M15 Refining TANDEM

Step 1: TANDEM transdisciplinary knowledge co-production framework refined and iteratively applied

Tuesday, 26 August 2025

Authors list: Janne Parviainen[1], Sukaina Bharwani[1], Lydia Cumiskey[2],

1. STOCKHOLM ENVIRONMENT INSTITUTE
2. UNIVERSITY COLLEGE CORK

Project: 101073978 — DIRECTED — HORIZON-CL3-2021-DRS-01

Funded by the European Union

Report overview

Project number	101073978
Project acronym	DIRECTED
Project name	Disaster Resilience for Extreme Climate Events providing Interoperable Data, Models, Communication and Governance
Call	HORIZON-CL3-2021-DRS-01
Topic	HORIZON-CL3-2021-DRS-01-02
Type of action	HORIZON Innovation Action
Responsible service	European Research Executive Agency
Project starting date	01/10/2022
Project duration	4 years
Period covered	1 October 2022 – 30 December 2023
Milestone due date	30 December 2023, submitted August 2024

Funded by the European Union

This project is an Innovation Action under the Civil Security for Society, Disaster-Resilient Societies programme of the Horizon Europe funded by the European Union.
Associate partners SEI Oxford and Oasis Hub are funded by Innovate UK and ETH Zurich is funded by The State Secretariat for Education, Research and Innovation (SERI), Switzerland

Document history

Version	Date	Comment
1	01.02.2024	First draft
2	15.03.2024	Second draft
3	13.08.2024	Final version ready for submission
4	26.08.2025	Reworked version for upload to Zenodo

Funded by the European Union

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1. Overview

WP 4 (led by SEI) will iteratively apply and refine the Tandem co-production framework (Daniels et al., 2020) in collaboration with WP 1 (RWLs) and within the wider Risk-Tandem process (WP 3) and as outlined in D1.2 (*Capacity Development Strategy for the Training of Trainers*). The refinement will be based on empirical evidence, lessons learned, emerging challenges and potential solutions. Collation and analysis of this evidence will be done between M6-48 to further refine Tandem into replicable, proven, and tested guidance for transdisciplinary co-production and information interoperability within Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) contexts, leading to deliverable D4.3.

This milestone lays the foundation for periodic reporting (M16-18) leading to D4.3 in M48 by: 1) explaining the conceptual framework and practical guidance underpinning the design of co-production process in DIRECTED; 2) starting to collate experiences and challenges regarding co-production through qualitative data from interviews, consultations, workshops, surveys, and other engagements with RWLs [1] during 2023; 3) reviewing progress and initial observations from the RWLs; 4) documenting the methodology that will be used to collect, systematically analyze and update the Tandem framework throughout the project (M16-18); and, 5) providing recommendations for strengthening the Tandem cycle to support its improved implementation in CCA-DRM contexts, and as a part of the wider implementation of Risk-Tandem in collaboration with WP 3.

For partners beyond WP 4, the analysis that will be documented in periodic Tandem milestone reports will provide insights for transforming governance mechanisms (WP 3), developing transformative tools (WP 2), and informing the needs of users for the Data Fabric (WP 5) to increase interoperability for improved CCA and DRM. In terms of wider application, periodic evaluation of the Tandem approach, will seek to identify and leverage different conditions of the framework's applicability to DRM and CCA in a range of decision contexts, to further refine the existing guidance to enable it to be more easily applied elsewhere and at scale.

[1] RWL: Copenhagen (RWL 1), Emilia-Romagna (RWL 2), Danube (RWL 3), Zala (RWL 3), Erftverband (RWL 4).

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2. Tandem framework for co-production

The Tandem framework was initially developed to address the disconnect between research policy and adaptation action (Klein and Juhola, 2014), with a particular focus on enabling collaboration for the purposes of co-designing and co-developing adaptation solutions toward long-term climate resilience and sustainability. It represents an attempt to "refocus climate services lens" (Daniels, et al., 2020), moving from products toward process-oriented engagement in which users and providers of climate information increase its usability and impact. There are also co-benefits: continued engagement is likely to generate intangible outputs – including confidence, trust and increased capacity (supporting D1.2) – which are required to support planning and implementation of adaptation actions (ibid.).

During its lifetime, the framework has been refined and further developed based on its application across various decision-making contexts. The first version (Figure 1) was developed iteratively to guide the strengthening of climate services[2] beyond supply-driven and unidirectional approaches, which often limit the usability of climate information available for decision-makers (ibid.). Based on comprehensive literature reviews and lessons derived from the implementation of the FRACTAL project in Lusaka, Zambia, Tandem was established to embed the design of climate services within institutional and decision-making contexts, in efforts to improve their relevance, usability and sustainability. In Zambia, participatory processes and engagements supporting the integration and use of climate information was applied to urban water security concerns in particular (Daniels, et al., 2019). Applied within Learning Labs, researchers sought to enable the co-exploration of "adaptation challenges" through a transdisciplinary approach involving city council departments, water utility companies, Disaster Risk Management authorities, meteorological services and civil society organizations. Through the engagement, water insecurity and limited access to safe drinking water emerged as a priority concern, especially in peri-urban areas (ibid.).

This engagement led to the first iteration of the Tandem framework for co-designing climate services (Figure 1), in efforts to structure and guide the process of knowledge co-production (sometimes critiqued due to its lack of empirical evidence and practical methodologies), through a set of guiding questions[3] that can support its implementation.

