical issue for MAP and the resulting climate service. As such, recognition and inclusion of different voices and perspectives of groups that are marginalised is also crucial (Eriksson, 2022). Within the context of I-CISK we evaluated inclusion based on the following factors i) Multi-Actor Approach, ii) Age, iii) Gender; Regional representation, iv) vulnerability to climate risks, v) inclusion of new actors during the co-creation process, and inclusion of new perspectives in co-creating CS. The inclusion of local knowledge was an intricate part of the co-creation process in all LLs and we elected to not evaluate that in this deliverable, as this topic is addressed within the project by other deliverables (e.g. Pesquer et al., 2024; Van den Homberg et al., 2024; Rastogi et al., 2025).

While the inclusion of various stakeholder groups (e.g., policy and decision-makers, academia and research, business and industry, citizens and NGOs) was reasonably good across all LLs (Figure 7), the results on other factors were distributed unevenly across the LLs. Only two LL (Crete and Alazani) were reported to have *good* and *very good* inclusion for age, gender, regional representation, vulnerability to climate risks) (Figure 12). The inclusion in terms of age was reported as *fair* to *good*. This could be due to the higher degree of representation of age groups above 40 years in most of the LLs. The ratings on gender were mostly indicating very good to fair representation of women in 5 LLs, with exception of the LLs in the Netherlands and Lesotho, which reported a poor gender balance. The highest variability was observed in the case of new actors, which was reported to be across the range of being not inclusive to being completely inclusive. While there were no barriers in the way of including new actors, this only happened for the MAPs of the LLs in Georgia and Greece, in response to the recommendations made by the project reviewer. On the other hand, the participation of in Lesotho decreased over time as the district disaster management authorities did not actively engage, and no new actors were involved. For the LL in the Netherlands, no new sectors were added to the MAP, though there were some changes in membership within the sectors represented. However, the inclusion of new perspectives received high ratings (completely inclusive: 3 LLs; mostly inclusive: 3 LLs; inclusive: 1 LL). Overall, the Lesotho LL faced challenges with inclusivity with all factors with the highest recorded being fair. The second

LL that struggled with inclusivity was the Budapest LL which had two factors (new actors and new perspectives) as good while the rest were *fair* and *poor*. Rest of the LLs reported good progress on inclusion, in general, though self-reflections indicated variable degree of achievements

Living Labs	Age	Gender	Regional representation	Vulnerability to the climate risks	Inclusion of new actors	Inclusion of new perspectives
Rijnland Delta, the Netherlands	Fair	Poor	Very good	Very good	Not inclusive	Mostly inclusive
Andalucía, Spain	Fair	Fair	Very good	Very good	Completely inclusive	Completely inclusive
Emilia-Romagna, Italy	Very good	Very good	Fair	Good	Fairly inclusive	Completely inclusive
Erzsébetváros, Budapest, Hungary	Fair	Fair	Fair	Poor	Mostly inclusive	Mostly inclusive
Crete, Greece	Good	Very good	Good	Very good	Completely inclusive	Completely inclusive
Alazani river basin, Georgia	Good	Good	Good	Good	Mostly inclusive	Mostly inclusive
Southern Lowlands Districts, Lesotho	Fair	Poor	Poor	Fair	Poorly inclusive	Fairly inclusive

Figure 12: Inclusion in the I-CISK Multi-Actor Platforms.

The case of the LL in Lesotho having *very poor* inclusion in terms of gender and regional representation may be explained by the focus area and the limited personnel that were active in the LL. Additionally, the CS that was being developed was specific to the Lesotho Red Cross Society and this limited the representation to only the members in the Lesotho Meteorological Society and the Lesotho Red Cross Society itself. This may also explain the poor inclusion of new actors recorded within the LL. Although the vulnerability to climate risks was recorded as low, the LL started with drought as the only hazard in focus but evolved to include extreme cold spells as being considered in the LL as the CS developed.

The Budapest LL recorded *very poor* inclusion in vulnerability to climate risks. This is explained by the focus on one form of climate risk (heatwaves) in the LL and how the LL co-creation process did not evolve to include other climate risks in the climate service that was developed. The MAP of the LL in Rijnland, the Netherlands was dominated by male members, as the sector organizations in the region had low representation of women, in general.

