Stockholm Environment Institute

Co-designing climate services to integrate traditional ecological knowledge

A case study from Bali, Indonesia

SEI report
October 2020

Natalia Biskupska

Albert Salamanca

Stockholm Environment Institute
Linnégatan 87D 115 23 Stockholm, Sweden
Tel: +46 8 30 80 44 www.sei.org

Author contacts:
natalia.biskupska@sei.org
albert.salamanca@sei.org
Editor: Karen Brandon
Layout: Richard Clay
Cover photo: © su-re.co

Stockholm Environment Institute is an international non-profit research and policy organization that tackles environment and development challenges.
We connect science and decision-making to develop solutions for a sustainable future for all.
Our approach is highly collaborative: stakeholder involvement is at the heart of our efforts to build capacity, strengthen institutions, and equip partners for the long term.
Our work spans climate, water, air, and land-use issues, and integrates evidence and perspectives on governance, the economy, gender and human health.
Across our eight centres in Europe, Asia, Africa and the Americas, we engage with policy processes, development action and business practice throughout the world.

Contents

Key messages

- **Indigenous Peoples possess distinct, unique and locally relevant knowledge systems. Many of these populations are especially vulnerable to the impacts of climate change. Thus, climate change adaptation processes should enable the participation of Indigenous Peoples, and include their knowledge systems into planning for the regions in which they live.**
- **The scientific information and services on climate and agriculture provided by meteorological bureaus can be made more meaningful for Indigenous Peoples by integrating their traditional ecological knowledge. This knowledge is rooted in the ways in which individuals and communities observe, discuss and make sense of their environment.**
- **Indigenous Peoples are more likely to consider knowledge from climate and agricultural science service providers to be legitimate and applicable to their situations if the information aligns with their worldviews, rituals, and practices. To help indigenous communities adapt, more effort is required to better understand the links between contemporary science and traditional knowledge.**
- **The Tandem framework offers a way to integrate Indigenous People's traditional ecological knowledge into climate change adaptation processes. Climate field schools offer vehicles for co-designing climate services that incorporate both scientific sources of information, and traditional ecological knowledge.**
- **This case study suggests that helping vulnerable indigenous populations adapt to climate change will require a reassessment of prevailing perceptions of their traditional ecological knowledge. For a wide variety of reasons, the climate adaptation agenda rarely treats such knowledge as equal to technical knowledge. For climate change adaptation co-production processes to succeed, local knowledge must be treated as an equally legitimate perspective.**

Introduction

Indigenous Peoples have distinct knowledge of the local social-ecological systems where they have lived for many generations. Over these generations, they have developed an interdependent relationship with their environment. This long-view perspective and intimate knowledge about local social-ecological systems offer insights on how to adapt to the impacts of climate change. Their knowledge has the potential to inform locally appropriate and culturally responsive strategies for adaptation and resilience building. However, the role of their knowledge in enabling an inclusive and locally responsive climate change adaptation and resilience building remains largely unexplored (Galloway McLean 2010). This continues to be the case despite the international recognition that "Indigenous, local, and traditional knowledge systems and practices, including Indigenous Peoples' holistic view of community and environment, are a major resource for adapting to climate change"; and that "integrating such forms of knowledge with existing practices increases the effectiveness of adaptation" (IPCC 2014a, p.26).

Indigenous, local and traditional knowledge and practices have been defined as broadly encompassing the local experiences, observations, technologies, innovations, skills, practices and beliefs uniting local people, often accumulated and tested over generations of living and adapted to local culture and environment (Camacho et al. 2016; Nakashima et al. 2013). One such knowledge system is traditional ecological knowledge (TEK). TEK refers to a "cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 2012, p.7).

This brief underscores the importance of TEK, and fills an important gap in understanding about the ways it can be integrated with conventional climate services to improve our response to the challenges of building resilience and adapting to climate change impacts. The brief draws on insights from a case study that applied the Tandem framework. The framework offers a collaborative approach for the co-design of climate services to enhance the usability, relevance and sustainability of a service to inform climate change adaptation decisions and policies (Daniels et al. (2020).[1] The brief asseses the use of the Tandem framework in designing and implementing a climate field school programme in Bali, Indonesia. We analyse the framework's use as a model for enabling the delivery of locally and culturally responsive, context sensitive, and participatory climate information that may better guide local action, policy and support to smallholder communities. The brief is guided by the following questions:

- What are the adaptation challenges and related needs of the climate service users?
- Why is a co-design process important in enabling locally and culturally responsive and participatory climate services?
- What lessons can inform adaptation decision-making processes generally?