[2] Which can encapsulate numerous methods and approaches, including future climate risk modelling, loss and damage assessments, risk/impact assessments, and so on.
[3] https://weadapt.org/wp-content/uploads/2024/08/Tandem-Guidance-2024-final.pdf

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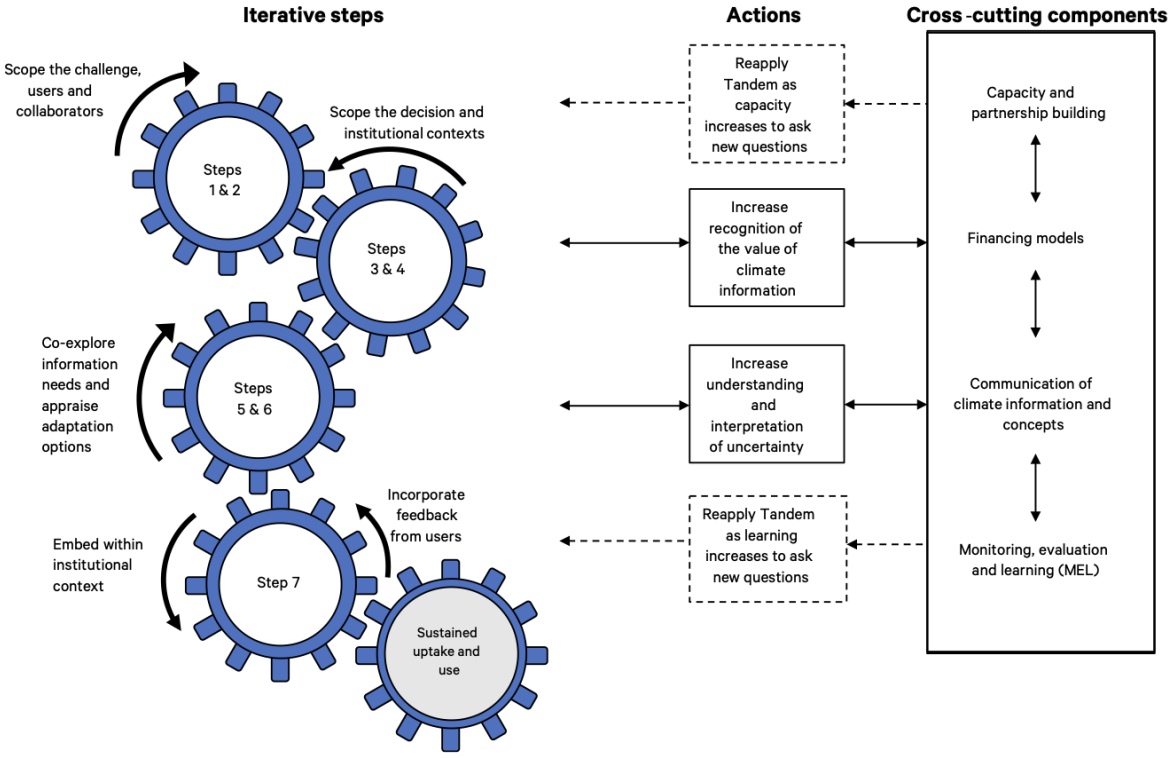

Figure 1: Iterative steps of the first Tandem framework for co-designing climate services (Daniels et al., 2019).

Steps 1 (identify adaptation challenges) and 2 (identify and engage with potential users and collaborators) sought to support the building of a shared understanding of adaptation challenges that could benefit from the integration of climate information. To enable co-exploration, it was necessary to also support the identification of actors who would have a role/could influence the scoping and management of the adaptation challenge (either users of climate services, or its providers and intermediaries). The inclusion of local intermediaries was also highlighted, in efforts to facilitate the integration and sharing of indigenous, traditional or practice-based knowledges.

Steps 3 (gaining understanding of desired objectives and identifying early actions and existing services) and **4 (building an understanding of institutional and decision-making contexts)** closely follow. Building upon diverse knowledges, this sought to guide the scoping of the context and challenges where the support of climate services is needed, as well as the scoping of institutional arrangements behind them. Creating and finding opportunities for coordination and collaboration across stakeholders was highlighted, including the exploration of constraints and barriers that may shape potential objectives (and the co-design process).

Steps 5 (co-explore data and information needs, sources, formats, and modes of dissemination) and **6 (appraisal of adaptation options)** represent the stage where decision methods, data, information needs and modes of dissemination can be co-explored. In

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particular, users' specific needs, narratives and perspectives were discussed, in relation to available planning tools, data, risk maps or impact models. This information could then be used to co-develop decision-support methods, and to identify, appraise and prioritize interventions fit-for-purpose and context.

Steps 7 (maintaining, evaluating, and upgrading the service). The final step intended to co-explore how services can become institutionally embedded, evaluated, and refined as user needs evolve, in consideration of actors' roles and responsibilities.

Capacity development and partnership building, sustainable financing models, and building in monitoring, evaluation and learning activities were highlighted as cross-cutting components supporting the implementation of the initial Tandem process. They were integrated in consideration of the institutional and institutional capacity gaps and needs often affecting providers, intermediaries, and users of climate services. In addition, collaborations, partnerships and financing the delivery of services were highlighted, since product-driven and siloed innovation alone tends to fall short in achieving long-term socio-economic benefits and sustainable integration of climate information into decision-making. Finally, to fully understand and iteratively refine knowledge co-production, the centrality of MEL was introduced, including the co-development of indicators for monitoring the effectiveness of the design process, and the service itself.