6.2 Value representation

Value representation is closely associated with issues such as power dynamics, the type and quality of inclusion in the process, and the sustainability of the collaboration after projects end (Turnhout et al., 2020; Suhari et al., 2022). According to (Eriksson, 2022), there are two types of exclusion; one where one is not invited into the process all together and another where participants are not allowed to voice their needs and values in the process. Value representation has to do with the former type of exclusion which has been found to reinforce existing power dynamics (Turnhout et al., 2020) and have actors represented in the MAP through tokenism (Caperon et al., 2023). Representation of values of the MAP members in the climate service and co-creation process aligns with the core of co-creation and is key to building trust with, and ownership from the actors (Vincent et al., 2018) which are key for effective collaboration. Increasingly, value representation in the end product has been linked to use of CS (Nkiaka et al., 2019). Finally, collaboration and how decisions are made in the process are reflected in whose values are recorded and taken seriously. Ensuring that values are represented in the climate service and the process ensures that MAP has a strong foundation and healthy functioning.

The LLs were found to be effective at representing the values of the respondents in the co-creation process with four of seven LLs (Netherlands, Spain, Italy and Greece) having completely represented the values of the

MAPs in the co-creation process (Figure 13). In two of the seven (Georgia and Hungary) LLs, representation of values was recorded as *fairly represented* followed by one of seven (Lesotho) of the LLs *mostly representing* the values of the MAP in the process. In one LL (Georgia) the level to which the MAP values had been represented in the process was not reflected (so reported as unknown) but could be considered (at least) *fairly represented* based on the overall experience with this MAP.

Since representation of values in the co-creation process and the climate service is related to issues of power dynamics, voice and overall level of collaboration of the co-creation processes was also rated *good* in most cases. This was evident from the similar pattern of ratings across the LLs, with exception of Lesotho indicating *poor effectiveness* in the equal distribution of power and influence. Similarly, most of the MAPs demonstrate equal opportunities for contribution, with exception of Hungary showing a *poorly effective* response. Overall, the results show that the power dynamics and voices of the MAPs were heard and that participation within the MAPs was not merely performative. However, three of the seven LLs (Lesotho, Hungary and Georgia) highlight the challenges in balancing between values and needs of various stakeholders. This is mirrored by the note from one respondent:

> *"Although not all of MAP members' expectations regarding the developed CS were met, a good representation of members' needs was taken into account and all were addressed in the co-creation process. Some members have had more prominence than others, perhaps because their needs are more clearly related to climate."*

Living Labs	Equal opportunities to contribute	Equitable distribution of power and influence	Values and interests
Rijnland Delta, the Netherlands	Mostly equal	Mostly effective	Completely represented
Andalucía, Spain	Completely equal	Mostly effective	Completely represented
Emilia-Romagna, Italy	Mostly equal	Mostly effective	Completely represented
Erzsébetváros, Budapest, Hungary	Poorly equal	Fairly effective	Fairly represented
Crete, Greece	Mostly equal	Mostly effective	Completely represented
Alazani river basin, Georgia	Mostly equal	Fairly effective	Fairly represented
Southern Lowlands Districts, Lesotho	Fairly equal	Poorly effective	Mostly represented

Figure 13: Representation of MAP values, distribution of power and opportunities to contribute in the co-creation process.

6.3 Flexibility of the process

Flexibility is one of the principles identified by Vincent et al. (2018) as crucial in a co-creation process with multiple actors. Firstly, within the MAPs are people with different needs, interests and values that may not be harmonised easily (Bojovic *et al.,* 2021). Ensuring a flexible process helps to navigate and incorporate changing

needs while ensuring that the process is not compromised. Second, when co-creating a CS, the process itself should not be set in stone at the beginning (Vincent *et al.,* 2018). Additionally, how time is managed between each stage of co-creation depends on the actors within the MAP, therefore how time is managed, and the balance between such time allocations and flexibility become crucial for the functioning of the MAP. Therefore, within I-CISK we evaluated flexibility based on how the process was responsive/ adjusted based on feedback from the MAP members and how the co-creation processes in the MAPs were balanced in terms of the time spent at each stage and flexibility of the process.

