Stockholm Environment Institute

The Tandem framework: a holistic approach to co-designing climate services

SEI brief
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Key messages

- **Decision-makers under-utilize climate information. The situation calls for a fundamental shift: away from provider-led services *for* decision-makers, and to a collaborative approach working *in tandem* with decision-makers.**
- **The Tandem framework provides a holistic approach for the *co-design of climate services*. It engages intended users of services as *full* design partners collaborating with providers and intermediaries. The framework proposes iterative steps that the three parties can collectively use to inform, guide and structure their transdisciplinary interaction.**
- **Tandem embeds the co-design of climate services within the institutional and decision contexts in which they will operate to enhance their *usability, relevance, and sustainability* - all critical for climate-resilient planning underpinned by science, now and into the future.**

The basic premise: when climate scientists work in tandem with users, climate science is more likely to be incorporated into decisions and policies.

Background

Decisions underpinned by climate science are needed to respond to the global challenge of climate change and to meet Agenda 2030 goals. For example, farmers benefit from knowing the expected onset of rains, and policymakers benefit from understanding how the distribution of vector-borne diseases can shift with changes in temperature and rainfall. Despite the tremendous potential to integrate climate information into decision-making and planning, **climate services** (see Box 1) often remain poorly designed and under-utilized (Porter and Dessai, 2017). To address the "usability gap" (Lemos et al., 2012), climate information must be robust, relevant, and tailored to the needs, capacities, and institutional and decision contexts of the services' potential users (e.g., decision-makers, city planners and extension officers).

This brief considers climate services in their broadest context. Climate services can take many forms (i.e., models, assessments, participatory processes), and can support many types of climate-resilient planning and decision-making (i.e., adaptation, mitigation, disaster risk reduction). This brief focuses on climate services that support decision-making for adaptation (hereafter, decision-making or decisions). Though the brief largely targets climate information providers (e.g., climatologists, meteorologists) and **intermediaries** (e.g., adaptation and learning specialists, natural and social scientists) - the two groups *currently* leading climate service design processes - it should prove useful in empowering decision-makers to lead, plan and take action.

Photo (above): Multi-person tandem bicycle © 123DUCU / GETTY

This brief includes:

- a summary of key barriers to the use of climate information, specifically for adaptation planning and decision-making;
- an explanation of why collaborative and iterative processes are important for effective climate service design;
- a new framework, "Tandem", to inform, guide, and structure interaction between the providers of climate information, intermediaries, and users; and
- an urban water-security planning example from Lusaka, Zambia, that illustrates the added value of the Tandem framework.

Barriers to climate information use

Climate change adaptation research has been slow to impact policy and practice (Klein and Juhola, 2014, Lemos et al., 2012). Table 1 provides an overview of key barriers to the use of climate information in adaptation decision-making. These factors increase the likelihood that decision-makers find climate services incomprehensible or irrelevant, and make decisions that lack relevant scientific underpinning.[1]

Table 1.