3. The evolution of Tandem

Based on the implementation process (and lessons learned) under the FRACTAL project, and a survey targeting climate services stakeholders, Tandem was further refined (Daniels, et al., 2020, Figure 2). Building on the steps as identified in figure 1., Tandem was expanded to provide a clearer illustration of the non-linearity of the knowledge co-production process (often requiring a return to the previous steps during progress to integrate feedback and learning toward long-term change). Although the steps remained largely the same, they were separated into distinct phases and revised to support the application to a wider range of contexts (based on an analysis of the climate information co-production process in Lusaka, seeking to identify the process "elements" and "characteristics" that have led to positive change). The guiding questions sought to aid the process of creating a shared understanding, networks, trust and shifts in perspectives toward increased resilience and sustainability via lessons learned (Daniels, et al. 2020). Based on the urban case study in Lusaka (as well as the accompanying survey and literature reviews), the elements were solidified to support others in implementing iterative-yet-structured knowledge co-production processes and strengthen its underpinning philosophy emphasizing trusted communication as a solution to complex adaptation challenges.

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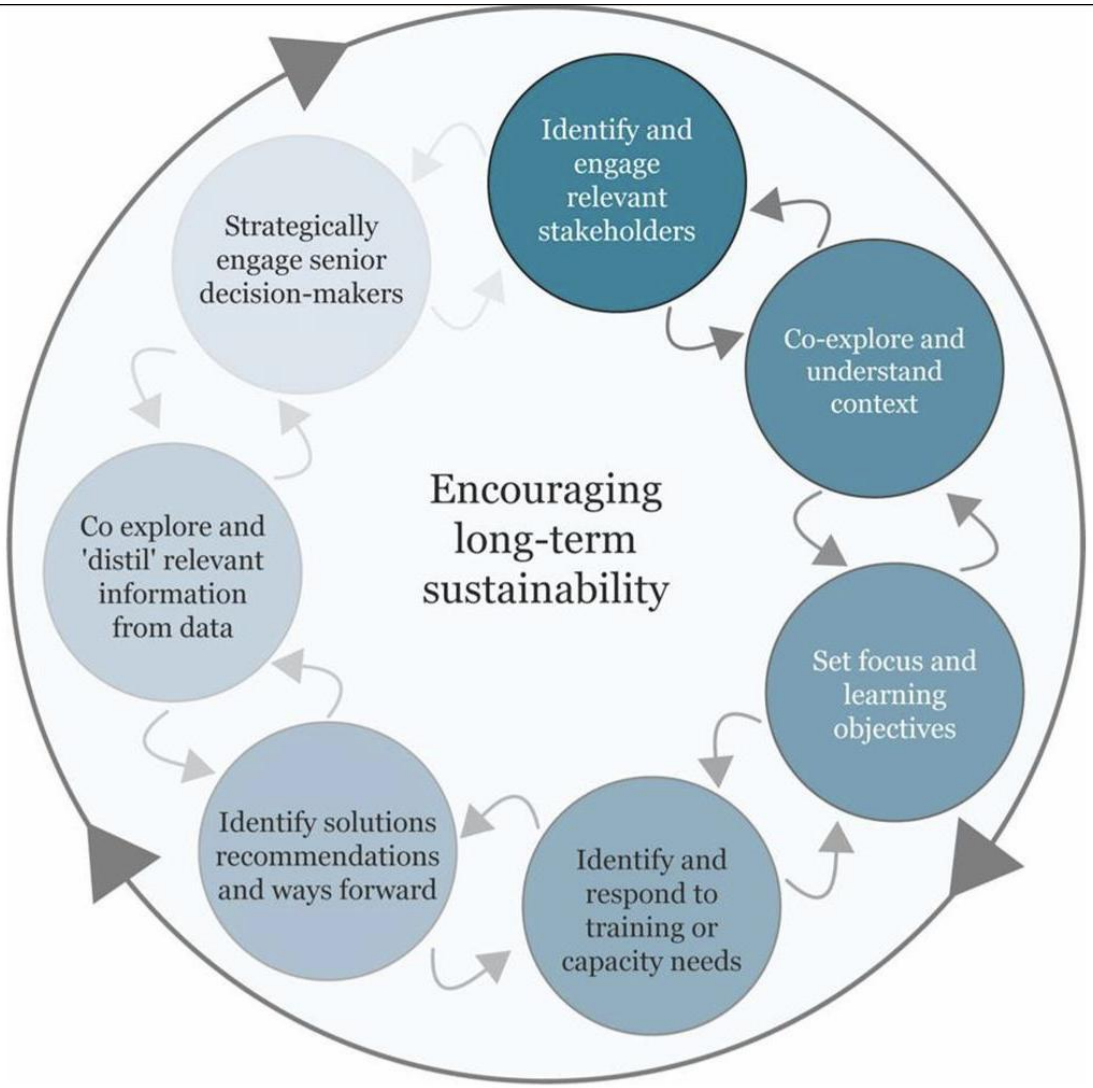

Figure 2: Constituent elements of the Tandem framework (Daniels et al., 2020).

The most recent iteration of Tandem was developed based on its application in three case studies in rural community in Indonesia, two cities in Sweden, and with communities in a river basin in Colombia (Bharwani, et al., 2024). The interactive guidance can be found here: https://weadapt.org/tandem/. It was applied to diverse problems, including addressing the impacts of climate change to agriculture (Indonesia), supporting planners in addressing climate-related flood impacts and heat stress (Sweden), and tackling the issues of water scarcity and equitable use (Colombia). The framework provided several benefits, including: 1) moving from 'useful' to 'usable' information by building trust; 2) increasing institutional embedding through strengthened relationships and networks; 3) improving climate information uptake and use; 4) increasing capacity, confidence and a shared understanding of climate information by users, and the decision context by providers; and, 5) serving as a non-prescriptive guide for users, intermediaries and providers to co-design and structure an effective process for collaborative learning and action.

