The Role of Indigenous and Traditional Knowledge in Ecosystem-Based Adaptation: A Review of the Literature and Case Studies from the Pacific Islands

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ABSTRACT

Ecosystem-based Adaptation (EbA) is increasingly being advocated as a climate adaptation approach that can deliver multiple benefits to communities. EbA scholarship argues that community-based projects can strengthen those ecosystems that deliver critical services to communities and in doing so enhance community resilience. In particular, the inclusion of indigenous and traditional knowledge (ITK) into community-based EbA projects is positioned as critical to successful climate adaptation. Yet, there is surprisingly little investigation into how ITK is being defined and incorporated into EbA initiatives. This paper critically reviews EbA literature and provides empirical examples from Vanuatu and Samoa to demonstrate the different ways ITK relates to EbA projects. We find that there is widespread recognition that ITK is important for indigenous and local communities and can be employed successfully in EbA. However, this recognition is more aspirational than practical and is not being necessarily translated into ITK-informed or ITK-driven EbA projects. ITK should not be conceptualized simply as a collection of local environmental information that is integrated with Western scientific knowledge. Instead, ITK is part of nested knowledge systems (information–practices–worldviews) of indigenous peoples. This knowledge includes local natural resource management, sociocultural governance structures, social norms, spiritual beliefs, and historical and contemporary experiences of colonial dispossession and marginalization. At present, most EbA projects focus on the provision of information to main decision-makers only; however, since ITK is held collectively, it is essential that entire communities are included in ITK EbA projects. There is a huge potential for researchers and ITK holders to coproduce knowledge that would be best placed to drive climate adaptation in a changing world.

1. Introduction

Globally, indigenous peoples are identified as highly vulnerable to the negative impacts of climate change, but are similarly noted as possessing specific knowledge of use for climate adaptation. Most scholars frame indigenous peoples' vulnerability in terms of a mixture of

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biophysical and contextual terms including their exposure to climatic hazards and the direct impacts of climate change (Ford et al. 2006; Ford 2007; Green et al. 2009, 2010); their reliance on climate-sensitive, resource-based livelihoods; and limited financial, technological, and political resources (Nakashima et al. 2012; Lebel 2013; Williams and Hardison 2013). Some scholars, however, draw attention to procedural vulnerability, whereby high climate change vulnerability in indigenous communities is traced to the consequences of ''disaster of colonization'' for indigenous societies and the secondary disasters of ill health, poverty, environmental dispossession, and sociopolitical marginalization (Cameron 2012; Veland et al. 2013; Parsons 2015). Yet, indigenous communities are not simply passive victims of environmental hazards and climate change (Warrick et al. 2017). Instead of emphasizing their vulnerability, indigenous scholars argue there is a need for researchers and practitioners to focus on indigenous resilience and their capacities to adapt, as evidenced by their adapting histories of coping with and responding to changing social, cultural, political, economic, and environmental conditions over millennia.

For indigenous and traditional knowledge (ITK) holders, their relational place-based knowledge informs their day-to-day decision-making and encompasses language, resource use and management, systems of classification (including biota and biophysical conditions), social interactions, cultural practices, and spirituality (UNFCCC 2013; Mackey and Claudie 2015; Leonard et al. 2013). Multiple terms are currently being used regarding ITK, including indigenous knowledge (IK), traditional ecological knowledge (TEK), local knowledge (LK), and traditional knowledge (TK; Becken et al. 2013; Huntington et al. 2004; Parsons et al. 2016). The lack of clear consensus about terminology is partly reflective of different academic traditions (such as among anthropology, ecology, and indigenous studies) and also geographical and sociopolitical differences between what types of indigenous communities are being examined. For instance, the terms IK or TEK are more frequently used in regards to the indigenous peoples of settler societies, such as Australia, Canada, New Zealand, and the United States, who are ethnic minorities in their traditional lands and are subject to ongoing colonial rule, while TK and TEK are more commonly applied in reference to indigenous peoples who comprise the ethnic majorities of their countries but are former colonies. LK is used to refer to local people who may or may not be indigenous, but nevertheless hold detailed environmental knowledge that is based on personal and collective experiences of their local environments (Nalau et al. 2017).

Gómez-Baggethun et al. (2013, p. 647) emphasize that IK is both a process and a subject: ''It is the capacity to generate and apply knowledge—and not the knowledge itself—that contributes to the resilience of the system.'' In this way, it is flexible, fluid, and dynamic, continually being updated and reviewed. In the Australian context, Leonard et al. (2013) demonstrate that ITK is dynamic and cumulative and comprises knowledge of the local environment held collectively, with specific aspects only known to certain individuals or groups (such as different genders, ages, or occupations). For the purpose of this paper, we use the term ITK to refer to the ways of knowing indigenous peoples have derived through longstanding interactions with ancestral territories. Indigenous peoples' cosmologies do not draw strict separations between people and the natural environment, physical and metaphysical, and rational and nonrational, unlike Western intellectual traditions informed by Cartesian philosophy. Yet, as Smith and Sharp (2012, p. 468) aptly observe, no ''indigenous person would classify their understanding of the world as TEK per se,'' with the field of study and analytical concepts (IK, TEK, TK, and LK) a product of contemporary Western science and social science research.