Theme	Barriers to climate information use, particularly in the global South	Selected references
Lack of demand for climate information from decision-makers	• Decision-makers underestimate the potential value of climate (and other) information in decision-making processes. Information may be used in a limited way or unused in decision-making processes in some contexts, and thus not demanded or seen as a need. • Decision-makers may perceive climate change as less of a pressing issue relative to other urgent challenges (e.g. water and energy insecurity, growth of informal settlements, rising disease epidemics, etc.) and may not see or make the linkages between these issues and climate.	Brasseur and Gallardo, 2016; Vaughan and Dessai, 2014
Limited capacity of providers and user	• The user community has insufficient technical, analytical and institutional capacity to interpret and use climate data and information. • Providers may have a narrow perception of user types (i.e. those that are highly technical and numerate like themselves) and thus a limited understanding of users' varying (and potentially limited) capacity to understand and interpret climate data.	Klein and Juhola, 2014; Lemos et al., 2012; Porter and Dessai, 2017; Singh et al., 2017; Vaughan and Dessai, 2014
Mismatch between research and decision-making needs	• There is a "usability" gap between what providers understand as "useful" information and what users recognise as "usable" in their decision-making. • There is a mismatch between the spatial and temporal scales of climate projections and those of decision-making and policy-making needs and timescales. • Providers have incomplete understanding of complex decision contexts and an underestimation of the value of integrating different knowledge types (e.g. indigenous knowledge).	Brasseur and Gallardo, 2016; Klein and Juhola, 2014; Lemos et al., 2012; Singh et al., 2017; Vaughan and Dessai, 2014
Weak interaction and engagement	• Interactions and relationships among providers and users are limited, weak or ad hoc. Engagement between providers and users may be insufficient in quantity, quality, or both.	Brasseur and Gallardo, 2016; Lemos et al., 2012
Lack of trust and meaningful communication	• Users can view scientific information and its providers as lacking credibility and legitimacy. • Scientific terminology, language and concepts used by providers are not easily understood by users. Providers' communication about and explanation of underlying assumptions and concepts (such as uncertainty) is insufficient. • Users face confusion arising from multiple sources of information, inconsistent results, and inaccessible formats in which information is communicated.	Brasseur and Gallardo 2016; Cash et al., 2003; Lemos et al., 2012; Vaughan and Dessai, 2014
Data availability and access	• Data availability and reliability may be poor (e.g., there are gaps in historical observational records). • Users face restricted access to information, including through gender and power imbalances.	Singh et al., 2017; Tall et al., 2014
Lack of funding	• Climate services face inadequate funding levels, and lack viable business models. • Decision-makers often have short-term priorities, with limited financial resources or incentives to address long-term issues. • Participants lack and underestimate the high level of resources required to undertake co-production processes.	Brasseur and Gallardo, 2016; Vaughan and Dessai, 2014; Vincent et al., 2018

1 The list in Table 1 is not exhaustive; addressing barriers to furthering pure climate science is beyond the scope of this brief.

A collaborative process for the co-design of climate services

Traditional supply-driven climate services establish a one-directional, science-to-policy relationship that has seldom led to policy action. A call is growing for a new approach, for climate services to evolve by producing and sharing information through a collaborative *demand-and-decision-driven* relationship. Research shows that, with some caveats, **co-exploration, co-production** and **transdisciplinary approaches** create knowledge that is more relevant for users (Bremer and Meisch, 2017; Meadow et al., 2015; Taylor et al., 2017), and, thus, is more likely to be used. A key aspect of such approaches is collaboration and partnership between different stakeholders (e.g. climate scientists, impact modellers, social scientists, adaptation and learning specialists, decision-makers and planners).

A shared and iterative co-design process can build stronger relationships and strengthen both individual and institutional capacities. Providers are likely to gain greater insight into users' information requirements and decision-making complexities; users are likely to enhance their understanding of climate projections and data, and their capacity to deal with the associated uncertainties or limitations (Lemos et al., 2012; Lemos and Morehouse, 2005; Tall et al., 2014).

We recognize that the resources and capacities required to undertake intensive **co-exploration** and **co-production** are limited, particularly in global South contexts, even if the benefits of such engagements are acknowledged (Singh et al., 2017; Vincent et al., 2018). Innovative ways to address these constraints need to be factored into co-design processes.

The Tandem framework

Consider a tandem bicycle. Two people with differing skills, styles, and fitness levels need to overcome these differences to pedal in harmony to move forward to reach a given destination. To achieve this, riders need to communicate with one another, and to adapt their individual approaches, learning as they go, perhaps somewhat tentatively at first, until a rhythm is set. The alternative - for each rider to embark on a solo journey at her own pace and style – may seem easier. But independent riders on such journeys face risks. Riders who find themselves adrift from a fellow rider may lose their way, or they may choose different endpoints as events unfold along the way. Indeed, without close communication en route about complications (traffic, road closures, weather, for example), independent riders may never reach the same destination.