In terms of the responsiveness to the feedback three of seven (Andalucía- Los Pedroches, Emilia Romagna, and Rijnland) LL were reported to have been *mostly responsive* to the feedback of the MAP in the process (Figure 13). In two of seven (Crete and Alazani) the responsiveness was reported to be *fair* while the remaining two LL (Lesotho and Budapest) reported to have been *poorly responsive* to the feedback of the MAP in the process.

In terms of balance between time, flexibility and reflexivity, one of seven (Crete) LL was reported to have *complete balance* in the time, flexibility and reflexibility. Three of seven (Andalucía – Los Pedroches, Emilia Romagna, and Budapest) LLs were reported as *mostly balanced* while the remaining three (Alazani, Rijnland, and Lesotho) LLs were reported to be *fairly balanced* (Figure 15).

The poor balance in time is common with co-creation processes particularly those that are within the innovation-oriented typology as outlined in Nyamakura et al. (2025) as most time is spent at the earlier stages of the process and the resulting stages are rushed; one respondent noted this challenge (see quote below). Additionally, responsiveness to the needs and feedback of the MAP members was found to shape the processes in LLs. Below we see a reflection on how time balance and flexibility and how these are informed by the needs and feedback from the MAP members:

"In terms of balancing time, my impression is that the scoping phases and co-design phase received enough time and the co-creation process was very well, whereas for the co-development and co-evaluation phase less time remained such that only two or one iterations is done of the pilot application developed…

Partly this is also as agreed way of working, because the other stakeholder groups indicated not wanting to be consulted more than two-times per year. But on the other hand we lost one round of such opportunity because of lack of time because the development of the pilot application took longer than anticipated."

"Availability of stakeholders must be managed wisely as they are not partners and they do not get budget for their participation."