Many communities in Small Island Developing States (SIDS), particularly in rural areas, still employ ITK extensively, given their high dependence on natural resources. In Pacific SIDS, traditional and hybrid sociocultural governance structures remain a feature. National-level governance structures (be it parliament, government, or military) typically include passing mention of the importance of preserving indigenous rights and knowledge but are largely dominated by strategies that render climate adaptation a series of technical and economic challenges. At the local level, however, indigenous designed and operated institutions such as village councils and tribal authorities are involved in the distribution of entitlements. Thus, ITK forms an essential, but underappreciated, part of many Pacific communities' capacities to adapt to changing environmental conditions (Parsons et al. 2017b; Warrick et al. 2017). It is in this critical context that we seek to examine how Ecosystem-based Adaptation (EbA) research and practices can better include ITK to reduce vulnerability, enhance resilience, and produce multiple benefits for local social and ecological communities (Chong 2014; Mercer et al. 2014).

At the global level, the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) both acknowledge the importance of ITK to climate adaptation (Adger et al. 2014; Chanza and de Wit 2016; UNFCCC 2013). ITK is considered to be crucial in particular in EbA, which is generally defined as the use of biodiversity and ecosystem services to help communities to adapt to the impacts of climate change (Munang et al. 2013).

As part of an overall climate adaptation strategy, EbA aims to increase the resilience of and reduce the vulnerability of ecosystems and people by drawing upon the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate (CBD 2009; Ojea 2015; Reid 2016; Roberts et al. 2012).

The focus on community is a common feature of EbA research and projects, and often EbA is seen as aligned with and mutually supportive of community-based adaptation (CBA; Vignola et al. 2009; Brink et al. 2016). CBA uses the community scale to ensure that climate adaptation efforts work hand in hand with local development goals and seek to enhance community well-being and resilience (Reid 2016). Many CBA researchers championed the uptake of EbA, typically emphasizing food and water security, livelihoods, and indigenous knowledge systems (Forsyth 2014; Reid 2016). Both EbA and CBA are part of the global climate adaptation policy agenda through UNFCCC National Adaptation Plan for Action (NAPA), the Cancun agreement, and the Nairobi Workplan for Adaptation (Reid 2016). Research from both CBA and EbA highlights how the codesign process involving two-way knowledge transfer (among scientists, planners, and community members), multiple benefits, and use of local sociocultural institutional arrangements translates into better climate adaptation outcomes (Andrade et al. 2011; Chong 2014; Munang et al. 2013).

Climate adaptation is often framed as a new area of research and policy (Preston et al. 2015), while EbA itself is seen as a relatively ''new discipline'' (Mercer et al. 2014; Reid 2016) and new concept (Doswald et al. 2014), which also means that many of its core elements are still to be developed and evaluated. Yet, few scholars have examined the current assumptions as to the kind of knowledge that is most relevant to effective EbA implementation [exceptions are Doswald et al. (2014) and Milman and Jagannathan (2017)]. Interrogation of core assumptions is essential for any discipline to develop (Keenan et al. 2013; Preston et al. 2015; Kuhn 1996; Nalau et al. 2015). Such analysis forms an important part of narrative analysis of how policy issues are framed and which actions and strategies are accepted as solutions (Leach et al. 1997), as well as which types of knowledge become legitimized in the process. This paper therefore examines three core themes: how ITK is defined in EbA-specific literature, how to identify which specific climate adaptation activities are seen to be ITK based, and how ITK and Western science have been used together when planning and designing EbA projects.

The paper is organized as follows. Section 2 gives a brief overview of the methodology underpinning the paper, including an explanation on coding and analysis and the underlying methodological assumptions driving the analysis. Section 3 presents the results of the content analysis of ITK in EbA literature and stakeholder interviews and community discussions in Vanuatu and Samoa on the three key themes. Section 4 provides a discussion on what our observations mean for the development of EbA at conceptual and practical levels, and section 5 sets out the main conclusions and ways forward.

2. Methods

We used an exploratory social science study approach to determine how the concept of ITK is used in relation to climate adaptation and EbA in particular. Such approaches are often used when there is no existing framework and there is a need to collect multiple views on the issue under study (Nalau et al. 2017; Shakeela and Becken 2015; Warren and Karner 2010). We had three distinct research questions: 1) How is ITK used and documented as a concept in published EbA literature? 2) Which EbA activities are seen as ITK based? 3) What are the specific challenges and opportunities in including ITK in EbA research and policy?

Two different approaches were used to address the goals of the study (Table 1). The first was a comprehensive content analysis of key papers on EbA, which was then augmented with the collection of primary data. The aim of the literature analysis was to establish a baseline understanding of whether and how earlier research recognized ITK as a relevant factor in EbA conceptualization and implementation. The empirical parts of this paper then aimed to ground truth insights gained from the literature analysis. The aim was not to collect statistical information, but to increase our understanding of the role of ITK in EbA approaches. We used semistructured interviews and community discussions, because these methods are well suited and established to collect data on different responses and expectations (Gaskell 2000; Teddlie and Yu 2007). The interviews focused on exploring people's perceptions of climate adaptation actions, decision-making processes, and the kind of knowledge that was referred to in decision-making.

a. Data sources

The literature for the content analysis were found using scholarly search engines such as Scopus, Web of Science, and Griffith Online Library with the search term ''ecosystem-based adaptation'' during August 2016

TABLE 1. Main data sources used in the study.