This is the philosophy that underpins the tandem concept. Providers driving a climate service design process may ultimately steer in a direction that suits their purposes, but this direction may not necessarily be relevant or usable for intended users – rendering it ineffective for decision-making. Working *in tandem* with users, while more challenging, ultimately reduces this risk. Going on the journey together promotes a shared understanding of obstacles, and fosters greater collaboration and learning along the way.

The Tandem framework is an iterative, holistic, process that draws on lessons learned from scientific literature and ongoing SEI research, including a climate services-related project in Lusaka, Zambia.[2]

Tandem proposes steps that providers, intermediaries and users can collectively use to inform, guide, and structure their transdisciplinary interaction. Neither prescriptive, nor exhaustive, Tandem guides a wide range of actors *through an iterative process* of working together to co-design effective climate services. Crucially, Tandem embeds the design of climate services within the decision and institutional contexts in which they will operate to enhance their *relevance*, *usability* and *sustainability*. We use urban water security planning in Lusaka, Zambia, as a case example of the design of participatory processes and engagements that support climate information use. While we use a global South water security example here, we see Tandem as being applicable and relevant to other regions and decision contexts.

BOX 1. WHAT ARE CLIMATE SERVICES?

As an emerging field, climate services remain subject to diverse definitions (Vaughan and Dessai, 2014). The Global Framework for Climate Services (GFCS) defines such services as providing "climate information to help individuals and organizations make climate smart decisions" (WMO, 2019).

The European Commission Climate Services Roadmap describes the "transformation of climate-related data - together with other relevant information - into customised products … and any other service in relation to climate that may be of use for the society at large" (EC, 2015:10).

Decision-makers' agendas include many other (often interlinked and interacting) priorities and issues in addition to climate change. As such, we consider *effective* climate services to facilitate the *sustained use* of *relevant* climate (and other) data and information for better informed planning and decision-making.

2 Part of the Future Climate for Africa programme, Future Resilience for African CiTies And Lands (FRACTAL) is a UK-funded (Department for International Development/Natural Environment Research Council) project, using transdisciplinary approaches to co-create climate information with decision-makers in nine cities in southern Africa.

The framework steps:

The framework includes seven steps, although we suggest that a certain level of iteration is required between particular steps; as such, some steps are presented in pairs. The example, shown in italics for each pair of framework steps outlined in this brief, is designed to illustrate how providers, intermediaries and users can use the steps to guide and structure their approach to co-design.