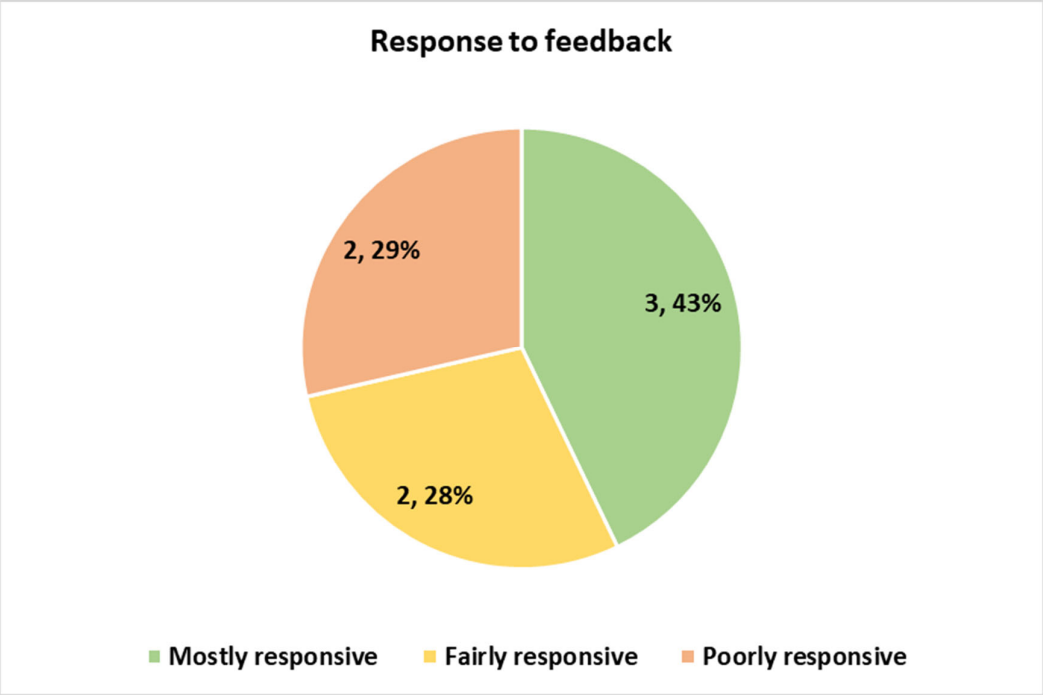


Figure 14: Responsiveness of the process to feedback

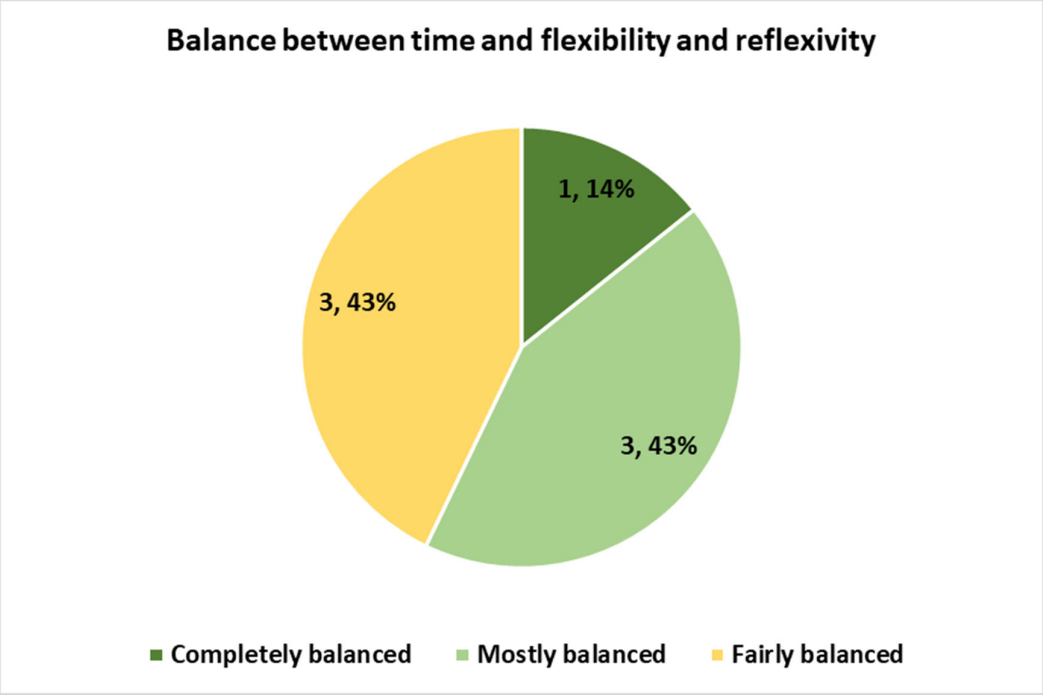


Figure 15: Balance between time and flexibility and reflexivity

6.4 Sustainability of the Multi-Actor Platforms

The forming of MAPs in various LL is crucial to the co-creation process, it is therefore also essential that networks developed, and that the collaboration is sustained beyond the lifecycle of the project. This avoids projects being exploitative and extractive, which may lead to fatigued stakeholders that are not open to engagement with the scientific community (Cosgrave *et al.,* 2022; Caperon *et al.,* 2023). The sustainability of networks and the MAPs depend on various factors such as, the process of co-creation including the building of trust and ownership (Cosgrave *et al.,* 2022), capacity building, and product of the co-creation ensuring that projects are producing needed science (Vincent *et al.,* 2022), how the results are disseminated at the end of the project, as well as the availability of capacity and resources to sustain the MAPs.

Within this deliverable we evaluated sustainability of the MAP based on the sufficiency of the capacity and resources to sustain the MAP as well as the likelihood of the MAP being sustained. In five (Crete, Andalucía – Los Pedroches, Alazani, Emilia Romagna, and Rijnland) LL, the responses indicated that the MAP were found to be *sustainable* beyond the project, while Budapest indicated that the MAP was *not sustainable* beyond the project, and Lesotho indicated that the MAP was *fairly sustainable* beyond the project (Figure 15). In Andalucía- Los Pedroches and Rijnland the capacity and resources to sustain the LL were reported to be *mostly sufficient*, while in Crete the capacity was evaluated as being *fairly sufficient.* In the Alazani LL, the sufficiency of the resources was unknown (Figure 16). In Emilia Romagna, while the resources were *mostly sufficient*, the capacity was considered *fairly sufficient*.