Method and data source	Key aims	Code category
Content analysis: 60 peer-reviewed papers and 2 reports	To see how the EbA-specific literature uses the terms IK/TK, and LK and to see in which climate adaptation activities this body of knowledge seems to be most relevant	IK/TK and LK
Community discussions: Field notes from community discussions on Tanna Island, Vanuatu ($N = 4$ communities, approximately 100 people)	To understand the lived experience of indigenous remote communities and how they consider traditional knowledge in decision-making	Communities 1–4
Interviews with tourism operators and government official: Interview transcripts from Samoa ($N = 7$)	To understand the lived experience of tourism operators and other decision-makers in regard to climate adaptation decision-making and use of IK/TK and LK in that process	Operators 1–6 and Government official 1 (government 1)
Interviews with international experts: Interview transcripts with experts ($N = 8$)	To get a better understanding of how IK/TK and LK is being considered in EbA processes and approaches at regional (Pacific Islands) and global levels (science and policy)	Experts 1–8

and updated in August 2017. Papers were included if they referred to EbA in the title, abstract, keywords, or text and dealt with human adaptation to climate change and/or addressed climate change and ecosystem services/management. The selected material consisted of both peer-reviewed papers ($N = 60$) and reports from the gray literature ($N = 2$). Each output was saved as a PDF file, with a citation record in EndNote, and then imported into the qualitative analysis program NVivo 11. Community, stakeholder, and expert discussions then supported the in-depth content analysis.

We focused our fieldwork data collection on Vanuatu and Samoa as part of a larger project that investigates EbA in the Pacific Islands. In Vanuatu, we visited four communities ($N = 100$ participants) on Tanna Island (Vanuatu; March 2017) and arranged community discussions to find out what ecosystem services different stakeholders rely on, how they are affected by climate change, what kind of EbA interventions are needed, and how these can be best tailored to the local cultural context. These questions were aimed at understanding the current issues within the communities. Because most tribes only speak a local language, we were assisted by local indigenous people who translated questions and discussion to local language from English in community discussions, while the stakeholder workshop was held in English. Rather than talking about climate change risk and impacts, we spoke about people's worries related to the natural resources, and rather than asking about EbA solutions, we spoke about solving problems by working with nature. We organized separate community discussions with men and women to also grasp gender differences in knowledge use and climate adaptation needs. Research notes were taken on each occasion, which were included in the analysis.

In addition to Tanna Island, we included Samoa, one of the most advanced Pacific Island nations in terms of climate adaptation projects, which provides a contrasting context to learn from. In Samoa (July 2017), we conducted semistructured interviews ($N = 7$) on the island of Savai'i with mainly indigenous small- and medium-sized community tourism operators and indigenous government staff about recent climate adaptation projects and policy development processes. The interviews were conducted in English but with the assistance of a local Samoan research assistant.

To gain further insight into the role ITK plays in the Pacific, we interviewed international experts ($N = 8$) to learn about perceptions of ITK and its relevance in climate adaptation. The experts were selected based on their knowledge of EbA and SIDS context in particular. Questions for the experts included asking how ITK is usually used in EbA projects and if they could give any examples where they had seen this done well. In terms of the interviews, we explored how EbA is defined and what challenges are related to its use as a climate adaptation measure, followed by questions on what kinds of knowledge systems and worldviews support EbA approaches. Interviews were tape recorded and transcribed verbatim for further analysis. Griffith University ethics research protocol (2017/108) was followed in all interactions, with the stakeholders including provision of research information sheets, informed consent forms, and oral explanation and oral consent in cases where stakeholders (e.g., rural communities) did not possess literacy skills.

b. Analysis

Our analysis included reviewing and analyzing the literature and comparing these findings with fieldwork data. We used simple node trees in NVivo 11 to delineate the differences between concepts and to keep track of the different kinds of assumptions that emerged from the literature. Node trees are hierarchical structures in NVivo, which are used to group concepts and ideas and to provide hierarchical analysis [e.g., with a top code (ITK and EbA) that has child codes under it (activities, definitions; Bazeley 2007)]. Nodes are often specific meanings, strategies, and activities (Lewins and Silver 2007) and can be abstract or specific (Punch 2005). For example, we constructed node tree ''Knowledge sources & ITK & EbA,'' under which we coded examples of ITK that were later transferred to analysis tables. We also coded examples in child trees such as ''TK & EbA,'' ''Local Knowledge and EbA,'' and ''IK and EbA'' to delineate which concepts were used in which context as part of the queries.

We used text queries in NVivo 11 to search the selected publications (see online supplemental material) for mentions of ITK with following key terms: ''traditional knowledge,'' ''local knowledge,'' and ''indigenous knowledge.'' Two-thirds (40 out of 60) of the papers used these terms, which were included in further analysis in this paper (see Table 2). The key terms (IK, TK, and LK) are often used interchangeably in the literature and even within the same article, but we were interested in understanding which of these are most prominent and how they are used in EbA discourse. We then structured analysis of the interviews and community discussions around the three main aims of the study: definitions and assumptions about ITK in EbA discourse, kinds of activities mentioned that relate to ITK, and how ITK and Western science were supposed to be used as knowledge sources for robust EbA. The results in the subsequent section are organized following these categories.

TABLE 2. Reviewed papers that mention the key search terms (IK, TK, LK).

Reference	IK	LK	TK
Ahammad et al. (2013)		×	
Andrade et al. (2011)	×	×	×
Aswani (2015)	×		
Bennet et al. (2016)	×		×
Boer and Clarke (2012)		×	×
Brink et al. (2016)	×	×	
Cartwright et al. (2013)		×	
Chanza and de Wit (2016)	×		
Chong (2014)	×	×	×
Cilliers et al. (2013)	×		
Curtin and Prellezo (2010)			×
Dhar and Khirfan (2016)		×	
Doswald and Osti (2011)			×
Doswald et al. (2014)			×
Fatorić and Morén-Alegret (2013)		×	×
Faulkner et al. (2015)		×	
Forsyth (2013)		×	
Geneletti and Zardo (2016)			×
Girot et al. (2012)		×	×
Girvetz et al. (2014)		×	
Grantham et al. (2011)		×	
Hay et al. (2013)			×
Huq (2016)		×	
Jupiter et al. (2014)			×
Loos (2015)		×	
Mercer et al. (2014)	×	×	×
Munang et al. (2013)	×		×
Munroe et al. (2012)	×		
Oloukoi et al. (2014)			×
Pramova et al. (2012a)		×	×
Reid (2016)			×
Sierra-Correa and Cantera Kintz (2015)			×
Spalding et al. (2014)		×	
Travers et al. (2012)			
Uy et al. (2012)	×	×	
Vignola et al. (2009)		×	×
Wamsler et al. (2014)		×	
Wells et al. (2016)		×	
Wongbusarakum et al. (2015)		×	×
World Bank (2009)		×	×