1 Note: The Tandem framework is designed to evolve as experiences and applications in the field generate new insights. The most up-to-date information is available through online guidance at https://www.weadapt.org/tandem.

BOX 1. KEY CONCEPTS

Climate service users (e.g. local planners and decision makers) employ climate information and knowledge for decision-making; they may or may not participate in developing the service itself.

Climate service providers are actors (e.g. climatologists, meteorologists, consultants) who supply climate information and knowledge.

Climate service intermediaries are actors who “translate” between providers (e.g. adaptation and learning specialists, project managers, consultants and researchers) and users.

Co-design processes involve end-users throughout the process of designing a climate service.

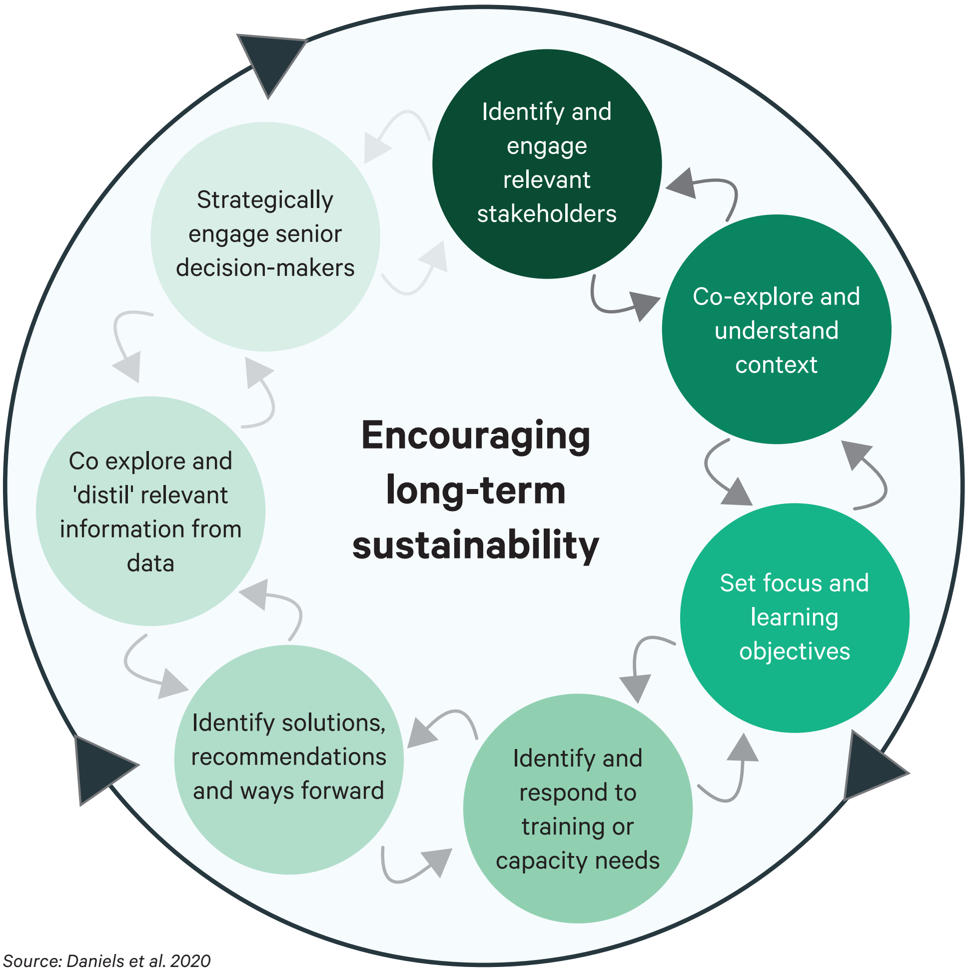
Sources: Daniels 2019; Vaughan and Dessai 2014

The Tandem framework

The Tandem framework has been developed to guide providers and intermediaries (see Box 1) of climate information through seven iterative elements (See Figure 1) that are intended to produce relevant, actionable and sustainable climate services that meet the needs of the users of the climate information:

- **Element 1** consists of identifying and defining an adaptation challenge that would benefit from the use of a climate service.
- **Element 2** focuses on identifying and engaging with potential users of a climate service.
- **Element 3** involves co-defining the desired objectives of a climate service and reviewing advantages and shortcomings of existing services.
- **Element 4** entails gaining an understanding of the institutional and decision contexts in which the climate service will be embedded.
- **Element 5** guides providers and users of the climate service in co-exploring data and information needs, including their sources, formats and modes of dissemination.
- **Element 6** consists of appraising adaptation measures, in which decision-support methods may be used to identify, evaluate, prioritize and sequence interventions.
- **Element 7** ensures that the climate service is used in practice by embedding it in existing institutions, and ensuring that mechanisms are in place for maintaining, evaluating and upgrading the service as appropriate.

Figure 1. Elements of the Tandem framework to co-design climate services



Source: Daniels et al. 2020

Developing locally responsive and participatory climate services in Indonesia

Climate change increasingly impacts Indonesia (Ministry of National Development Planning/National Development Planning Agency (Bappenas) et al. 2013). Agriculture faces the brunt of such impacts, with smallholders particularly affected. In Bali, agriculture provides a main source of income, and many farming families have lived in the area for generations; they have a long history of interaction and an interdependent relationship with their environment (Lansing 2007). As a result, farmers have developed a deep understanding of the social-ecological systems to guide their everyday practices (see Box 2). Such understanding closely relates to their agricultural practices, and informs, for example, the planning and management of crops, and the resources and strategies for coping with environmental changes (Galloway McLean 2010; Nakashima et al. 2013).

Elements of the Tandem framework were applied to the process of designing and implementing two rounds of a climate field school programme with coffee and cacao farmers and trainers in Jembrana in Bali, Indonesia. The programme was co-created through a partnership of farmers, a local NGO (Sustainability and Resilience Co. (su-re.co)), agricultural extension workers, representatives of the Meteorology, Climatology, and Geophysical Agency (BMKG) of Indonesia, and the SEI Climate Services Initiative. The programme was designed to bring together the existing local knowledge and practices of farmers working in tandem with representatives from BMKG and their technical, meteorological and climatological information. The aim was to develop information that could be used by farmers to adapt agricultural practices to climate change impacts, and to build the resilience of their livelihoods.

Aspects of Tandem were tested by SEI researchers working in partnership with su-re.co throughout various stages of the field school design and implementation process (specifically elements 1-3). In the initial stages of the project, scoping exercises were undertaken to assess the status of climate information services, and the contexts and needs of coffee and cacao farmers, who were the main climate information users in the study. This process included conducting interviews and holding focus group discussions with coffee and cacao farmers, BMKG officials, members of agricultural cooperative groups, and representatives of non-government organizations and government agencies responsible for agriculture and estate crops. The intent was to understand the varying perspectives on local and regional adaptation challenges, needs, interests and available services.

Findings helped identify specific climate knowledge, gaps in knowledge, and areas of shared understanding. This, in turn, informed the design of a pilot programme implemented in Bali through field- and classroom-based exercises in 2018. Building on lessons learned from the pilot and several feedback sessions with farmers, su-re.co, agricultural extension workers and BMKG, the curriculum and design of the programme was revised to more closely consider how to more effectively integrate TEK. The revised curriculum included information on the importance of TEK and how conventional climate information in Bali aligns with local perceptions of the climate. The resulting School of Climate and Living Tradition (SaLT) was implemented in 2019 as a “training of trainers” programme.

BOX 2: TRADITIONAL ECOLOGICAL KNOWLEDGE AND PRACTICES IN INDONESIA

For generations, the people of Indonesia have lived in dynamic harmony with nature. They have undertaken and maintained long-term observations of the natural environment, such as clouds, animals, plants and insects, and celestial bodies, such as the moon, stars and sun; to think about how these relate to environmental changes over time (Hiwasaki, Luna, Syamsidik, et al. 2014).

Many strongly believe in philosophical principles that interconnect the natural, human and spiritual worlds. Day-to-day local thinking and actions of the local communities reflect these beliefs. As a result, traditional or religious rituals and ceremonies, along with customary laws, play an important role in guiding their relationship with the environment around them. These practices are seen as a way of governing behavior, strengthening social cohesion, and showing appreciation and respect for nature (Hiwasaki, Luna, Syamsidik et al. 2014).