Sustainability of the product, which is the pre-operational CS co-created under I-CISK, is not discussed in detail here, as it is covered under the project deliverables related to business and exploitation plans for these CS (Ziogas et al., 2025 a&b). However, the survey results mostly corroborate with the findings reported by Ziogas et al. (2025 a& b). The respondents indicated that in order to ensure sustainability of the CS several LLs have been engaging with MAP members on the exploitation of the pilot CS and its long-term sustainability, some respondents noted:

"We are working with the Regional Authority, member of the MAP, to favour and sustain innovative water management practices like the climate service in the incoming revised Regional Water Protection Plan"

"Netherlands Red Cross will support Lesotho Red Cross with the Climate Service information system developed and guarantee long-term sustainability."

The MAP and consortium members have planned for the I-CISK Rijnland drought pilot application to remain running and accessible online for all MAP members, for two years beyond the end of I-CISK project. For seeking funding for further development, and longer operation of the app, discussions have started among consortium members involved, and will extend to the complete MAP in September and October."

In terms of the sustainability of the MAP after the project, while the survey responses in Figure 15 show a good outlook for most LL, other responses showed a lack of full confidence in the sustainability of the MAPs due to barriers in resources and capacity at institutional level.

*"While the MAP has facilitated valuable collaboration and co-creation during the I-CISK project, its **sustainability beyond the project is uncertain due to insufficient capacity and resources**."*

*"All MAP members are interested in the afterlife of the CS and the MAP itself, most of them have a mere strong interest. For now, the **main barriers are institutional, also in connection to resources (mainly regarding available personnel and partially financial)**."*

Living Labs	Capacity	Resources	Networks and collaborations
Rijnland Delta, the Netherlands	Mostly sufficient	Mostly sufficient	Mostly sustainable
Andalucía, Spain	Mostly sufficient	Mostly sufficient	Mostly sustainable
Emilia-Romagna, Italy	Fairly sufficient	Mostly sufficient	Mostly sustainable
Erzsébetváros, Budapest, Hungary	Insufficient	Poorly sufficient	Fairly sustainable
Crete, Greece	Mostly sufficient	Fairly sufficient	Mostly sustainable
Alazani river basin, Georgia	Mostly sufficient	I don't know	Mostly sustainable
Southern Lowlands Districts, Lesotho	Fairly sufficient	Mostly sufficient	Fairly sustainable

Figure 16. Factors contributing to the sustainability of the MAPs beyond the lifespan of the I-CISK project.

6.5 Reflections on the functioning and sustainability of I-CISK MAPs

The establishment of I-CISK MAPs was essential in providing the space and people that could engage in the co-creation process in each LL. While some LLs struggled to fulfil some key factors in terms of inclusion, the overall level of inclusion within LL MAPs may be considered as being good. The experiences in the LL MAPs highlight the challenges of MAP formation in specific fields and countries, and points towards the need to be more intentional in continuously adding new actors and perspectives at various points in the MAP to ensure a fair and balanced inclusion. The recommendation for further development of MAPs is to enhance communication with project partners embedded in the LLs the crucial need for a balanced and inclusive MAP for the functioning of the LL. This may necessitate that MAPs established in such spaces as the LLs of the I-CISK project are built on existing networks (where available) that may be more balanced than establishing new MAPs. Finally, measures could be taken to support LLs that are not well positioned to leverage other strengths and approach inclusion in ways that is contextually relevant for the CS and MAP.

While the LLs could improve the level of inclusion in terms of the representation of values of the MAP members in the co-creation process and climate service, MAPs in LL were largely effective at representing the values of

MAP members in the co-creation process and climate services under development. Additionally, most MAPs in the LLs were responsive to the feedback of the MAP members and had a good balance between time and flexibility. This may point towards the decision-making approaches applied in the process. Further improvement could have been made through ensuring that the process is continuously monitored and that learning occurred through all stages at the LL level.