3. Results

This section will first provide some insights into how ITK is defined in EbA studies and the difficulty of delineating it from other forms of knowledge. Specific examples of how ITK can strengthen EbA were considered, and the notion of integrating multiple knowledge systems was explored as one of the core expectations of what ITK can add to successful climate adaptation.

a. *Definitions and assumptions about ITK*

The 40 papers that mentioned IK, LK, and/or TK used these terms sometimes in an overlapping manner (Table 2). IK was mentioned 14 times, LK had 75 mentions, and TK was mentioned 31 times across the papers. The question of whether there are differences in the terms TK, IK, and LK was futile in our analysis. It was not possible to track each concept separately, as many papers use all these terms together, sometimes in a single sentence. For example, Uy et al. (2012, p. 12) noted that best-practice EbA is about community engagement, given that ''EbA strategies are accessible to rural communities that provide them the opportunity to use local, traditional, and Indigenous knowledge and participate directly in developing and applying ecosystem-based solutions.'' Most of the articles did not define ITK further but focused on how such knowledge should be included and what it can deliver for more locally accepted climate adaptation. Overall, most papers reviewed described these types of knowledge as core factors in enhancing and ensuring locally appropriate EbA (Andrade et al. 2011;

Boer and Clarke 2012; Brink et al. 2016; Grantham et al. 2011). In the United Kingdom, Huq (2016) also noted the importance of LK in informing climate adaptation planning in a nonindigenous context.

The analysis of the role of ITK in EbA papers demonstrated a strong belief in how ITK and community participation should go hand in hand in climate adaptation. Andrade et al. (2011) refer to the Cancun Adaptation Framework Principles and note that ITK is a prerequisite for effective climate adaptation, including community participation. Brink et al. (2016) also note in the context of South Africa that the most robust EbA approaches actively seek community participation. Likewise, Boer and Clarke (2012) note how involving ITK via community participation in strategic plans for EbA increases community ownership. Grantham et al. (2011) echo that such knowledge inclusion in climate adaptation planning and community involvement is necessary to secure locally applicable EbA. Spalding et al. (2014) also note the benefits in engaging communities so they can gain ownership of climate adaptation projects and use their ITK in the process. Chong (2014) also refers to the Cancun Adaptation Framework Principles and argues that ITK should be guiding climate adaptation activities and community participation. This kind of climate adaptation fulfils "a need to consider vulnerable groups, communities, and ecosystems, and also acknowledges the importance of traditional and Indigenous knowledge in guiding adaptation activities" (Chong 2014, p. 395).

While community participation is recognized as a key factor in engaging successfully in EbA processes, Oloukoi et al. (2014) argue that many livelihood activities are gender differentiated, and thus, so is ITK. In Nigeria, men engage in firewood collection and charcoal production and are much more concerned about impacts on forests, whereas women collect seeds and herbs and practice agroforestry and are concerned about impacts on these ecosystems (Oloukoi et al. 2014). The cultural context where men are the main decision-makers also means that women are not as well informed about climate change, as men attend public meetings where climate change–related decisions are made and information is shared (Oloukoi et al. 2014). Therefore, when discussing EbA options, men's and women's preferences can differ quite vastly due to main livelihood strategies (forests for wood products vs forests for agroforestry). Girot et al. (2012) also recognize the importance of considering gender differences in EbA approaches based on the premise that many livelihood activities differ between genders and hence, so does people's access to particular ITK and its use.

This was particularly relevant in the context of Tanna Island (Vanuatu), where women and men clearly hold different kinds of ITK, which in turn impacts the kinds of livelihoods they practiced and the knowledge they used in those activities. For example, men make decisions in the communities and households and hold the right to traditional stories about ancestors and knowledge of traditional weather indicators (e.g., early warning indicators, indicators for planting times). Women do most of the gardening, animal rearing, water collection, and food preparation and hold knowledge about women-specific traditions and expected behavior (e.g., in marriage and other ceremonies). Similarly, in Samoa, traditional gender roles mean that, for example, it is women who decide on which plants to plant in coastal areas, as this is seen as part of beautification of the areas rather than a direct response to coastal hazards.

One particular constraint, however, emerged in Samoa that could explain why ITK is not necessarily used in climate adaptation projects, policies, and program design. Many Samoan research participants critiqued the design, assessment, and implementation of climate adaptation planning and strategies in Samoa for failing to consider local concerns, needs, and aspirations for the future. Accordingly, many were keen to explore alternative approaches (including the use of historical experiences—an essential component of ITK—as a basis for decision-making about climate risks) but were unsure how to go about seeking information or gaining support. Although there were lower levels of awareness of EbA among Samoan stakeholders, most (when prompted) expressed support for potential EbA projects—such as the planting of vegetation to stabilize coastal and riparian zones, conserve mangroves, and improve land management—so long as there were clear cobenefits such as improvements in fish numbers or decreased damage caused by storm surges. In addition, emphasis was placed on the need for climate adaptation projects to be channeled through village councils (Matai councils) and centered on Samoan values (fa'asamoa) rather than Western values and institutions. The central principles around fa'asamoa, such as the importance of family, reciprocity, and relationships or social networks, play a fundamental role in how climate adaptation takes place in Samoa and contributes to people's adaptive capacity (Parsons et al. 2017b) and contrast Western values to a degree that is more centered around individualism and materialism.

b. *ITK-based activities in the context of EbA*

The identified EbA papers were also analyzed for specific climate adaptation activities that clearly related to or made use of ITK (Table 3). Given that ITK is often central for livelihood activities, many papers stressed the importance of maintaining existing ITK for improved

TABLE 3. Examples of specific climate adaptation activities that have a strong IK/TK or LK focus.

