Climate Policy

ISSN: 1469-3062 (Print) 1752-7457 (Online) Journal homepage: http://www.tandfonline.com/loi/tcpo20

Overcoming barriers to climate change information management in small island developing states: lessons from pacific SIDS

Samuel Mackay, Rebecca Brown, Makelesi Gonelevu, Netatua Pelesikoti, Talei Kocovanua, Rebecca Iaken, Florence Iautu, Luisa Tuiafitu-Malolo, Sione Fulivai, Ma'asi Lepa & Brendan Mackey

To cite this article: Samuel Mackay, Rebecca Brown, Makelesi Gonelevu, Netatua Pelesikoti, Talei Kocovanua, Rebecca Iaken, Florence Iautu, Luisa Tuiafitu-Malolo, Sione Fulivai, Ma'asi Lepa & Brendan Mackey (2018): Overcoming barriers to climate change information management in small island developing states: lessons from pacific SIDS, Climate Policy, DOI: 10.1080/14693062.2018.1455573

To link to this article: https://doi.org/10.1080/14693062.2018.1455573

Published online: 02 Apr 2018.

CLIMATE POLICY, 2018
https://doi.org/10.1080/14693062.2018.1455573

Taylor & Francis
Taylor & Francis Group

POLICY ANALYSIS ARTICLE

Overcoming barriers to climate change information management in small island developing states: lessons from pacific SIDS

Samuel Mackay[a], Rebecca Brown [a], Makelesi Gonelevu[b], Netatua Pelesikoti[b], Talei Kocovanua[c], Rebecca Iaken[d], Florence Iautu[d], Luisa Tuiafitu-Malolo[e], Sione Fulivai[e], Ma'asi Lepa[e] and Brendan Mackey[a]

[a]Griffith Climate Change Response Program, Griffith University, Southport, Australia; [b]Secretariat of the Pacific Regional Environment Programme (SPREP), Apia, Samoa; [c]Climate Change Division in Ministry of Economy, Fiji Government, Ro Lalabalavu House, Suva, Fiji; [d]Program Management Unit, National Advisory Board on Climate Change and Disaster Risk Reduction, Government of Vanuatu, Port Vila, Vanuatu; [e]Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC), Tonga Government, Nuku'alofa, Tonga

ABSTRACT

We live in a rapidly advancing digital information age where the ability to discover, access and utilize high-quality information in a reliable and timely manner is often assumed to be the norm. However, this is not always the experience of researchers, practitioners and decision makers responding to the challenges of a rapidly changing climate, despite the billions now being made available for investment in climate change adaptation initiatives throughout the world and particularly in developing countries. In recognition of the importance of information in adaptation planning, Article 7.7 of the Paris Agreement sets out clear guidance for parties to develop, share, manage and deliver climate change knowledge, information and data as a means to strengthening cooperation and action on adaptation. This article provides some key lessons and insights on climate change information and knowledge management (IKM) in small island developing States (SIDS) from the perspective of Pacific SIDS. A situation analysis of current climate change IKM practices in Fiji, Tonga and Vanuatu was conducted and key barriers to effective climate change IKM identified. The outcome of this article is a range of pragmatic policy considerations for overcoming common barriers to climate change IKM in the Pacific, which may be of value to SIDS more widely.

Key policy insights

- The partnership approach of co-investigating climate change IKM barriers in collaboration with Pacific SIDS generated considerable trust, a shared purpose and therefore rich IKM lessons and insights.
- Turning climate change IKM aspirations into practice is significantly more complicated than expected, and requires a long-term commitment from both national governments and development partners.
- Pacific SIDS need to establish national guiding climate change IKM Frameworks that leverage rather than duplicate growing national investments in whole-of-government IKM.
- Reframing climate change IKM in the Pacific towards demand and user needs will be critical to ensuring widespread ownership and participation in IKM solutions that lead to greater adaptation and resilience outcomes.
- It is also critical that IKM activities in SIDS support the development of national capacity to scope, develop, deploy and maintain decision support systems.
- Federated IKM systems are ideal for encouraging greater IKM collaboration.