Aligned with this, many local communities devise traditional seasonal calendars. For instance, many regions in Indonesia have their own local calendars, such as the *Sasih* (lunar calendar) in Bali, the *Pranoto Mongso* (traditional seasonal calendar) in Central Java, and the *Keuneunong* (traditional Acehnese calendar) in Aceh.

These deeply embedded social-ecological systems have evolved to create an expansive knowledge base, tested over generations of living, and adapted to local culture and environment. This guides people in undertaking their own monitoring, making predictions, and developing local strategies for mitigating, preparing for, and responding to environmental changes.

Results

The process of designing and implementing the climate field school activities in Bali highlights some important benefits and challenges in bridging technical and local aspects in the co-development of a climate service. These insights inform how TEK can be better integrated into the design of climate services.

Framing the challenges of adapting farming practices to a changing climate

In Bali, the main adaptation challenges faced by the coffee and cacao farmers are adapting their farming practices to the changing climate in the region. Declining rainfall has led to reduced crop quality and yields, and crop failures (Takama et al. 2014; Takama et al. 2017). The changes pose new problems for farmers, whose practices have typically relied on traditional seasonal calendars, past experiences, and daily observations (Salamanca et al. 2013). They can no longer rely on these approaches due to shifts in the timing and length of the seasons, which link to a changing climate (IPCC 2014b).

Perceptions of climate change and the adaptation challenge were explored from the perspectives of all participants: the main user group (the farmers), members of agricultural cooperative groups, and those offering meteorological services (BMKG) and agricultural extension services. The different groups had different perspectives and needs related to challenges they faced. For instance, farmers tended to focus on the short term. They highlighted the recent unpredictability of weather patterns and the impacts on their crops, and the need for more appropriate technologies and agricultural support to boost production – rather than climate-related information, which they either did not trust or considered to be unreliable. BMKG, on the other hand, offered more long-term perspectives on the changing climate, which they considered critical in informing agricultural practices into the future. It was, however, clear that they all contributed in some way to an overarching, shared understanding of the main challenges. Each actor brought important components into the conversation related to different scales (e.g. local to national; long- and short-term), knowledge systems (e.g. local/indigenous and technical), and areas of expertise (e.g. climate and agriculture) – all of which needed to be considered.

The experiences in this case study demonstrate that such interaction should not be a one-time activity conducted only at the start of the project. Rather this identification effort should be part of a continuing iterative and facilitated process that evolves as insights lead participants to refine project direction and activities. Understanding adaptation challenges from the perspectives of the farmers and other relevant actors was a necessary first step, in order to inform the design of the initial activities. In the case of the climate field school, the design of the syllabus and modules, which, in turn, guide the roles of the people providing different resources (i.e., climate forecasters, agricultural extension agents, and facilitator). The processes of implementing the activities and building relationships enabled participants to more deeply face and explore relevant issues. This learning catalysed changes in perceptions that were captured and integrated into the redesign of ensuing activities. For example, experiences led BMKG to recognize the value and importance of the *Sasih*, the traditional Balinese lunar calendar, as a key instrument guiding farmers in their daily practices; as a result, BMKG developed a new module that attempted to relate its climate information with the *Sasih*.

Through the engagements linked to other elements of Tandem, particularly through identifying and engaging with users and collaborators (Element 2) and understanding objectives, and identifying early actions and existing services (Element 3), a deeper understanding of the adaptation challenge emerged. These experiences highlight that the Tandem elements should not be considered as linear but rather iterative, with regular revisiting of Tandem elements taking place throughout the process.

Engaging with farmers and other collaborators in the climate field school design

Prior to the climate field school design process, interaction between participants had been limited. The farmers' main interaction with those outside their communities consisted largely of working on technical issues with representatives from agriculture offices. There were no links to climate-related agencies.

The situation underscored the need to consider a broader, more diverse and inclusive range of actors and knowledge systems than previously had been engaged to inform the development of the climate service. In this case, the use of Tandem broadened the range of actors and knowledge systems to include TEK, cultural gender constructs, ethnic identity, and religious and spiritual perspectives. Our experiences suggest that those seeking to include such diverse groups that have previously not been considered or engaged in the climate field school would do well to carefully present their participation as crucial pieces of a larger puzzle for climate adaptation understanding, rather than exclusively for the sake of including marginalized or other groups. These very diverse and rich perspectives are important to expanding the range of dynamic knowledge, and such perspectives should not face the risk of being devalued or deprioritized.