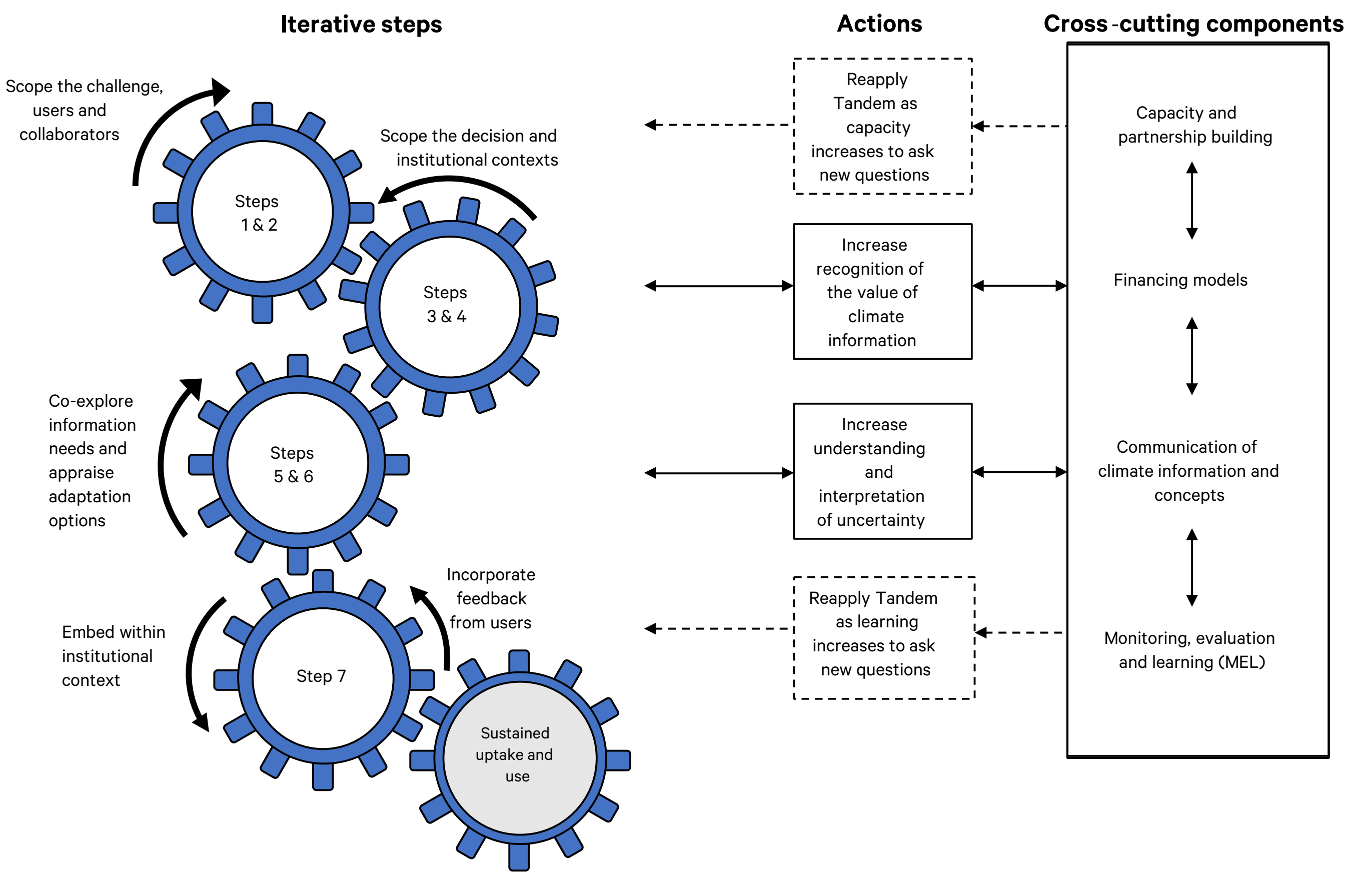
Step 1: Identify the adaptation challenge(s).
Step 2: Identify and engage with potential users and other collaborators.

Identify and build a shared understanding of the "adaptation challenge" that could benefit from the use of climate information. This involves co-exploring interlinked issues and drivers of change (both climate and non-climate; current and projected) with relevant actors. Identify actors (i.e. potential users of a climate service) who have a decision-making role, or who can influence the adaptation challenge and broader system. This requires iterative engagement and scoping of issues and actors from the general to the more specific to identify:

- potential users of a prospective climate service - and a subset of these to engage with more deeply during the co-design process; and
- other providers and intermediaries with whom to collaborate.

Local intermediaries may be critical to facilitate the sharing of different knowledge types (e.g. indigenous/traditional, practice-based). These may be representatives of local initiatives, research institutions, NGOs or Community-Based Organizations (CBOs) that may not initially identify themselves as intermediaries.

Figure 1. Iterative steps of the Tandem framework for co-designing climate services.



In Lusaka, initial scoping meetings and transdisciplinary workshops, known as Learning Labs (Arrighi et al., 2016), were held to co-explore "adaptation challenges" with a broad range of stakeholders and networks, including representatives from: various departments in the city council, water utilities and regulators, disaster risk management units, national ministries, meteorological services, and civil society organizations, such as the Zambia Homeless and Poor People's Federation. Participants took part in issue and actor mapping. Stakeholders prioritized two key adaptation challenges: water insecurity, particularly in peri-urban areas, and limited access to safe drinking water.

Step 3: Gain understanding of desired objectives, and identify early actions and existing services.
Step 4: Build understanding of institutional and decision contexts.