ARTICLE HISTORY
Received 30 June 2017
Accepted 18 March 2018

KEYWORDS
Climate change adaptation; information and knowledge management (IKM); Pacific; resilience; SIDS

CONTACT Samuel Mackay samuel.mackay@griffith.edu.au Griffith Climate Change Response Program, Griffith University, Gold Coast Campus, Southport QLD 4222, Australia

1. Introduction

While it is axiomatic that data and information are needed for adaptation and resilience planning and decision making, it cannot be assumed that they will be available when needed. In practice, the fragility of this unwarranted assumption is all too often exposed by difficulties in discovering, accessing or utilizing existing data and information. For those in developing countries responding to risks arising from a rapidly changing climate, these difficulties are prevalent and, in some cases, such as responding to natural disasters, can have dire consequences. With increasing recognition globally of the need to share, access and utilize key climate change information for adaptation and resilience planning (Hanger, Pfenninger, Dreyfus, & Patt, 2013), there is an emerging emphasis on information management in climate change policies and plans from all levels around the world (Jones et al., 2015).

The Paris Agreement on climate change (UNFCCC, 2015) further bolsters the significance of climate change information management by setting out guidance in Article 7.7 for parties to develop, share, manage and deliver climate change knowledge, information and data. In the Pacific region, the need for climate change information management is referenced in most national climate change policies, while the new regional Framework for Resilient Development in the Pacific (FRDP) further highlights the importance of good quality information, and information systems, to effective adaptation and resilience planning (Secretariat Pacific Community [SPC] et al., 2016).

This article examines the barriers to managing and delivering climate change information in small island developing States (SIDS), and provides some lessons and insights for overcoming these, based on experiences in Fiji, Tonga and Vanuatu. The term 'information and knowledge management' (IKM) is used throughout to characterize the process of managing the rich array of data, information and knowledge required for adaptation and resilience planning and decision making.

2. Policy context: national climate change IKM

The policy environment for climate change IKM is complex and has multiple components, which both directly and indirectly influence national IKM practice. In this context, the Paris Agreement serves as the paramount international policy framework influencing national IKM responses by: (i) recommending under Article 7.7 IKM actions by which parties can better develop, share, manage and deliver climate change knowledge, information and data; and (ii) recommending activities that indirectly require some level of IKM from parties in order to fulfil their national adaptation planning (Article 4.2) and reporting (Article 7.10) obligations under the agreement. The indirect IKM actions identified under the Paris Agreement necessitate the use of IKM practices to systematically inform adaptation and disaster risk reduction options, track progress and support the collection and updating of priority information, particularly in known gap areas (Ford & Berrang-Ford, 2016).

For developing countries, climate finance presents an additional driver for national climate change IKM, given that it is tightly embedded within funding requirements. The Green Climate Fund (GCF) in particular is a strong driver of national climate change and resilience IKM in developing countries with GCF's current funding guideline for Readiness and Preparatory Support recommending 'adaptation knowledge management, information sharing, and communication' as key elements for consideration in funding requests for national adaptation planning support (GCF, 2017a). With US$10.3 billion in funding currently pledged to the GCF, of which 50% will support adaptation in developing countries (GCF, 2017b), it is clear that GCF funding requirements for adaptation will have considerable influence on how developing countries shape their adaptation and resilience planning, and the role that IKM will play in this.

Growing international consensus that adaptation and disaster risk reduction (DRR) activities share common targets and goals and therefore should be better integrated at a national policy level (Begum, Sarkar, Jaafar, & Pereira, 2014) raises new questions about the scope of IKM content and efforts. While the literature on how best to integrate adaptation and DRR continues to evolve, consideration of this integration is already being reflected in climate change IKM in the Pacific, where interoperability between the vocabularies and common terms used to manage adaptation and DRR information has commenced (Brown & Gonelevu, 2015). The FRDP, which integrates both adaptation and DRR objectives, also provides a framework for meeting national obligations under

the Paris Agreement. In doing so, the FRDP directly addresses the need for IKM action and suggests a number of discrete IKM actions that Pacific countries can implement to support their national adaptation and resilience planning (SPC et al., 2016).