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Insights from each case study were compiled to demonstrate the benefits of the Tandem framework in different contexts, and to further refine it to enhance the inclusion of: climate and non-climate vulnerabilities and risks; gender, social equity and power, local knowledge; horizontal and vertical governance at appropriate decision-making scales; and, flexible starting points, with early identification of impact indicators. This process led to a revised set of guiding questions[4], and a new design of the framework, in efforts to continue emphasizing the iterative and non-linear nature of the steps toward knowledge co-production and knowledge integration facing complex challenges (Figure 3).

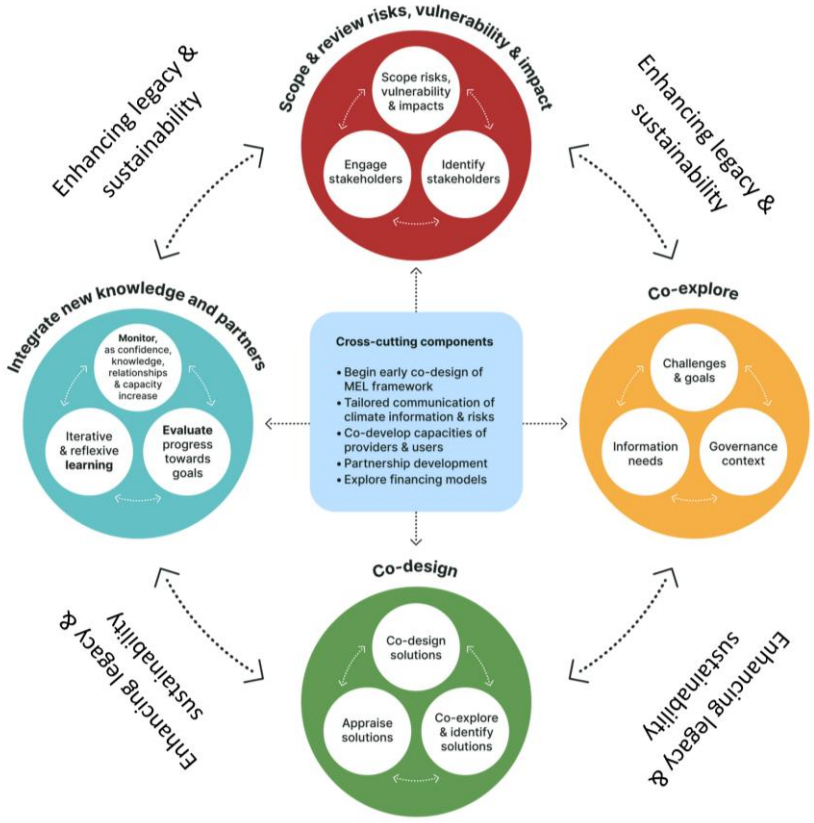

Figure 3: Updated Tandem framework, emphasizing the iterative, complex and non-linear process (Bharwani et al., 2024).

More specifically, lessons learned from the case studies, included expanding the focus of scoping beyond climate toward non-climate risks which may affect its management (including socio-economic issues which may exacerbate vulnerability, or matters of the governance context that may affect risk management). Different formats for engagement were also included in the guidance, in efforts to avoid unwanted power dynamics between stakeholders (suggesting the dividing of groups into smaller group discussions or individual discussions when deemed necessary). In Indonesia, the guiding questions were expanded to consider various knowledge types, in efforts to introduce traditional ecological knowledge into discussions on equal terms with scientific knowledge – to manage power imbalances between researchers, planners and indigenous peoples. To accommodate the complexities of politics, power and informality of many planning and policy processes, Tandem questions were also revised to address the question of scale (in recognition of the fact that not all questions are relevant for all levels of governance). Finally, the Swedish case studies supported the revision

[4] https://weadapt.org/wp-content/uploads/2024/08/Tandem-Guidance-2024-final.pdf

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to better accommodate flexibility in identifying and evaluating adaptation challenges, facing the messy and complex reality of trying to co-create and co-deploy adaptation solutions.

In DIRECTED, guiding questions informing the implementation of knowledge co-production (WP 4) within Risk-Tandem (WP 3) are based on the latest version of the Tandem guidance (Bharwani et al., 2024). Lessons learned from application in the RWLs will enable further testing and refinement of Tandem, to support its relevance to a wider range of geographies and decision contexts.

4. Tandem in RWLs

The application of the Tandem co-production cycle in the RWLs has taken place within the context of the Risk-Tandem (WP 3) Framework since Q2 of 2023, as a part of the objectives of WP 3 to enhance risk governance.

The first steps toward integrating Tandem co-production cycle with risk governance mechanisms and approaches were taken in February 2023, in a workshop between University College Cork (WP 3) and Stockholm Environment Institute (WP 4). The first draft of the Risk-Tandem Framework was developed and introduced to partners based on the preliminary literature review seeking to conceptually overlay the responsibilities of these work packages, (later cultivated in D3.1. where Risk-Tandem was fully formalized and further described). This began the process of mainstreaming Tandem co-production cycle in the RWLs, with an effort to begin understanding and assessing where the entry points for co-production may emerge in European risk governance contexts.