Iteratively scope the decision(s) that the climate service needs to support, and the institutional arrangements required for this support. These steps require co-exploring: users' objectives, priorities, decision-making approaches and constraints; relevant policies, processes or projects; and, "windows of opportunity" in the decision/policy cycle (Watkiss, 2015). Consider the advantages and shortcomings of existing climate and related services (e.g., existing forecasting or early warning services) that could be adapted or better tailored to user needs. Identify relevant governance arrangements for embedding a climate service within local, regional, or national institutions for long-term use. This requires finding or creating opportunities for coordination between information producers, managers, communicators, translators, packagers and (potentially) multiple users. This will require exploring and addressing constraints (e.g. a lack of financial or human resources) that may act as obstacles. These constraints will shape the nature and ambition of objectives that can be set.

Shared objective(s) and joint ownership of the process will support the co-development of indicators to monitor and evaluate the effectiveness of the climate service (see monitoring, evaluation and learning (MEL)). MEL activities should start early, once a shared objective has been co-defined. The goal may evolve as users (and intermediaries) strengthen their understanding of climate information, uncertainty and capacities, and as providers gain a deeper understanding of user needs. As such, it is important to iteratively reflect on and refine the objective(s) of the climate service.

The Lusaka Water Security Initiative (LuWSI), a collaboration of public, private and civil society actors was identified early as a key network to engage. As an influential institutional arrangement, LuWSI leads the development of a Water Security Action and Investment Plan (WSAIP). This is a key "window of opportunity". The WSAIP will feed into the ongoing Local Area Planning processes being led by the Lusaka City Council. As such, co-produced climate information could help directly address the adaptation challenge of water insecurity in peri-urban areas.

Step 5: Co-explore data and information needs, sources, formats and modes of dissemination.
Step 6: Appraise adaptation options.

Iteratively co-explore decision methods and (climate and non-climate) data and information needs, sources, formats and modes of dissemination. The availability of climate (and other) data and information (Step 5) can inform the selection of decision-support method(s) (Step 6), which, in many cases, will also inform the variables and format of data and information required.

Co-exploring users' specific needs provides insight into particular parameters, scales and preferred formats of climate data and information, and highlights requirements for integrating these into existing planning tools or impact models. Discussing risk maps, time series, narratives and visualizations, for example, enhances users' awareness of the range of data, information and formats available; and develops their capacity to understand and interpret this information and its limitations. The modes used to share information are important and may vary widely between users.

BOX 2. KEY DEFINITIONS

Co-design: providers, intermediaries and users work together to design a climate service based on a shared understanding of decision-making needs and complexities, and individual and institutional capacities.

Co-exploration: a participatory process that explores different knowledge types to develop a shared understanding of concerns and needs (e.g. from scientists, decision-makers, planners, researchers and adaptation and learning specialists).

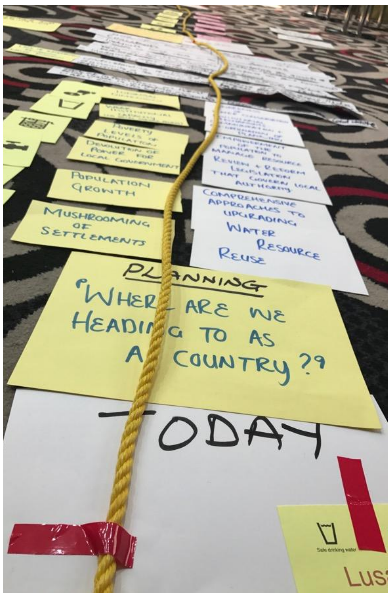
Co-production: a process in which providers and users work together (often with the help of intermediaries) to combine different knowledge, skills and practices to create new, relevant knowledge that meets the needs of users, and addresses a shared concern or need (Taylor et al., 2017; Vaughan & Dessai, 2014).

Intermediaries: actors who "translate" between providers and users. Examples include adaptation and learning specialists, project managers, consultants and researchers.

Learning Labs: engagement processes designed to co-explore climate information needs with a wide spectrum of providers, intermediaries and users, through serious games and participatory exercises.

Transdisciplinary approaches: approaches that value and integrate different knowledge types from both science and society to create new knowledge.