3. Managing and delivering adaptation information: IKM thinking and challenges for adaptation

Current thinking in information management values data, information and knowledge as key assets for decision making (Barnes & Milton, 2015) and organizational success (Geisler & Wickramasinghe, 2009). The 'open data' movement furthers this by suggesting that the value of information is maximized if published in open access repositories and able to be freely used, modified and shared (Van den et al., 2011), with the common objective to exploit information to its fullest extent (Molloy, 2011). In practice, good information management typically involves engaging people, processes, and technology to capture and deliver the right content to the right people at the right time (Duffy, 2001). This means that, for information to be useful, it needs be systematically identified, captured, collected, organized, indexed, stored, integrated and shared (Geisler & Wickramasinghe, 2009). The principles and benefits underpinning good information management can be grouped under four themes (ANDS, 2015):

- Secure and sustainable storage – Providing the capability to store information on stable infrastructure that will be available over the long-term;
- Connectivity – Improving the capability to discover information through greater connectivity among repositories;
- Discoverability – Ensuring that information is clearly described with standard metadata, making it more widely discoverable; and
- Reusability – Ensuring that baseline data, data produced from tools, and information from studies are formatted and described in a way that makes them reusable.

Notwithstanding the merit of current thinking on how to effectively manage and deliver information, the process of operationalizing such thinking is often complex and varies among specific communities of practice (Lee & Samuel, 2017). In general, the process of transforming data to useful information and then knowledge can be long, complicated and involve multiple steps that require input from different areas of expertise (Ahern, Leavy, & Byrne, 2014). It is also clear from the evolving nature of science and its application to solve complex problems, that the data, information and knowledge relied upon is finite and there is an ongoing need to update and review data, information, knowledge and the effectiveness of scientific methodologies used (McIver, Lengnick-Hall, Lengnick-Hall, & Ramachandran, 2013).

In the area of climate change adaptation, while it is now widely accepted that the ability to effectively develop and deliver adaptation and resilience plans is partly dependent on being able to access and utilize the best available information (Conway & Mustelin, 2014), the cross-disciplinary nature of many climate change problems makes this difficult (Curdt, Andrew Cox, & Hoffmeister, 2015). These difficulties are exacerbated further by the different methodologies used in analysing adaptation responses among varying disciplines (Maru & Stafford Smith, 2014) and the need to integrate responses at multiple geographic scales, from local, subnational, national and regional through to global (Lynch, Tryhorn, & Abramson, 2008). Even within a single discipline and scale, the process of turning climate projection data into useful risk-based information to assess vulnerability and impact, and then generate adaptation options and knowledge, is a long and complex chain with numerous opportunities for breakdown (Head, 2014; Mullan, Kingsmill, Agrawala, & Matus Kramer, 2013).

Imbalances between information supply and demand are often cited as factors further complicating the management and delivery of adaptation information (Archie, Dilling, Milford, & Pampel, 2014; Dunn, 2015). This is in part due to the diverse ethnography in which users operate (L. Head, Gibson, Gill, Carr, & Waitt, 2016), along with difficulties associated with identifying and framing information to meet user needs (Petr, Boerboom, Ray, & van der Veen, 2016), and recognition that the effective application of information is dependent on a user's capacity to receive, understand and apply it (Wilby et al., 2009). It is therefore not unusual for those

developing and delivering climate information to struggle to know how to make it purposeful for the user; conversely, it is often challenging for those needing adaptation information to articulate their information requirements when they are not fully aware of the science (Kalafatis, Lemos, Lo, & Frank, 2015; Lemos, Kirchhoff, & Ramprasad, 2012).

Increasing attention on decision support systems and climate services in recent years has re-focused information delivery towards user needs for specific climate change problems (Feldman & Ingram, 2009; McNie, 2013). In particular, these approaches place the user at the centre of the information delivery process, resulting in greater emphasis on how best to engage users, meet their usability requirements, deliver information via appropriate mechanisms and bridge any capacity gaps (Street, Sanderson, & Clare, 2015). The targeted and often bespoke nature of climate services and decision support systems help to avoid complexities associated with delivering information across disciplines and multiple geographic scales (Eisenack et al., 2014; Moser & Ekstrom, 2010).