In alignment with Tandem phases, online meetings were then organized with the RWLs to identify how WP 3 and 4 could provide support for stakeholder engagement as labs were beginning to form – particularly in terms of supporting engagement across disciplines and levels of governance. Among consultations and support, Tandem questions[5] were integrated into capacity needs assessment (see D1.2, Annex III) and stakeholder identification tool (D3.1 Annex IV on stakeholder selection) for engaging RWLs, thus also providing a framework for documenting the process during 2023. In particular, the questions sought to encourage RWL hosts to identify and approach stakeholders at different levels of government, but also from existing forums or networks, and at the community level (in efforts to build foundations for transdisciplinary knowledge co-production).

In March 2023, the Risk-Tandem approach was introduced to RWL hosts with a briefing note (see D3.1, Annex V) and a slide deck to prepare for the RWL activation workshops. This included a description of the knowledge co-production process and associated steps for facilitating engagement under DIRECTED. This guidance was piloted with the hosts of the Emilia-Romagna (RWL 2) region who were in the process of arranging their first workshop, and was later shared with partners in Copenhagen (RWL 1) and Rhine-Erft (RWL 4). By April 2023 (M8), RWLs from Copenhagen, Emilia-Romagna, and Rhine-Erft had delivered the

[5] https://weadapt.org/wp-content/uploads/2024/08/Tandem-Guidance-2024-final.pdf

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activation workshop with their selected stakeholders, and all had signed stakeholder agreements – thus officially launching DIRECTED through their living labs.

During March and April 2023, WP 3 and WP 4 also organized joint support calls for the RWLs, in efforts to begin scoping their needs (especially in terms of facilitation) and the implementation of Risk-Tandem, in efforts to maximize coordination between partners and the lab as the planning for further workshops took place). In the case of Rhine-Erft, many of these consultations focused on the General Assembly that was to be held in September 2023, with a particular focus on integrating co-production-based risk governance methodologies and activities into the agenda. On the other hand, some meetings focused more on scoping the risk governance context, such as with the Danish team. Scoping activities continued in June 2023 with the Danube (RWL 3), as WP 3 and WP 4 sought to establish contact with the hosts with a meeting seeking to assess progress and challenges the hosts have met in trying to coordinate the lab in Vienna, and its sub-labs in Hungary and Serbia.

Based on the engagement and emerging needs from the RWLs during Q1 and Q2 of 2023, the first capacity development module was developed, with an intention to provide a more practical approach to operationalizing knowledge co-production within risk governance approaches (see D1.2). Although providing a brief theoretical premise describing the linkages between complex risks and knowledge co-production, it also included an engaging exercise on Miro that could be translated into a risk scoping exercise in RWLs (in alignment with Tandem *phase 2: co-exploring context,* noting that the Tandem co-production cycle guides the timing of activities for the wider implementation of Risk-Tandem). The activity as introduced in the module was also implemented by the RWL in Emilia-Romagna in their risk scoping and prioritization workshop.

The refinement of the DIRECTED approach to knowledge co-production continued with the Capacity Development Strategy for training of trainers (D1.2), first full draft of which was finalized in July 2023. Linking to the Risk-Tandem Framework – and its practical implementation in particular – the strategy outlined an approach to enabling "triple-loop learning" with the potential to drive systems change from the bottom-up. By placing knowledge co-production and stakeholder engagement at its core, the strategy seeks to inform the development of capacity development modules and other activities that can aid RWL hosts to develop clear and actionable plans through knowledge co-production with their stakeholders, and support the integration of the Risk-Tandem (and Tandem) into planning. Importantly, the strategy was tentative and designed as an iterative guide that could be leveraged to meet emerging needs, instead of acting as a prescriptive task that each of the labs must follow. As such, the process of implementation has led to some changes and delayed timelines for implementation based on RWL feedback.

In August and September 2023, mainstreaming of knowledge co-production focused on planning activities for the General Assembly organized in Cologne in September, 2023. This entailed the development of activities supporting the co-exploration of the RWL risk and risk governance context, with the intention to nurture a deeper understanding of the issues between partners, other RWLs and their hosts (particularly between partners and WP 5, who are primarily responsible for the development of the Data Fabric). WPs 3 and 4 also jointly organized a serious game *Breaking Silos* intended to instigate discussions around complexity,

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communication, knowledge integration, and coordination with the help of a hypothetical DRR and disaster management scenario (see blog post[6]).

Following the creation of the Capacity Development Strategy (D1.2), planning for semi-structured scoping interviews began (M4.2, *Scoping consultations with RWL and mapping of capacity development needs)* in October 2023. A questionnaire (D1.2, Annex III) was developed based on the Risk-Tandem Framework and Capacity Development Strategy, supported by Tandem questions to maintain a focus on integrating knowledge co-production within all RWL stakeholder engagement processes. Scoping interviews were conducted during Q4 of 2023 with all RWLs.

4. RWL – challenges and opportunities

During 2023, the process of mainstreaming Tandem began within the Risk-Tandem Framework in efforts to structure and guide knowledge co-production within risk governance contexts, and embed these practices into existing mechanisms, tools, and approaches. Contrary to previous case studies where Tandem has been applied, however, DIRECTED utilises a Training of Trainers approach, under which the Real World Lab hosts are trained to the apply Risk-Tandem Framework (by designing and facilitating knowledge co-production processes). Thus, the process is almost entirely locally led, and researchers act in a supporting role by providing guidance, capacity development, and responding to emerging needs. This represents new challenges and opportunities not only for the refinement of the Tandem in risk governance and data interoperability contexts, but also in terms of evaluating how the Framework is applied in practice, in the absence of researchers designing, developing, or implementing it. This chapter provides a brief overview of findings from RWL engagement during 2023, with an emphasis on the challenges and opportunities for further cultivating Tandem and knowledge co-production processes to support their application within DIRECTED RWLs.