It is therefore important to reflect on the ways in which these various knowledge systems and actors are referenced, and the ways in which their vision and systems guide or are integrated into the design of programming and technical policy work. This was a challenge in the design of the climate field school. Even though local farmers were central to the process, their knowledge and practices were still perceived by some as less important or less relevant to the knowledge generated by technical agencies. There is also a tendency among technical experts to speak in the languages of their fields which can be confusing and alienating to others.

This aspect was explored alongside other Tandem elements. Identifying the adaptation challenge (Element 1) and understanding desired objectives (Element 3) were emphasized because these issues were central to the process of pinpointing and addressing priority issues. As the main user group, the coffee and cacao farmers were central to the project design process. The curriculum design process also brought in relevant actors, such as agricultural cooperatives (e.g. a cacao cooperative) and government agencies that work on issues related to the adaptation challenges. This was done in part to understand these groups' influence on shared climate adaptation concerns and potential actions, and the nature of the interaction between and across various actors and groups. For future consideration, a stakeholder mapping exercise would have been beneficial to understand the interactions between and among related actors, and an interest and power assessment would also have been useful.

Co-exploration of information and service needs

Though participants reached a joint appreciation of varying and convergent objectives, some challenges arose. The existing services and information from the perspective of a range of cultures, people and groups, came into sharp relief, especially in terms of credibility and reliability. For example, farmers believed that their traditional ways, which had worked for them for generations, were best. Though they admitted that some practices were becoming less effective due to environmental changes, they remained skeptical of new information coming in from other knowledge sources. On the other hand, representatives of BMKG and agricultural extension services believed that TEK and related practices were no longer effective responses in light of the changing climate. Technical representatives, therefore, emphasized that their knowledge and practices should prevail over traditional ways. However, they also recognized that farmers continued to return to their traditional practices despite numerous trainings suggesting that they make changes. This led BMKG to reconsider.

Following the first phase of climate field school, both parties began to recognize the benefits and the shortcomings of each knowledge system. For instance, farmers began to see the benefit of weather forecasts provided by BMKG in informing their daily decision-making on their farms; previously they either had not trusted this information, or had not understood how it related to their local contexts. BMKG also took a second look of the value and importance of the *Sasih* calendar for the farmers in informing their agricultural practices. Thus, the second, redesigned phase of the climate school presented opportunities to bring together the two knowledge systems to build a more tailored service. Changes resulted. Participating farmers, who had originally been considered too remote to engage with BMKG, began reaching out to the agency for more information. In turn, BMKG became more interested in producing more frequent and better tailored forecasts for the farmers' local contexts. In subsequent training sessions, BMKG included information in presentations about how the TEK-aligned observations of farmers aligned with BMKG information. Farmers, in turn, shared their stories about how they use their knowledge in their farms. This had two effects: The alignment between BMKG's information and TEK gave the technical information new legitimacy among the farmers. At the same time, the recognition BMKG gave about the validity of farmers' knowledge systems demonstrated respect towards the farmers, and this itself became empowering. These are important ingredients towards creating a productive relationship which are built on trust and credible information. The climate field schools and SaLT became platforms for this emerging relationship.

Thus, when considering credibility and trust of existing climate information and services, it is equally important to consider varying and diverging perspectives. The climate field school experiences reveal the importance of inclusively and respectfully integrating multiple perspectives and knowledge systems into the design of a service, to benefit and enrich the understanding of all involved. Bringing these knowledge systems together is a process in itself. There is a lot to learn about how to do it without devaluing any certain knowledge system. The information provided in the various elements in Tandem can offer guidance on what questions to ask or consider.

Working together with diverse ranges of knowledge systems and perspectives

The Bali case study points to the importance of the multiple perspectives of all those involved. For example, the perceptions and knowledge bases of the main climate service users (the farmers) and the main climate service provider (BMKG) differ in relation to the climate and environmental challenges being faced, and why they are occurring. The ways in which these divergent actors monitor and predict changes in weather and climate, and the information upon which they base their decision making also vary. Farmers typically rely on local observations, past experiences and traditional calendars. BMKG's advice relies on analysis of meteorological data and forecast information generated by technical monitoring models and tools.

Despite these differences, the co-development process highlights the interlinkages between these different perspectives and ways of understanding. The process engaged here supports a shared appreciation of how confluent aspects create mutual benefits . The process and lessons learned emphasize the need to consider a broad and inclusive range of relevant knowledge systems with recognition of their equal value. Participants must avoid labelling a particular knowledge systems as "other", because to do so risks devaluing and marginalizing some in the climate service development process. For example, it is important to consider the perspectives of those assessing, and questioning, the credibility and reliability of a certain information.