A range of decision-support methods, from participatory approaches through to more structured, formal methods or economic analyses, [3] is available to help users identify, appraise and prioritize a set or sequence of interventions ranging from early to future adaptation actions and strategies. These methods include probability-based approaches; approaches that consider both quantitative and qualitative data in the ranking of alternative options; and analytic, scenario-based approaches (which perform well over a wide range of futures, and under conditions of deep uncertainty, when little or no probabilistic information is available). The understanding of users' priorities, objectives and approaches to making decisions (steps 2-4) will guide the selection of appropriate methods, as will the availability of data and information.



Outputs from a visioning exercise held at a Learning Lab in Lusaka, Zambia, as part of the FRACTAL project.
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The Kafue River is critical for Lusaka's water supply. Civil engineers and city stakeholders co-developed a hydrological model to explore the future potential of the Kafue River to satisfy Lusaka's water demand (Ilunga, 2018). Participants in Learning Labs co-defined system performance thresholds such as, for example, the ability of water supply to meet 80% of demand.

To assess the system's resilience across a range of climate, demographic and water-use change scenarios, a decision-scaling [4] approach (ibid.) was selected both to address data sparsity and to incorporate a bottom-up, participatory approach. Risk maps showing these results were coloured using a simple traffic-light rating to clearly communicate key messages to city stakeholders.

Results indicated that the water available in the Kafue River is sufficient to meet Lusaka's demand. Further increases in temperature (1-2° Celsius) will, however, reduce hydropower reliability (and, thus, the ability to pump available water to Lusaka) to below 70%. Reductions in rainfall will reduce this further to near 60%. Increases in rainfall will maintain reliability at around 80% or above.

Learning Lab participants reflected on the model's assumptions, such as increases in total city population, reductions in peri-urban population size, and reductions of non-revenue water (i.e. the improvement of bulk water infrastructure to limit water losses). When co-exploring the nature, use, value and impact of climate information for planning processes, such assumptions require careful reflection with stakeholders (as supported by the Learning Lab process).

Step 7. Maintain, evaluate and upgrade the service.

Explore how a service can be institutionally embedded, evaluated and refined as user needs evolve. There should be mutual agreement on actors' roles and responsibilities for regular and systematic feedback mechanisms (i.e. obtaining, collating and acting upon feedback to refine services). Changes in the scope of a required climate service, or in the scale or composition of users identified through MEL activities, may result in the need to re-apply the full process, to ensure that the service meets the needs of these different users and circumstances (Carr et al., 2017). Sharing evidence of use, and the value of that use with other users and donors, can encourage institutional embedding and further funding of the service.

LuWSI is committed to integrating policy recommendations co-created with stakeholders through the Learning Lab participatory processes that have supported climate information understanding and uptake. The ongoing, collaborative Local Area Planning processes mean that uptake of the co-created climate information is more likely to occur.

Cross-cutting components

The co-design process continuously highlights four cross-cutting components to maximize the potential to institutionally embed a climate service for long-term use:

- **Communication of climate information and concepts.** How information is packaged and communicated (e.g., risk narratives/stories/infographics/climate plots) to differentiated users

3 For reviews of a range of decision-support methods see FRACTAL Working Paper "Research Methods for Understanding and Supporting Decision Processes in African Cities" (Taylor et al., 2017) (https://bit.ly/2ZjvzJ1), Choosing salient approaches and methods for adaptation: Decision Support Methods for Adaptation" (Bisaro and Hinkel, 2013) (https://bit.ly/2vb4cmx).

4 Decision scaling is a bottom-up, stakeholder-defined approach that connects "bottom-up" vulnerability analysis with "top-down" climate model information.

(e.g., women, the elderly, and minority groups) can critically affect buy-in for use. That is, some may prefer to use or have limited access to certain formats, channels or modes of communication. Technical staff and senior decision-makers will also likely have different needs and preferences. Technical staff may seek further information on issues of uncertainty. Senior decision-makers may have greater interest in understanding emerging risks and the value (i.e. socio-economic benefits) of acting based on climate information.