4.1. Identifying and engaging stakeholders

Activities during 2023 focused primarily on setting up the labs, and arranging introductory meetings. As such, informal interviews, online engagement, and presentations have characterized the engagement thus far. As described with partners in Emilia-Romagna in D1.1, the process has been slower than expected given the high numbers of organizations involved, and in Vienna, maintaining the interest of stakeholders has been difficult since the project is slow, and outputs are not immediate (discussed during scoping consultations). In Copenhagen (RWL 1), debriefing with hosts in March 2023 revealed that whilst emergency responders knew each other, planners had had no previous contact with them (thus

[6] Blog post on the Breaking the Silos game application with the RWLs: https://directedproject.eu/blog/breaking-the-silos-towards-knowledge-co-production-in-real-world-lab/

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necessitating the building of new relationships to begin co-production processes). Therefore, the introduction of new methods must be planned carefully, and staged according to context: in Zala county (RWL 3), for example, it was noted that stakeholders are not accustomed to working in a "co-productive mode" (noted during scoping consultations).

Stakeholders engaged: Given the locally led nature of the implementation of Risk-Tandem and knowledge co-production, DIRECTED partners have limited influence over the process and stakeholder engagement. During Q1-Q3 of 2023, WP 3 and WP 4 continued to provide their support for stakeholder engagement – including with a guidance note with an integrated Tandem questionnaire intended for transdisciplinary engagement. During 2023, however, challenges associated with this "hands-off" approach have already emerged. For instance, thematic analyses assessing stakeholders as outlined under D1.1 revealed that of the 65 organizations involved to date, 36% represent municipal authorities, followed by regional authorities (26%). In addition, 21% of the stakeholders involved operate at the national level. Put together, 83% of all DIRECTED RWL actors are affiliated with their country governments. In addition, there are no vulnerable groups/persons at risk are not represented in current deliberations, and socio-economic vulnerabilities are not considered as a priority in any of the RWLs. Consequently, questions regarding representation remain unaddressed (including in the dimension of gender).

Knowledge systems engaged: Currently, RWLs have a heavy preference in supporting preparedness for disaster response, particularly in the cases of Copenhagen (RWL1), Emilia-Romagna (RWL 2). Given the nature of stakeholders involved, the knowledge systems are also practice-based and technical – although the specific nature of specialist knowledges involved is currently unmapped. Supporting the Data Fabric via the development of shared language and terminology through taxonomies (WP 2) will be a focus during upcoming engagements, building on guidance (Barrott et al., 2020) developed in the PLACARD[7] project, upon which DIRECTED builds. WP 5 is geared toward understanding the technical aspects of modelling approaches involved in the project; integration of knowledge co-production into this task will become crucial to support both the relevance and the usability (and interoperability) of data.

4.2 Scoping risks, vulnerability and impacts

Currently, socio-economic challenges and vulnerability issues are not addressed under any of the RWLs beyond concerns regarding loss and damages, or impacts to infrastructure and housing. Across all documents assessed under the thematic review, references to socio-economic vulnerability appear four times. It appears that no data regarding socio-economic vulnerabilities are available (besides data regarding the exposure of economic assets and infrastructure). Wider socio-economic challenges relating to disaster and climate vulnerabilities in each RWL working context remain undiscussed. Findings from 2023 are briefly summarised here.

[7] https://www.placard-network.eu/

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Challenges identified relating to risk governance include risk communication and public engagement (RWL 2/3), collaboration and coordination of stakeholders in polycentric risk governance settings (RWL 1/RWL 2/RWL 4), and cultivating public and private partnerships (RWL 3). In terms of communication, RWL hosts have noted that language barriers are an issue (especially in terms of facilitating engagements between partners and the labs), and may constitute problems in terms of data analysis. The lack of formalized mechanisms for multi-scalar communication have also been highlighted in each lab, thus providing a potential entry point (and a challenge) for Tandem. In terms of disaster and climate risks, all the labs emphasize coastal and riverine flood risk management at the expense of multi-hazard approaches and medium to longer term climate risk. Most data and available model capacities are also dedicated to flood risk modelling and short-term projections. However, there is emerging interest in accommodating drought risk management (RWL 1, RWL 3), and wildfires (RWL 2 and RWL 3, Zala County), which could provide an opportunity for further scoping and co-exploration. Socio-economic impacts, vulnerability concerns and other underpinning risk factors also require further exploration.

In terms of adaptation and risk reduction challenges, emerging concerns include emphasis on response among the RWL stakeholders at the expense of longer-term DRR and climate resilient planning (RWL 1 and RWL 3). Regarding the integration of CCA, hosts of RWL 1 pointed out that whilst appetite for such work exists, lack of policy frameworks, national level guidance, financing and issues of coordinating tasks limit their effectiveness in practice (as discussed in workshop debriefs). In RWLs 2 and 3, a challenge for local governance regarding DRR and CCA is limited capacity to coordinate and support multiple stakeholders in planning, and the lack of experience among stakeholders to incorporate considerations for climate risks (described as “lack of awareness” in D1.1). In Zala county (RWL 3), the impacts of droughts and floods have necessitated the development of shared sustainable water management strategies incorporating aspects of CCA, together with local authorities and other stakeholders (D1.1). Landslides in the region are also a recently emerging risk, yet to be addressed.