Tandem does emphasize the need for co-exploring interlinked issues and knowledge systems with relevant actors. Nevertheless, it is important to reflect on whether the various steps involved adequately draw out the multiple perspectives from relevant actors, to ensure that a single perspective does not dominate discussions and decisions. Furthermore, there is a need to reflect on how to bring multiple perspectives together to ensure that all issues are considered in an appropriate way in the design of a service.

Challenges and opportunities

This research highlights some of the challenges of working with local knowledge systems and integrating them alongside conventional knowledge systems. One clear challenge emerges relating to the process through which TEK is perceived and conceptualized by those attempting to understand and work with it.

Dominant trends in literature and practice point to an understanding that considers TEK almost exclusively as a source of data to be extracted, transformed and integrated to fit within formal science and climate models (Klenk et al. 2017). TEK and local knowledge in general are rarely seen as equal to other conventional or technical knowledge systems (Briggs 2013). This may explain why global processes and assessments, such as those used by the Intergovernmental Panel on Climate Change(IPCC), are subject to intense scrutiny, give preference to the peer-reviewed, quantitative information and "expert" judgments of formal science over the qualitative and human dimensions of local knowledge, and why such processes undervalue and marginalize this knowledge base (Alexander et al. 2011).

Our case study suggests that such views fail to acknowledge the complexity of on-the-ground reality. To move forward, those working with such communities would benefit from reassessing these perceptions. TEK is more than a data source; it is a process, practice, or "way of knowing" rooted in the ways in which individuals and communities observe, discuss and make sense of new information (Berkes 2009; Briggs 2013). Thus, reflexive and situated approaches should seek to ground TEK in a particular context in the face of changing circumstances (Briggs 2013; Klenk et al. 2017). These approaches should focus on the knowledge co-production processes as the purpose of climate services (Daniels et al. 2020). True co-production inherently treats the input of all relevant stakeholders equally throughout all stages of the development process (Klenk et al. 2017). In this respect, Tandem has the potential to play an important role in facilitating knowledge co-production – which is essential to enhance understanding of TEK systems, and to help vulnerable Indigenous Peoples adapt to growing impacts on their ways of life and livelihoods as the result of climate change.

References

Alexander, C., Bynum, N., Johnson, E., King, U., Mustonen, T., et al. (2011). Linking Indigenous and Scientific Knowledge of Climate Change. *BioScience*, 61(6). 477–84.

Berkes, F. (2009). Indigenous Ways of Knowing and the Study of Environmental Change. *Journal of the Royal Society of New Zealand*, 39(4). 151–56. DOI: 10.1080/03014220909510568

Berkes, F. (2012). *Sacred Ecology*. Third edition. Routledge, London

Briggs, J. (2013). Indigenous Knowledge: A False Dawn for Development Theory and Practice? *Progress in Development Studies*, 13(3). 231–43. DOI: 10.1177/1464993413486549

Camacho, L. D., Gevaña, D. T., Carandang, A. P. and Camacho, S. C. (2016). Indigenous Knowledge and Practices for the Sustainable Management of Ifugao Forests in Cordillera, Philippines. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 12(1–2). 5–13. DOI: 10.1080/21513732.2015.1124453

Daniels, E., Bharwani, S., Swartling, Å. G., Vulturius, G. and Brandon, K. (2020). Refocusing the climate services lens: introducing a framework for co-designing "transdisciplinary knowledge integration processes" to build climate resilience. *Climate Services*, 19. DOI: https://doi.org/10.1016/j.cliser.2020.100181

Daniels, L. (2019). The Tandem framework: a holistic approach to co-designing climate services | weADAPT | Climate change adaptation planning, research and practice. https://www.weadapt.org/knowledge-base/climate-services/the-tandem-framework

Galloway McLean, K. (2010). *Advance Guard: Climate Change Impacts, Adaptation, Mitigation and Indigenous Peoples—a Compendium of Case Studies*. United Nations University-Traditional Knowledge Initiative, Darwin

Hiwasaki, L., Luna, E. and Syamsidik, S. R. (2014). *Local & Indigenous Knowledge for Community Resilience: Hydro-Meteorological Disaster Risk Reduction and Climate Change Adaptation in Coastal and Small Island Communities*. UNESCO, Jakarta