In terms of the sustainability of the networks developed within the MAP, the capacity and resources within the LLs were mostly sufficient. While the resources and capacity are available, the recommendation is to embed the MAPs into existing structures that have been sustained over time. The inconsistencies in the level of ambition to sustain the networks and the LLs and the reality of the capacity and resource sufficiency in some LLs highlight a disconnect. The recommendation would be for LL MAPs to have the sustainability of the networks in mind earlier in the process and work towards identifying funding sources to help sustain these networks independently of the project.

7 Summary of key lessons, conclusions and recommendations

The I-CISK experience with the LLs and MAPs demonstrate the critical role these have in a successful co-creation process for developing human centred CS. This underscores the importance of bringing together all the key actors in the CS value chain. The work carried out under WP1, including contributions of LLs lead teams and MAPs made significant contributions towards achieving the objectives and expected impacts of WP1 as well as for the overall I-CISK project. The LLs and MAPs effectively and efficiently contributed to the co-creation process through successfully engaging with MAP members and the I-CISK project team. The LLs and MAPs played a central role in contributing to successfully executing various tasks of WP2-WP6, and the resulting deliverables that were underpinned by the substantial inputs from them. These efforts have significantly contributed to co-creation of fifteen novel climate services besides making valuable contribution to several other outputs of I-CISK (e.g. I-CISK web-based platform that hosts these CS). While overall experience with LLs and MAPs in co-creation process was positive and successful, there were several challenges faced, and lessons drawn from the work. The key lessons, conclusions and recommendations stemming from the I-CISK experience with the LLs and MAPs are summarized in Figure 17 and discussed below. We use the DAKI tool (Drop, Add, Keep, Improve) to structure these key lessons.

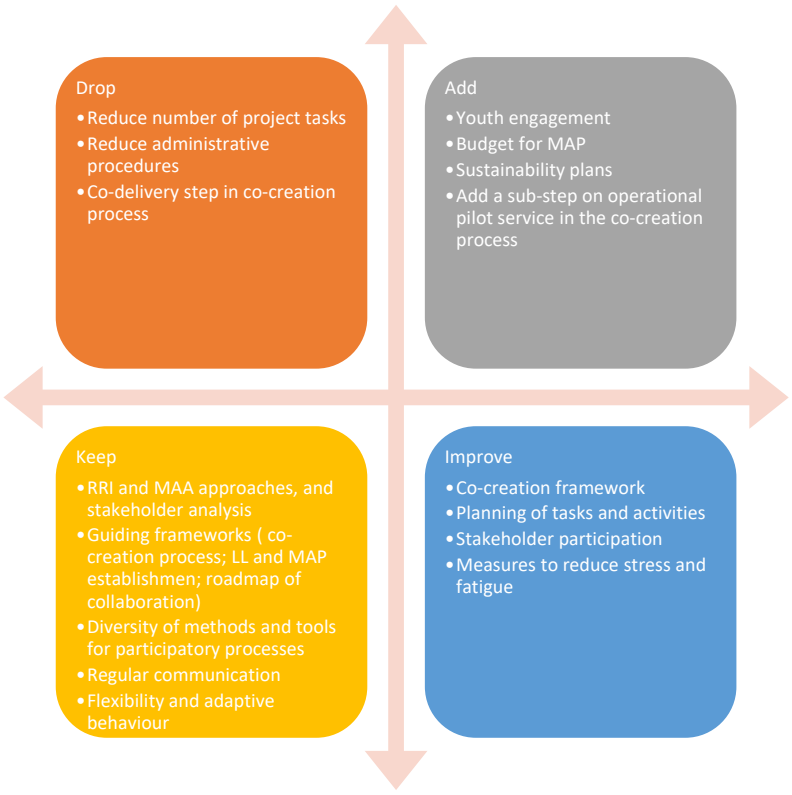


Figure 17. The summary of key lessons, conclusions and recommendations stemming from the I-CISK experience with the seven living labs and their associated Multi-Actor Platforms.