- **Capacity and partnership building.** The co-design process will highlight institutional and individual capacity gaps and needs of providers, intermediaries and users. These gaps, which will vary by actor and context, may be technical (e.g., interpreting climate data or impact model outputs) or operational (e.g., co-exploring user needs, communication and collaboration between relevant actors). The co-design process will, in itself, enhance capacities of all involved stakeholders. Collaborations and partnerships will be needed: it is unlikely (and undesirable) that a single provider or intermediary can cover all steps or design considerations without the support of and collaboration with others.
- **Developing a sustainable financing model.** Potential funding sources and the development of a sustainable business model for the continued delivery of a climate service should be considered early - particularly given that existing financial resources may be limited. Such focus is imperative for services to be accessible to users, and to support continued improvement as user needs and technical capabilities evolve, as highlighted by continued MEL. To drive discussions around funding, all involved must recognise the value of climate information, and the economic and/or social benefits of taking "early action" using climate information. Applying a MEL framework can provide robust evidence pinpointing where the climate service supports decision-making in practice (see below).
- **Building in monitoring, evaluation and learning (MEL).** MEL activities need to be integrated throughout the design process, and embedded within its longer-term delivery. Co-developing indicators of effectiveness for both the design process and the service itself, and co-designing appropriate feedback mechanisms with users, including differentiated user groups, are critical. This feedback should deliver learning that will not only drive improvements to the service as user needs and capacities evolve, but also promote good research and practice in the climate services community.

Conclusion and discussion

Encouraging a transdisciplinary approach, the Tandem philosophy and framework integrate the strengths of different disciplines and actors to support a holistic and iterative co-design process. While the engagement of wide-ranging actors, and the integration of different (and potentially competing) perspectives and knowledge may present challenges, such collaborations promote the innovative thinking needed to create effective climate services (Blome et al., 2017). By emphasizing coordination and partnerships, and building on existing services and institutional structures where possible, this approach encourages uptake and sustainability, and potentially reduces stakeholder fatigue, wasted time, and misspent resources.

We acknowledge the fundamental tension that exists in the balance of power between providers, on the one side, and users of their services, on the other. Our decision to focus primarily on reaching providers and intermediaries reflects the nature of funding opportunities and capacities that put them in the driver's seat - rather than a view that the Tandem approach is somehow less valuable or less relevant for other participants or end users. To the contrary, the Tandem framework offers a powerful vehicle for such users to assess whether they are being included as full design partners, and to advocate for changes where they see the need. Evidence showing that many data- and supply-driven approaches fail to gain traction suggests that new approaches are needed. The concepts put forward here require humility on the part of scientific experts, their willingness to empower users, and a fundamental rethinking of what constitutes "expertise."

Applying Tandem could underpin adaptation planning and action at a range of scales and in different contexts, among them: supporting climate-resilient cities, climate proofing infrastructure, increasing the use of seasonal forecasts in farmers' planning, and enhancing the robustness of national or sector development plans. Partnerships in Southeast Asia, Latin America, Sub-Saharan Africa and Northern Europe are testing the Tandem approach, [5] and the findings are likely to spur further refinement of the steps that underpin the framework.

Participants at a FRACTAL engagement in Lusaka, Zambia, play a game designed to create a shared understanding of common terms used by climate scientists, social scientists and city planners. © FRACTAL

5 Through the SEI Climate Services Initiative.

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References

Arrighi, J., Koelle, B., Besa, M. C., Spires, M., Kavonic, J., Scott, D., Kadihasanoglu, A., Bharwani, S. and Jack, C. (2016). *Dialogue for Decision-Making: Unpacking the 'City Learning Lab' Approach*. Working Paper Series No. 7. Red Cross/Red Crescent Climate Centre.

Blome, T., Hänsler, A., Máñez-Costa, M. and Jacob, D. (2017). Innovation in Climate Services and Capacity Building - Conference report: Fifth International Conference on Climate Services (ICCS5). *Climate Services Partnership* Cape Town, South Africa.

Brasseur, G. P. and Gallardo, L. (2016). Climate services: Lessons learned and future prospects. *Earth's Future*, 4(3). 79–89. DOI:10.1002/2015EF000338.