Hiwasaki, L., Luna, E., Syamsidik and Shaw, R. (2014). Process for integrating local and indigenous knowledge with science for hydro-meteorological disaster risk reduction and climate change adaptation in coastal and small island communities. *International Journal of Disaster Risk Reduction*, 10. 15–27. DOI: 10.1016/j.ijdrr.2014.07.007

IPCC (2014a). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

IPCC (2014b). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Klenk, N., Fiume, A., Meehan, K. and Gibbes, C. (2017). Local knowledge in climate adaptation research: moving knowledge frameworks from extraction to co-production: Local knowledge in climate adaptation research. *Wiley Interdisciplinary Reviews: Climate Change*, 8(5). e475. DOI: 10.1002/wcc.475

Lansing, J. S. (2007). *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali*. Princeton University Press, Princeton, NJ, US

Ministry of National Development Planning/National Development Planning Agency (Bappenas), Ministry of Environment, National Council on Climate Change and Climatological Meteorological and Geophysical Agency (2013). *National Action Plan for Climate Change Adaptation (RAN-API): Synthesis Report*. Ministry of National Development Planning/National Development Planning Agency (Bappenas), Jakarta

Nakashima, D., McLean, K. G., Thulstrup, H. D., Castillo, A. R. and Rubis, J. T. (2013). *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation*. UNESCO and UNU, Paris

Salamanca, A., Dwisasanti, N., Rigg, J. and Turner-Walker, S. (2013). *Assessment of Adaptation Needs, Policies and Priorities: Cases from Indonesian Islands*. SEI and AKP, Bangkok. http://static.weadapt.org/knowledge-base/files/1188/5174b1b4c423dindonesia-web.pdf

Takama, T., Aldrian, E., Kusumaningtyas, S. D. A. and Sulistya, W. (2017). Identified vulnerability contexts for a paddy production assessment with climate change in Bali, Indonesia. *Climate and Development*, 9(2). 110–23. DOI: 10.1080/17565529.2016.1167658

Takama, T., Setyani, P. and Aldrian, E. (2014). Climate Change Vulnerability to Rice Paddy Production in Bali, Indonesia. In *Handbook of Climate Change Adaptation*. Springer Berlin Heidelberg, Berlin, Heidelberg. 1–23

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

Visit us

SEI Headquarters
Linnégatan 87D Box 24218
104 51 Stockholm Sweden
Tel: +46 8 30 80 44
info@sei.org

Måns Nilsson
Executive Director

SEI Africa
World Agroforestry Centre
United Nations Avenue
Gigiri P.O. Box 30677
Nairobi 00100 Kenya
Tel: +254 20 722 4886
info-Africa@sei.org

Philip Osano
Centre Director

SEI Asia
10th Floor, Kasem Uttayanin Building,
254 Chulalongkorn University,
Henri Dunant Road, Pathumwan, Bangkok,
10330 Thailand
Tel: +66 2 251 4415
info-Asia@sei.org

Niall O'Connor
Centre Director

SEI Tallinn
Arsenal Centre
Erika 14, 10416
Tallinn, Estonia
Tel: +372 6276 100
info-Tallinn@sei.org

Lauri Tammiste
Centre Director

SEI Oxford
Oxford Eco Centre, Roger House,
Osney Mead, Oxford,
OX2 0ES, UK
Tel: +44 1865 42 6316
info-Oxford@sei.org

Ruth Butterfield
Centre Director

SEI US Main Office
11 Curtis Avenue
Somerville MA 02144-1224 USA
Tel: +1 617 627 3786
info-US@sei.org

Michael Lazarus
Centre Director

SEI US Davis Office
400 F Street
Davis CA 95616 USA
Tel: +1 530 753 3035

SEI US Seattle Office
1402 Third Avenue Suite 900
Seattle WA 98101 USA
Tel: +1 206 547 4000

SEI York
University of York
Heslington York
YO10 5DD UK
Tel: +44 1904 32 2897
info-York@sei.org

Sarah West
Centre Director

SEI Latin America
Calle 71 # 11–10
Oficina 801
Bogota Colombia
Tel: +57 1 6355319
info-LatinAmerica@sei.org

David Purkey
Centre Director

SEI Stockholm Environment Institute

sei.org
@SEIresearch @SEIclimate