7.1 Drop

- Most of the EU projects, like I-CISK, often aim to address very ambitious objectives set out in the project calls. There is a tendency to design projects in a manner to address most (if not all) of the call objectives and expected outcomes and impacts. In doing so, proponents often propose projects with many objectives and a plethora of activities and tasks to achieve them. However, for projects that strongly build on the stakeholder engagement process, such as the I-CISK project, where co-creation with users is central, careful design of project objectives and tasks needing the involvement of stakeholders is crucial. Based on the I-CISK experience, it is recommended to reduce the number of tasks and activities needing stakeholder inputs in large and complex projects. This can address the issues of stakeholder fatigue and ensure active and more meaningful contribution from the stakeholders who (often) work voluntarily, without any financial compensation from the project for their valuable time and inputs.
- There are several administrative procedures recommended to ensure the commitment of stakeholders participating in projects. These procedures can overburden both the project partners and stakeholders. Therefore, reducing such processes as much as possible is highly recommended. These reductions will help in addressing delays to achieving key milestones and an early start of the real (content) work. For example, getting signed forms for the actors composing the MAPs and the voluntary participation of each actor took quite some time and efforts during the establishment of I-CISK LLs. This could have been avoided by simplifying these process (e.g., making an email or whatsapp message sufficient to affirm voluntary participation). More rigorous administrative procedures should be only used (as minimum as really required) in projects with formal arrangements and transactions of resources (e.g. finances).
- Regarding the phases of the creation framework, the term ‘co-delivery’, in the I-CISK co-creation process (Figure 2) can be dropped or modified because it may potentially give the false impression that all MAP members need to contribute to the operational delivery of the climate service. The I-CISK experience shows that it is usually only the data providers, CS developers and/or knowledge purveyors that deliver the climate service. Also, the way it was positioned in the original framework, as an arrow from the co-creation process to a usable climate service, may be interpreted as the co-delivery being an endpoint of the process, whereas iterative updating of the co-created CS, based on repeated cycling through the co-creation steps, is crucial.

7.2 Add

- Youth engagement in the co-creation process could provide a very valuable contribution. Despite following a comprehensive process to ensure diverse and inclusive stakeholder representation in the I-CISK LLs and MAPs, the element of youth engagement (diversity in age) was not explicitly considered like other factors such as gender balance and representation of key actors in CS value chain (Figure 1). Inclusion of youth in co-creation process would contribute to empowering of the next generation to better understand climate related issues, their needs to address them and possible adaptation measures including CS.
- Stakeholder participation in projects such as I-CISK is often designed as a voluntary activity with no or minimal compensation of time and resources used by participants. It is assumed that the project outputs and outcomes render considerable benefits to participants, which should contribute to compensate for their efforts and inputs. However, there are inherent uncertainties on the successful

delivery of the promised outputs and their usefulness because many research and innovation projects do not aim to deliver products at the market ready level or immediate applications in the planning and decision-making (such as pre-operational climate services in the case of the I-CISK project, which are not yet ready for market uptake or day to day decision making as these need further testing and refinements). Therefore, making provisions for budget allocation for stakeholder participation in the co-creation process can provide incentives to motivate regular and in-depth contribution from the users that may be non-project partners.

- Sustainability of the LLs, MAPs and CS was considered throughout the I-CISK project (right from the inception to the end). Although the issue was in focus and reflected on during several project meetings and outputs, these discussions could have been better structured and linked to dedicated outputs such as sustainability plans. These plans should strike a balance between ambition and reality. For example, sustaining MAPs beyond the lifespan of a project is a great ambition. However, one may ask the question "is it fair to expect voluntary participants to continue while the project consortium stops their commitment after the end of project?" Within I-CISK, experience shows that the LLs and MAPs have successfully contributed to the purposes for which they were established. The work demonstrated that there are clear benefits for continuity in most cases, which can be harnessed through investing in sustainability of the LLs, MAPs as well as the resulting CS and other exploitable assets from the I-CISK project.
- For the I-CISK co-creation framework, instead of the co-delivery, it is suggested to insert 'pre-operational pilot service', as a step in the iterative co-creation circle (Figure 2). Early operationalisation of pilot CS is an important step in the co-creation process to allow for testing by the MAP members and iteration of the other co-creation steps.