Issues around trust and integrity of climate change information can still occur between information developers and users (Feldman & Ingram, 2009; Scott-Parker et al., 2017), which in many ways is a representation of conflict between the two groups' concerns for ensuring the integrity of their activities, and related ethical considerations. For example, users need definitive information to form a strong justification for risk assessments and decision making, while those developing data and information are often concerned about misuse or misinterpretation of their work (Dunn, 2015). This common challenge can in some cases result in issues around the release of information or limitations to its terms of use (Crowley, 2014). Associated with this is the challenge of dealing with uncertainty of climate projections and subsequent risk assessment models, and how the issue of uncertainty is perceived by users and integrated into options for adaptation planning and decision making (Bhave, Conway, Dessai, & Stainforth, 2016).

Intellectual property rights and their application present another layer of complexity to the management and delivery of adaptation information, known as the 'access challenge' of the twenty-first century. Beldiman (2013) describes this challenge as the tension between fragmentation of knowledge as a result of strong intellectual property laws, and the interest in the free flow of information to innovate and further knowledge. Although laws and positions on intellectual property vary among jurisdictions, it is often the case that the application of restrictive intellectual property licenses means that climate change related information is fragmented and not always accessible (Overpeck, Meehl, Bony, & Easterling, 2011).

4. Role of effective IKM in adaptation

In order to conceptualize the role of IKM in adaptation, this article considers adaptation planning through a typical science-to-action frame. As summarized in Figure 1, transferring science into action generally involves undertaking scientific research which produces data, making sense of the data which results in information and then testing or applying the information which results in knowledge (Liew, 2007; Rowley, 2007). This process helps to achieve more effective policy and decision making by generating clear and synthesized scientific information. In the area of climate change adaptation planning, there is a parallel process which involves: (i) utilizing data to determine climate change projections and impacts; (ii) generating information on future climate related risks by applying data to undertake vulnerability assessments; and (iii) utilizing risk information to develop and evaluate adaptation options and plans (Pahl-Wostl et al., 2013). The common end goal of this adaptation planning process is better decision making for adaptation actions and policy. From an IKM perspective, the intended end outcome of these parallel processes is to facilitate the re-use of quality data, information and knowledge, which can reduce duplication of efforts and support better science, decision making and outcomes (Crowley, 2014; Innocenti & Albrito, 2011). Key to achieving all these end outcomes is ensuring that relevant data, information and knowledge is captured, stored, discoverable and accessible by key stakeholders in a format and type that is usable and meets their needs (Ramesh, Vivekavardhan, & Bharathi, 2015). It follows, then, that good information management standards, practices and systems have an important role to play in supporting the facilitation of science into practice and therefore the development of effective adaptation responses.