Activity	Geographical examples	Source
Food systems as IK systems	Tlokwe City Municipality, South Africa	Cilliers et al. (2013)
TK as part of climate adaptation food security strategy	Maldives	Mercer et al. (2014)
Rainwater harvesting in remote areas to deal with climate and weather hazards	Global scale	Andrade et al. (2011)
Storing seed stocks based on TK	Global scale	Girot et al. (2012)
Use of genetic diversity and native species in adapting to environmental and climate change	Global scale	Reid (2016)
Use of local crop varieties and cultivation methods	Global scale	Girot et al. (2012)
TK as local observations of weather, hazards, and impacts	Global scale	Girot et al. (2012)
TK to validate science: "Traditional knowledge is crucial for improving scientific phenomena understanding"	Coastal focus, global scale	Sierra-Correa and Cantera Kintz (2015, p. 386)
Science validating TK: Science used to validate local TK on agroforestry and using that TK to explain to community how to adapt to climate change	Awak, Pohnpei, Federates States of Micronesia	Wongbusarakum et al. (2015)
Monitoring of ecosystem service changes: Local people best "to recognise the gradual or 'weak' signals of change in ecosystems and their service delivery over short timeframes"	Global scale	Travers et al. (2012, p. 39)
Monitoring of the success of EbA interventions by using "people's situatedness in, and knowledge of, their local socioecological milieu"	Urban areas globally	Brink et al. (2016, p. 120)
Using science to produce "better referenced and validated traditional knowledge" for food security	Regional focus on Africa	Munang et al. (2013, p. 31)
Integrating TK into local climate adaptation planning	Bangladesh [Triple F model; Ahammad et al. (2013)], Nigeria, Fiji, Cambodia, Papua New Guinea	Ahammad et al. (2013); Andrade et al. (2011); Girvetz et al. (2014); Grantham et al. (2011); Mercer et al. (2014); Munang et al. (2013); Pramova et al. (2012b)
LK datasets on historical flooding to estimate flood occurrence and change in frequency in data-poor regions	Borneo, Indonesia	Wells et al. (2016)
Historical timelines and mapping seasonal calendars in combination with climate projections to provide a more accurate understanding of current, past, and future hazards in location	Micronesia and the Coral Triangle region	Wongbusarakum et al. (2015)
Use of indigenous crops and TK in agriculture: TK-based practices among highland communities with a robust set of "agrobiodiversity resources"	Yemen	World Bank (2009)
Integrating TK into water management	Mongolia, China	World Bank (2009)

agricultural practices to enhance food security at national and community levels. In the African context, Cilliers et al. (2013) point out that many food systems and agricultural practices actually are ITK systems themselves. Local agrobiodiversity knowledge has a lot of potential in responding to challenges of "land degradation, climate change, globalization, anthropogenic local factors" but is further threatened by all these processes in terms of losing ITK (World Bank 2009, p. 67).

ITK is also mentioned in National Adaptation Plans (NAPs): Mercer et al. (2014) highlight the case of the Maldives, where ITK is explicitly seen as a core component of the government's food security strategy. Gathering farmers' knowledge on different crop species and even related species that grow wild in nature can help in developing vulnerability profiles for particular crops (World Bank 2009). ITK datasets on flooding in Borneo, for example, can be used to determine the extent of past and current flooding, especially when scientific data are missing (Wells et al. 2016). Creating historical timelines and mapping seasonal calendars can help to capture ITK while also feeding this information into climate science and climate adaptation planning (Wongbusarakum et al. 2015).

Likewise, Girot et al. (2012) note how knowledge on local crop varieties, cultivation methods, and indigenous methods of storing seed stocks will become increasingly relevant for robust climate adaptation to climate change. Reid (2016) also recommends focusing on genetic diversity and native species in EbA approaches. Indigenous rainwater harvesting practices (Andrade et al. 2011) and using ITK in overall water management (World Bank 2009) were mentioned as key opportunities for improved water management in a changing climate. Mercer et al. (2014), however, criticize many of the current climate adaptation plans around food security, in particular for not being explicit enough in using ITK or at least acknowledging its value. This can potentially lead to elimination of ITK from planning approaches and project designs even if it might be implicitly recognized by the range of actors involved. This could be avoided by a clear requirement in climate adaptation planning and project guidance to demonstrate how ITK has been included and has informed climate adaptation approaches. ITK of local ecosystems is also argued to be a significant knowledge source that scientists need to understand and use in their work in designing appropriate EbA measures (Vignola et al. 2009).

Empirical examples from Tanna Island (Vanuatu) highlighted the existence of very sophisticated traditional crop rotation systems on Tanna Island that are still in use and maintain community food security. However, communities noted these were eroding, given the increased pressure of population growth and having to convert forests into agricultural areas. One key factor in land use is land ownership regulations and community decision-making on which areas can be used and for what. This was found to be relevant both in Samoa and Vanuatu, but also in the Pacific Islands more broadly. In Samoa, a number of coastal reforestation projects (mainly mangroves and native trees) have been undertaken to reduce erosion. Several experts noted a large difference in the sustainability of such projects and identified local ownership, community champions, and using the existing traditional (Matai) system of governance as key factors for project sustainability (see Table 1: experts 1, 7, 8). Here, sustainability is referred to as outcomes where communities continue to care for the plants even when project funding has finished for such activities. Similarly, on Tanna Island, traditional governance structures very much dictated the daily decisions on land use, traditional ceremonies, and activities.