7.3 Keep

- The I-CISK experience demonstrates that successful co-creation process is built on sound and well tested approaches, frameworks, methods and tools besides innovating these and applying them in a flexible and context sensitive manner. Therefore, it is recommended to using and innovating these in future co-creation endeavours. The recommendations include keeping: i) RRI and MAA approaches, and stakeholder analysis; ii) guiding frameworks (I-CISK co-creation framework; LL and MAP establishment methodology; roadmap of collaboration); iii) diversity of methods and tools for participatory processes (e.g., surveys, workshops, meetings, focused group discussions, participatory modelling and serious gaming); iv) regular communication (among project WPs, tasks and teams; cross-learning; consultation with the EU project officer); and v) flexibility and adaptive behaviour (e.g., in context sensitive application of co-creation framework, tools and participatory planning methods; time and resource allocations). For example, the flexible and context sensitive application of the I-CISK co-creation framework was found to be very helpful and therefore recommended for future co-creation projects focusing on human centred CS. The co-creation framework steps have been mostly experienced positively by the MAP members. All these steps yielded (sometimes unexpectedly) new insights that were important to feed into the CS design, development, and usability.

7.4 Improve

- Co-creation framework guidelines were developed at the start of the project to facilitate co-creation process to co-design user centred climate services. This framework and process was not cast in stone and was meant to guide the tailored applications, besides being improved from the feedback over

time based on the I-CISK experience. The LLs lead had provided their evaluation of the various phases, which provided useful information to improve the co-creation framework for future applications. These inputs are being considered in finalizing the co-creation guidelines (Wens et al., 2025). Additionally, insights from other activities and outputs of I-CISK as well as the experience of the I-CISK team could also be considered in fine-tuning the co-creation guide. The experience with the MAPs shows that the positioning of 'co-evaluation' and the resulting CS (right block of Figure 2) can both be improved. As mentioned above, the framework steps could improve by removing co-delivery sub-step and replacing it with a step dealing with pilot CS. Additionally, it is recommended that the co-evaluation phase could be positioned as one of the steps in the co-creation iterative cycle, and the 'resulting CS' is to be visualised as a full background block to emphasise that the CS will be updated through subsequent iterations of the co-creation cycle.

- While planning tasks and activities were reasonably good, these could be improved with a focus on reducing overlaps, building synergies and avoiding or minimising repetition in collecting the same information unless another iteration is necessary. This was taken care of during the project period to some extent and was found (partially) helpful. Future co-creation initiatives should pay good attention to planning during the proposal preparation but also implementation phases.
- Stakeholder participation was crucial for the success of I-CISK and was effective in general. The experience from I-CISK demonstrated the pivotal role of LLs and MAPs in the co-creation process. An enhanced understanding of the roles and expectations from each player representing the CS value chain is important to set up an efficient and trustworthy co-creation process. For example, the meaning of co-creation should be well understood and how each actor contributes towards the jointly agreed goals and expected outputs and impacts. A good understanding by all actors on the level of participation, such as from consultation to co-design to co-decision making and empowerment, could facilitate the design of the participatory activities and selection of suitable tools and methods. This also needs capacity development for all actors in the CS value chain (not just of MAPs). Every step in the co-creation process may not require only consultation or empowerment, hence it would require a fit-for-purpose design. This will also help in a sound and just evaluation of the process, outputs and impacts.
- Measures to reduce stress and fatigue were found very important for healthy functioning of LLs and MAPs. The I-CISK experience showed that reducing stress and fatigue in large and complex projects with multiple tasks, activities and outputs is a challenging undertaking. This affects everyone involved, project partners and voluntarily participating stakeholders alike. During the implementation of I-CISK, efforts were made to address these issues, with reasonably good degrees of success. The role of LL lead teams appeared crucial in scrutinising the activities before calling MAP members for their input and engagement. While this process certainly reduced stress and stakeholder fatigue, it put LL lead teams themselves under more pressure. This shows that project partners who act as purveyors are also highly vulnerable to fatigue alongside stakeholders, which are often considered most affected. Therefore, it is recommended to conduct regular monitoring and evaluation on the issues of stress and fatigue, and where necessary activate timely actions to address issues throughout the process of co-creation.

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I-CISK

HUMAN CENTRED CLIMATE SERVICES

Colophon:

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