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5. Evaluating Tandem

For assessing and evaluating the effectiveness of the Tandem co-production approach in DIRECTED, this milestone will use the same methodology to compare and assess RWL needs, potential entry points and barriers that may hinder the implementation of activities as intended under DIRECTED. It gathers data from activities as described under section 2, as well as the Deliverable 1.1, and findings from workshops/interviews arranged by the RWLs.

Where possible, qualitative data from these engagements was added to AtlasTI software, and an abductive thematic analysis (Thompson, 2022) was conducted to code source material to identify emerging themes and commonly shared challenges (or opportunities) across the RWLs in various categories that naturally emerged from the data (D1.2, Annex VII). Coding was followed by thematic categorization, following the most recent Tandem co-production phases (Table 1) and guiding questions of the Tandem framework[8] (Bharwani et al., 2024), during which codes were consolidated into wider semantic and conceptual themes, encapsulating a multitude of information to effectively portray phenomena (such as "challenges of risk governance", "challenges to co-production", or "hazards"). Though not all identified codes and themes appear to relate to co-production per se, they were included in the analysis given that the purpose of Tandem in DIRECTED is to integrate co-production within risk governance activities through Risk-Tandem (D3.1). The approach to coding – which will continue to evolve – is available in D1.2 (Annex VII). The codebook itself is not included as it is a living document.

To support the qualitative data analysis and Tandem approach, questions were coded into specific evaluation categories ("sub-codes") that can provide information about its theoretically 'optimal' integration toward impact and change ("impact codes") (Table 2). However, considering the early stages of implementation – and since much of 2023 was dedicated to operationalizing the labs – this milestone does not yet assess or evaluate impacts, but focuses on the design of the evaluation approach using Tandem phases and associated questions. Combining the coding frameworks from Tandem and the inductive approach emerging from data from the RWL will allow a comprehensive evaluation of the effectiveness and quality of the co-production process throughout DIRECTED. Results from this analysis will be documented in subsequent milestones (M16-18). Thus far, data mainly focuses on Scoping/reviewing risks, vulnerability and impacts, and Identifying and Engaging stakeholders (Figure 3). Tandem guidance has been coded with the integration of considerations for risk reduction and governance as appropriate (Table 2).

[8] https://weadapt.org/wp-content/uploads/2024/08/Tandem-Guidance-2024-final.pdf

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Table 1: Tandem co-production phases. Source: Bharwani et al., 2024.

Element	Description and notes on application
Scope, review identify and engage *The processes in Element 1 can lay the foundation for deeper discussions of challenges, goals, governance and information needs in Element 2.*	
1 a) Scope and review risks, vulnerabilities, challenges and decision context (optional, not always needed)	Initial scope and review of the risks, challenges, climate information and decision context (climate and non-climate).
1 b) Identify relevant actors, affected groups, decision makers and champions	This element helps to identify and engage relevant actors and champions and can begin to nurture new collaborations and partnerships that sustain beyond the lifetime of the project.
1 c) Engage relevant actors & champions	Many of these questions will be returned to in later stages and understanding of the issues increases.
Co-explore – go deeper *Questions on socio-economic challenges (Element 1) are equally important to cover (even if the scoping stage is not needed because previous work has been done), so they are also included in Element 2.* *This is an opportunity to delve deeper into some of the same questions with the targeted group of stakeholders that has been identified in Element 1.* *This may start to reveal some context-led impact indicators for monitoring progress towards achieving shared resilience goals.* *Many of these questions will be returned to in later stages, as understanding of issues, capacity and confidence increase.*	
2 a) Co-explore challenges and goals	This early stage may provide opportunities to co-develop context-led impact indicators with stakeholders for monitoring progress towards achieving shared goals.
2 b) Co-explore governance context	Consider the different types, scales and levels of participation, engagement and knowledge in decision-making when co-designing co-production activities. Also consider risks of maladaptation, compound and cascading risks.
Co-design solutions	
3. Co-explore, identify, appraise and co-design solutions	Appraisal should include consideration of uncertainty, maladaptation, compound and cascading risks, synergies, trade-offs and co-benefits.
Integrate new knowledge and partners	
4. Apply iterative and reflexive learning to deepen understanding of adaptation challenges. Monitor progress towards goals as confidence, knowledge, relationships and capacity increase.	MEL considerations should be integrated throughout the elements above and any learning should further refine and hone iterative co-exploration and co-production processes. Regular and systematic feedback mechanisms are established.
Cross-cutting elements and benefits provided by the processes above	
Communication	Tailored communication of climate and other information to meet user needs with appropriate, relevant formats and terminology.
Capacity development	A focus on developing the capacity of providers to understand the decision context as much as the capacity of stakeholders to understand the use and limits of climate information.
Partnership development	Strengthened relationships, partnerships and networks can be a valuable outcome and sustainable legacy of the co-production process.
Financing models	Strategy to sustainably embed, operationalize and institutionalize the climate service.

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Table 2: Tandem qualitative coding framework.