In Samoa, participants did not explicitly mention ITK in the context of climate adaptation measures. This reflects, in part, the history of Samoa, with the influence of Christian missionaries, colonization, and Western education and development regimes in the nineteenth and twentieth centuries, which resulted in decreased use of ITK. While ITK does remain in Samoa, maintained within the Samoan language, dances, stories, songs, weather forecasting, agricultural practices, and governance structures, it is not necessarily recognized by local people as ITK or considered to be directly relevant to the task of adapting to climate change. A government stakeholder (see Table 1: government 1) suggested that while ITK was applicable to past climate conditions, he was unsure how to explain the concept of climate change in terms of the traditional system of knowledge and beliefs.

Indigenous Samoan stakeholders overwhelmingly favored engineered solutions to sea level rise, inundation, and coastal erosion. Historical climate adaptation actions focused heavily on hard infrastructure solutions to climate hazards, with groins and seawalls (coastal) as well as levees (rivers) used extensively throughout the two main islands. The construction of hard infrastructure has created expectations among local residents who reported that they feel confident that coastal and flood infrastructure would protect them from climate risks (sea level rise, coastal erosion, storm surges, and flooding) both now and in the future. Although EbA projects have been implemented in Samoa, on the island of Savai'i, observations suggested that most EbA projects were implemented in combination with engineered approaches. Indeed, the primary focus of these voluntary EbA actions was to improve the aesthetics of seawalls (to make the hard structures more visually appealing and in keeping with the wider village landscape) rather than for coastal protection. An indigenous government stakeholder (see Table 1: government 1) noted that EbA approaches were simply too cheap when it came to planting and vegetation costs. Often, project budgets were large (hundreds of thousands of dollars), and there was an expectation from both donors and Samoan government officials that all the money should be spent within the allocated project time frame (usually a couple of years). In comparison to building a seawall or desalination plant, the planting of vegetation was not as expensive, and hence, government officials and development agencies often did not select ''green'' EbA strategies, as they claimed they were not costly enough to spend the whole budget.

c. Coproducing knowledge for robust EbA

The concept of knowledge integration emerged as a significant factor in determining the knowledge base for EbA-related projects and programs. Munang et al. (2013, p. 31) suggest that combining agricultural science and traditional knowledge for food security in Africa could result in "better referenced and validated indigenous knowledge." Faulkner et al. (2015, p. 8) note that novel climate knowledge comes from "blending climate change science with meaningful LK." Although ITK has enabled communities to cope with adverse weather events and disasters, given the changing climate, this knowledge is seen as no longer wholly sufficient (Andrade et al. 2011). Hay et al. (2013, p. 304) also point out that ITK might be "a poor guide" to decision-making under a changing climate.

Andrade et al. (2011, p. 4) further argue that knowledge integration is crucial, given that "EbA is based on the best available science and LK, and should foster knowledge integration and diffusion." In the context of food security in SIDS, Mercer et al. (2014) note that LK and science should be treated in a balanced manner in EbA approaches, as often LK is seen as inferior to technology-related Western science. Similarly, Girvetz et al. (2014, p. 238) note the importance of merging knowledge for robust EbA: "combining targeted climate change data, relevant scientific information and local knowledge as part of a facilitated stakeholder-engaged decision process in order to best plan for the resiliency of ecosystems and human livelihoods in the face of a changing climate."

Brink et al. (2016) also echo this recommendation in stating that there is an increasing need to integrate LK, gender dimensions, climate science, and community participation in developing robust EbA approaches. Often, such EbA strategies as buying urban land for ecosystem restoration fail to incorporate gender dimensions (whose livelihoods are impacted) or fail to include the community in the decision-making and planning process (Brink et al. 2016). Dhar and Khirfan (2016) likewise suggest that knowledge integration (ITK and science), community participation, and use of ecosystem services are the core tenets of EbA. Using participatory governance systems will lead to "collaborative decision-making and enhance transparency and accountability" while also taking into consideration the role of ITK, which all work together to increase community ownership of EbA projects (Boer and Clarke 2012). Integration of ITK with science, or more specifically, "building bridges between 'scientific' knowledge and traditional Indigenous knowledge," is reported as key for EbA (Pramova et al. 2012b).

Doswald et al. (2014) note that integrating and using ITK in EbA approaches and project design is inherently challenged by the fact that much of this knowledge is not necessarily written in documents, but passed on through social interaction such as telling stories. In Fiji, ITK was used as part of the EbA assessment undertaken by an environmental consultancy (see Table 1: expert 1). The use of ITK included identification of coastal native species that are suited to reduce erosion and reduce coastal flooding and gaining historical knowledge from the community about past flood events and impacts in the area and villages in identifying the EbA project site. This information was used to validate the storm-surge models of previous storms and, according to the expert, had led to a better understanding of the extent of flooding and the range of species that existed and could be used as part of replanting efforts on the coast (see Table 1: expert 1). During the first visit to the community, the experts and local community members identified a coastal area with significant erosion that could benefit from the EbA project. Yet, it was only during the second visit to the site that the villagers noted that the erosion was mostly due to sand mining by community members and external actors and not due to increased storm activity or sea level rise. We learned of similar examples in Vanuatu, where sand mining is increasing rates of erosion on coastal areas, and in Samoa, where sand mining, while forbidden, is still practiced by resorts for beautification purposes, contributing to the loss of sandy beaches. Understanding such local processes is therefore integral for robust EbA, rather than connecting, for example, increased erosion to climate change alone.