Bremer, S. and Meisch, S. (2017). Co-production in climate change research: reviewing different perspectives: Co-production in climate change research. *Wiley Interdisciplinary Reviews: Climate Change*, 8(6). e482. DOI:10.1002/wcc.482.

Carr, E. R., Goble, R., Rosko, H. M., Vaughan, C. and Hansen, J. (2017). *Identifying Climate Information Services Users and Their Needs in Sub-Saharan Africa: A Learning Agenda. A Learning Agenda on Climate Information Services in Sub-Saharan Africa (USAID).*

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., Jäger, J. and Mitchell, R. B. (2003). Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences*, 100(14). 8086–91. DOI:10.1073/pnas.1231332100.

European Commission, Street, R., Parry, M., Scott, J., Jacob, D., Runge, T. and Directorate-General for Research and Innovation (2015). *A European Research and Innovation Roadmap for Climate Services*. Publications Office, Luxembourg.

Ilunga, M. R. (2018) Fluid African Cities- Bottom-Up Adaptive Decision-Support for Resilient Urban Water Security: A case study of the application of decision-scaling for the city-centric water system of Lusaka, Zambia within the Kafue Flats sub-basin. Research Dissertation. Water, Engineering and Development Centre (WEDC), Loughborough University, UK.

Klein, R. J. T. and Juhola, S. (2014). A framework for Nordic actor-oriented climate adaptation research. *Environmental Science & Policy*, 40. 101–15. DOI:10.1016/j.envsci.2014.01.011.

Lemos, M. C., Kirchhoff, C. and Ramprasad, V. (2012). Narrowing the Climate Information Usability Gap. *Nature Climate Change*, 2. DOI:10.1038/NCLIMATE1614.

Lemos, M. C. and Morehouse, B. J. (2005). The co-production of science and policy in integrated climate assessments. *Global Environmental Change*, 15(1). 57–68. DOI:10.1016/j.gloenvcha.2004.09.004.

Meadow, A. M., Ferguson, D. B., Guido, Z., Horangic, A., Owen, G. and Wall, T. (2015). Moving toward the Deliberate Coproduction of Climate Science Knowledge. *Weather, Climate, and Society*, 7(2). 179–91. DOI:10.1175/WCAS-D-14-00050.1.

Porter, J. and Dessai, S. (2017). Mini-me: Why do climate scientists' misunderstand users and their needs? *Environmental Science & Policy*, 77. 9–14. DOI:10.1016/j.envsci.2017.07.004.

Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., Zaroug, M. and Kituyi, E. (2017). The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India. *Climate and Development*, . 1–17. DOI:10.1080/17565529.2017.1318744.

Tall, A., Hansen, J., Jay, A., Campbell, B., Kinyangi, J., Aggarwal, P. K. and Zougmoré, R. (2014). *Scaling up Climate Services for Farmers: Mission Possible. Learning from Good Practice in Africa and South Asia*. 13. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.

Taylor, A., Scott, D., Steynor, A. and McClure, A. (2017). *Transdisciplinarity, Co-Production, and Co-Exploration: Integrating Knowledge across Science, Policy and Practice in FRACTAL*. 3.

Vaughan, C. and Dessai, S. (2014). Climate services for society: origins, institutional arrangements, and design elements for an evaluation framework: Climate services for society. *Wiley Interdisciplinary Reviews: Climate Change*, 5(5). 587–603. DOI:10.1002/wcc.290.

Vincent, K., Daly, M., Scannell, C. and Leathes, B. (2018). What can climate services learn from theory and practice of co-production? *Climate Services*, 12. 48–58. DOI:10.1016/j.cliser.2018.11.001.

Watkiss, P. (2015). *Mainstreaming Climate Information into Sector Development Plans: The Case of Rwanda's Tea and Coffee Sectors*. Climate & Development Knowledge Network.

WMO (n.d.). What are climate services? http://www.wmo.int/gfcs/what-are-climate-services. [Accessed 8 February, 2019.]