Tandem Element	MEL Element[9]	Theme	Sub-code	Impact code[10]
Scope, review identify and engage	Context-based	Risks, vulnerability and challenges (climate and non-climate)	Natural hazards/disaster risks	Holistic overview of risks and vulnerabilities.
			Climate and disaster risks	
			Non-climate/disaster risks	
			Socio-economic vulnerabilities	
		Impacts	Natural hazards/disasters	Holistic overview of impacts.
			Environmental impacts	
			Climate and disaster impacts	
			Non-climate/disaster impacts	
			Socio-economic impacts	
	Pluralistic	Identified and engaged relevant actors and champions	Stakeholders relating to climate/risk information and data	Increased awareness and understanding of knowledge and stakeholder landscape.
			Stakeholders involved in decision-making process	
			Stakeholders vulnerable/at risk	
			Knowledge systems engaged with	Improved communication (e.g. trust, dialogue, co-production, language).
			Methods of engagement used	
		Co-explore challenges and goals	Socio-economic challenges (e.g. income, education)	
			Decision-making challenges (e.g. representation, responsibilities, data)	
			Communication challenges (e.g. language, terminology, channels)	

[9] Norström et al., 2020.
[10] Potential results from application, not assessed in this milestone.

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Co-explore	Goal-oriented		Adaptation challenges (e.g. climate, social, economic, political, environmental)	Creating shared understanding - consensus building around priorities, where it was absent previously, for example.
		Co-explore governance context	Windows of opportunity	Increased understand of governance levers of change.
			Institutional capacity/arrangements	
			Existing plans, policies, and projects	
			Governance mechanism	
			Funding	
		Co-explore information needs	Appropriate format	Increased awareness and understanding of challenges, risks, and impacts faced through enhanced understanding of the use and limits of data/models.
			Relevant language	
			Accessible terminology	
			Capacity to articulate needs	
			Information channel	
			Appropriate scales (relevant to temporal and spatial scales of decision)	
Co-design solutions		Co-explore and identify solutions	Relevant to decision context	Solutions that provide increased resilience to climate and disaster risk.
			Salience (priority need)	
			Credibility (trusted)	
		Appraise solutions	Preferences	Limiting interpretation due to underlying socio-cultural or technical assumptions. Creating prejudiced points of view.
			Uncertainty	
			Maladaptation	
			Compound risks	
			Cascading risks	
			Multiple hazards	
			Synergies or co-benefits	
			Trade-offs	

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			Assumptions	
			Cognitive bias	
		Co-design solutions	Applicability	Moving from useful to usable information.
			Usability	
			Desired needs met	
Integrate new knowledge and partners	Interactive	Communication	Tailored communication of climate information	Increased/continuous information sharing and exchange. More open modes of collaboration/communication.
			Tailored communication of non-climate information	
			Format	
			Language	
			Terminology	
			Capacity	
			Information channel	
		Capacity development	Capacities	Increased capacity and confidence of both providers and users of disaster and climate risk information.
			Confidence building	
			Increased understanding of the decision context	
			Increased understanding of the use and limits of climate information.	
		Partnership development	Strengthened relationships, partnerships and networks	Increased access to resources (e.g. information/networks/models).
		Financing models	Embedded	Sustainability and legacy.
			Operationalized	
			Institutionalized	

Tandem coding will be used to identify patterns and topics central for effectively implementing co-production within risk governance with the RWLs (and not evaluating performance of the RWLs *per se*). This structuring will also be used to reflect the ability of the Tandem questions to adequately structure the implementation of co-production in risk governance contexts, and to identify gaps or areas for improvement, with a particular focus on practice.

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6. Recommendations

As documented in this milestone, numerous opportunities and challenges have emerged from the RWL engagements, all with potential to inform and refine the Tandem framework in risk governance contexts and to enhance by data interoperability. However, as a non-prescriptive guide – applied through training of trainers and in the absence of co-production practitioners or researchers embedded in the RWL context (Taylor et al., 2021) – it is also at risk of falling short in achieving its intended goals unless challenges as described above, and in the comparative analysis are accounted for. The following priorities have been distilled for the remainder of project:

1. For RWL hosts, there is a need to: develop **facilitation skills guidance**; provide **practical examples** for knowledge co-production activities e.g. using serious games; and, provide suggestions for **structuring workshops**. Staff turnover during project lifetimes is a considerable challenge in designing and implementing long-term co-production processes, which require the capacity development of a wide range of participants to ensure institutional legacy (Bharwani, et al., 2024).

2. To provide evidence for further iterations of Tandem developed in closer coordination with partners, a clear MEL framework should be established for the co-production process that accounts for 'soft' or intangible outcomes of co-production, which make them challenging to measure (Bharwani et al., 2024). Thus, the knowledge co-production process with RWLs requires a co-designed **MEL strategy** for monitoring Tandem and its application through capacity development (see D1.2).

3. An approach is needed to expand the current set-up of the RWLs to cover **vulnerable groups/persons at risk**, and to assess them in terms of power relationships. For this purpose, tailored workshops and capacity development may be beneficial, alongside exercises dedicated to addressing sensitive questions (such as social network mapping for identifying power relations, or assessing questions of gender equality).

4. Currently, the Tandem guidance does not guide the mainstreaming of co-production to address questions such as **risk communication** or strengthening the delivery of early warnings at the last mile. In addition, clearer guidance is required to guide the integration of DRR and CCA through co-production with an assessment focusing on their synergies in situ. As such, Tandem can usefully be developed and adapted to guide the distillation of user needs to **enhance data and model interoperability** (D4.3) for DRM and CCA.

5. Explore ways to **build the capacity of providers** to understand the decision context as much as the capacity of stakeholders to understand the use and limits of climate information (Bharwani et al., 2024). Building capacity and bridging disciplinary and 'knowledge' divides will be achieved through the implementation of the capacity development strategy (D1.2).

6. **Strengthening institutional capacity,** particularly from a systems perspective to support long term change and sustainability, once the individual capacity of key stakeholders at different levels is achieved in DIRECTED, is a long-term ambition.

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