Another reason why ITK might not be contributing to climate adaptation processes and projects is potentially impacted by the way many climate adaptation studies and initiatives are conducted. In Samoa, research participants spoke of the government and NGO-sponsored climate adaptation studies and initiatives being top-down and externally directed without due recognition of ITK. Indigenous land owners expressed feelings of research fatigue, with most being repeatedly visited by researchers (mostly non-Samoans) who simply wanted to extract information for their research projects from local people about their knowledge of local environmental conditions. These researchers followed Western modes of conduct, and Samoan stakeholders reported that they received no follow up about the studies' findings, climate adaptation projects, or funding to facilitate climate adaptation. Since Western researchers were not following traditional cultural protocols and were (from the perspective of Samoan stakeholders) operating within a Western scientific framework, it is unsurprising that Samoan research participants were reluctant or embarrassed about sharing ITK (supposedly old ways of thinking or superstitions) with ''outside'' experts. This is similar to our experience elsewhere in the Pacific region, where at times there is embarrassment over ITK as old backward thinking.

In Vanuatu, communities on Tanna Island use ITK on a daily basis in agricultural activities and cultural ceremonies. When asking communities about their relationship with ecosystems, the importance of ITK in understanding seasons, planting, or fishing periods became obvious. For example, the chief can set taboo periods on particular marine areas if he considers the ecosystem to need time to recover. There are also environmental indicators that are used to guide the communities' planting activities: the flowering of a particular flower or fruit tree signals the start of a particular planting activity and subsequent ceremonies relating to planting (e.g., yam).

Consultations with communities on Tanna were also useful in order to gain insights into observed and experienced changes to the ecosystems and to better understand the two-way relationship between communities and their natural environment (see Table 1: communities 1–4). Similar to the experience of expert 1 (see Table 1), hearing about the productivity agriculture plots used to have (community 1), the abundance of fish species and rate at which fish stocks used to regenerate in the past (communities 2 and 4), and which forest areas are not used for living and collecting food (community 3) provided a baseline in cases where there are no scientific data. Overall, the Tannese culture is very centered on stories that represent causal factors, as has also been documented elsewhere (Lindstrom 1982, 2011). For example, through informal conversations, we heard explanations for why something had happened due to black magic and about particular men being able to control the weather due to holding specific ITK in that family line. Despite the high use of ITK in everyday life, the Tannese communities were interested in and expected more Western-type solutions (e.g., seawalls, other hard infrastructure) for climate adaptation projects for their area.

4. Discussion

This paper has examined the different assumptions, expectations, and activities related to ITK as a significant component in EbA. We examined the ways that ITK is defined and how stakeholders are considering ITK when discussing EbA options for planning and implementation. Not surprisingly, there was significant overlap between different terms used relating to ITK in the literature: ITK and LK were often used interchangeably and in many instances in the same sentence or paper, which in other literature often seems to be the case. The UNFCCC and IPCC have broadly agreed to use ITK as an overarching term, as this is seen to cover cognate knowledge bases and recognizes that some people and communities can hold knowledge about traditions even if they themselves would not be of indigenous heritage. The observations from Tanna Island and Samoa confirm that it is indeed difficult to differentiate ITK from LK where these relate to intimate understanding of the local environment and its dynamics.

The main assumptions about ''robust'' EbA are clearly centered on knowledge integration and community participation: the more ITK is incorporated with science and the more communities are involved and engaged in climate adaptation, the more robust the approach or program will eventually be (Andrade et al. 2011; Boer and Clarke 2012; Chong 2014; Dhar and Khirfan 2016; Girvetz et al. 2014). While this is a welcome recognition both for ITK and communities involved, it can easily result in a blanket approach where any ITK is included, even in cases where it might be misleading or not able to keep up with the changing climate, and as long as the ''community'' has participated, the approach is deemed successful.

This, however, does not pay attention to the fact that much of ITK is held only by particular individuals, with differences also based on gender, and where in some instances advocating by select groups of people (e.g., men, elders in the community) for a particular kind of ITK (e.g., traditional governance systems) can function to maintain the existing power relationships even if these disadvantage, for example, women and youth. This suggests the need for further critical assessment as to what ''local'' or ''indigenous'' knowledge actually includes, how it has developed as the knowledge base for particular activities (rainwater harvesting, indigenous crop rotation system), and the extent this knowledge can accommodate the changes in climate and ultimately in the target ecosystem. Such evaluation is most relevant and appropriately done by indigenous peoples themselves who are observing changes in their local environment.

Practical examples of how ''novel climate knowledge'' (Faulkner et al. 2015) is emerging across communities and from climate adaptation projects. Emphasis is often placed on how to ensure knowledge integration between ITK and Western scientific knowledge. However, critical social scientists increasingly question such ''integration'' projects. Many projects are often externally driven and make determinations of which parts of ITK are of value (weather conditions, phenology, medicinal uses of biota, and cosmological teachings) while ignoring other ITK aspects (Veland et al. 2013; Diver 2017). This is clearly seen in the case of Samoa, where much of the formal climate adaptation activity sits outside the traditional governance systems and knowledge.

The insights from indigenous peoples in Samoa and Australia, like those from Inuit in Canada and Sami in Sweden, raise broader queries about the classification, use, and incorporation of ITK (at the community, national, and international levels and within specific sociopolitical regimes). Projects that seek to include ITK in environmental management are, as Diver (2017, p. 1) aptly observes, ''fraught with contestation over knowledge values and interests.'' For instance, in Australia and Aotearoa New Zealand, scientists and policymakers frequently frame indigenous relationships to water and land in terms of ''indicators'' or ''cultural values,'' which are then integrated into and subsumed by (Western scientific) ecological indicators to justify planning and management strategies dominated by scientific thought. Many existing models of integrating ITK and scientific knowledge fail to challenge the status quo of Western thought, development, and climate adaptation options and do not navigate power asymmetries between groups effectively (Diver 2017). These ITK environmental indicators need to be seen as part of a separate system of knowledge that coexists with, but is not submerged into, another (scientific) knowledge system with its own environmental indicators. Indeed, in other contexts, it has been suggested that Western science and ITK are in fact separate but complementary knowledge traditions, each requiring validation on its own terms (Tengö et al. 2013).

We suggest the need to shift away from merely focusing on integration and toward the coproduction of knowledge. Examples of such knowledge coproduction in climate-related work are increasing (Bremer et al. 2018; Parsons et al. 2017a), but much more can be done to consider the ways in which ITK and Western science can support more holistic approaches to climate adaptation (Huntington et al. 2004). In relation to EbA, knowledge of indigenous plant species, historical events (such as flooding and tropical cyclones), and changes in the environment can all feed into EbA approaches that build upon the local context. It is also paramount to recognize that ITK is a changing dynamic knowledge. Given climate change, we need to better understand which parts of ITK remain relevant (e.g., early warning indicators or plant indicators for harvests and ceremonies) and where these are changing (e.g., Chand et al. 2014). In this regard, women are key observers of these changes, given that much of their traditional livelihood roles include, for example, animal and plant health and availability of water and plant species, all of which are impacted by climate change.

The examples from Samoa and Vanuatu highlight the ways in which ITK continues to underpin sociocultural and political structures and livelihood activities in various ways. However, as a wealth of scholarship demonstrates, there is a loss of ITK throughout the Pacific, linked to Western development, educational systems, urbanization, language loss, and migration (Brosi et al. 2007; McCarter and Gavin 2014a,b). Furthermore, within the climate adaptation sphere, researchers, governments, practitioners, and community members have often favored hard engineering solutions to climate risks (based on Western scientific assessments and projects), which could explain the underutilization of ITK within climate adaptation activities. Focus on hard engineering has also meant that EbA options have been deemed as less effective, for example, in Samoa (Fakhruddin et al. 2015). Here, there is a large opportunity for researchers, practitioners, and community members to collaborate in codesigning projects that include or are based upon indigenous systems of research, assessment, and validation (such as Talanoa, which is a Tonga narrative-based method for data collection and analysis) to identify and record ITK and employ ITK within EbA projects (Vaioleti 2013).

Although community participation is seen as an integral part of climate adaptation and, in particular, of EbA (Andrade et al. 2011; Reid 2016; Mercer et al. 2014; Munang et al. 2013), our experience in Samoa highlights the need for careful coordination and consideration about which kinds of interactions carry the most benefit for the communities in question. This is a prime example of the importance of utilizing traditional sociocultural governance structures (the Matai system) and ensuring that sufficient time is spent cultivating relationships between researchers and research participants, which builds trust and mutual understanding across cultures (Parsons et al. 2017b). Also, the colonial histories and their impact on the kinds of knowledge, practices, and worldviews that are seen as important need to be considered, especially when considering ITK in climate adaptation projects.

Likewise, in Vanuatu, with many remote rural communities, external interventions need to be carefully thought through, given the many existing traditional interpretations about causal factors such as occurrence of triggers (cyclones, black magic) and outcomes (increases in extreme events, loss of crop yields). ITK is being captured in Vanuatu at broader scales that will also be helpful in understanding how climate adaptation fits in the cultural context (Chand et al. 2014) and its integration with, for example, weather forecasting (Plotz et al. 2017). Understanding these cultural dimensions of causality is crucial for EbA; otherwise, many well-intended projects can face significant backlash at the community level. Indeed, as Hay et al. (2013) point out, understanding perceptions of causality is important: some changes occur due to global climate change, whereas other changes can be simply caused by maladaptive environmental practices or increased population growth. Engaging communities in the process of documenting and understanding long-term local trends and practices will enable more realistic insights on the causal linkages and what interventions are feasible and appropriate in each context. This also relates to discussions on the effectiveness of EbA (Bertram et al. 2017; Reid et al. 2017) and how both ITK and Western scientific assessments of change can learn from each other in advancing localized climate adaptation and EbA in particular.

5. Conclusions

The increasing body of EbA-specific literature provides strong support to such concepts as ‘‘community participation’’ and use of ITK in localizing climate adaptation activities to increase effectiveness and the feeling of ownership of climate adaptation outcomes. Yet, many of these do so without necessarily taking a critical look at the differing knowledge systems at play or the dynamic relationship between ITK and climate change. Existing models of integrating ITK and scientific knowledge fail to challenge the status quo of Western thought, development, and climate adaptation options, or to navigate power asymmetries between groups effectively, whereas indigenous communities often consider the concept of knowledge integration as another type of colonization.

In implementing and designing EbA, it becomes paramount to acknowledge and codesign approaches that recognize indigenous governance systems and broader ITK. This includes understanding perceptions of causality based on particular worldviews and cultural stories (black magic, environmental indicators of change). In the literature, identifying indigenous crop species for agriculture and improved food security by using ITK is already identified as an important way to localize climate adaptation. However, for EbA approaches in coastal areas, similar approaches could be used for identifying most robust species in reducing erosion and shoreline stabilization and understanding which groups and individuals hold that knowledge. Future research should therefore consider the inherent power relationships and internal debates about what ITK is, who claims to ‘‘own’’ it, and how ITK is changing under changing climatic conditions.

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