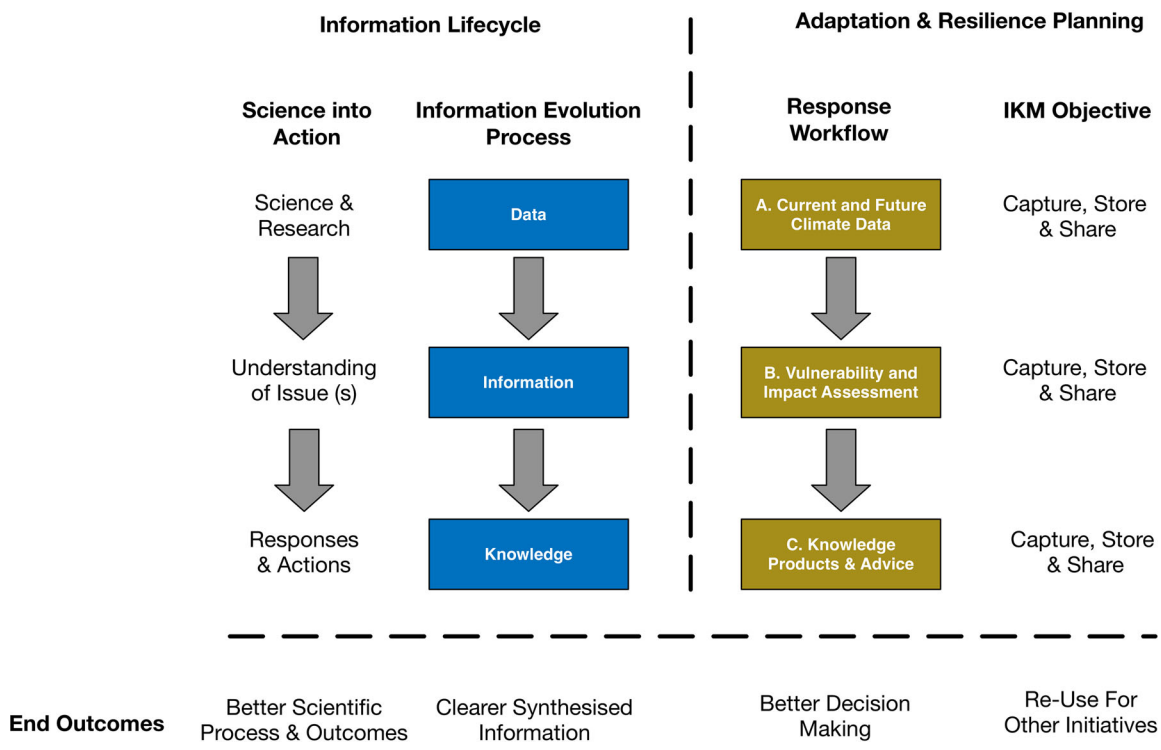

Figure 1. Summary of parallel data-information-knowledge process and IKM objectives for science to action and adaptation and resilience planning.

The type of user and their specific information needs is another key point of distinction that needs to be considered when looking at the role of IKM for adaptation. To date, much of the literature looking at adaptation users and their IKM needs tends to generalize all users as decision makers. While this article does not address and disaggregate the issue of different user types and their diverse IKM capacities and needs, it does recognize the importance of such activities to maximizing the relevance and impact of adaptation information.

5. Climate change IKM in pacific SIDS: situation analysis and barriers assessment

The Pacific region is home to 20 SIDS, which are among the most vulnerable in the world to natural hazards and climate change (Nurse et al., 2014). Over the last 60 years, the Pacific region has experienced over 2400 tropical cyclones, many of which have caused severe destruction, loss and death (World Bank, 2013b). Based on natural hazard data published by the World Bank in 2013, Pacific SIDS account for eight of the world's 20 most economically vulnerable SIDS, in which natural hazards have an average annual economic cost of between 2–6.5% of their gross domestic product (GDP) (World Bank, 2013a). In contrast, Pacific SIDS account for only 0.03% of global greenhouse gas emissions (Nurse et al., 2001).

Against this background of extant and emerging climate-related risks, the new FRDP (SPC et al., 2016) sets out a range of adaptation and resilient development actions for Pacific SIDS, a number of which focus on good information management practices. In order to better understand current climate change IKM practices in Pacific SIDS, a situation analysis was carried out with government representatives from the Pacific countries of Fiji, Tonga and Vanuatu. The aims of this analysis were to identify (i) the current status of climate change IKM practices in each participating country; and (ii) barriers preventing the effective utilization of climate change information in adaptation and resilience planning. The intent of the situation analysis was to work in collaboration with the participating countries as partners, in order to build greater ownership of the findings and response options.

The methodology used for the situation analysis was a questionnaire and a single follow up face-to-face regional workshop, which both involved engagement with: (i) national government staff responsible for climate change information management from Fiji, Tonga and Vanuatu; (ii) regional staff from the Secretariat for the Pacific Regional Environment Programme (SPREP) responsible for the Pacific Climate Change Portal (PCCP)[1]; and (iii) other national and regional stakeholders who either develop or utilize climate change information. The questionnaire and regional workshop focussed on identifying climate change IKM issues and needs for Pacific SIDS, based on participants acknowledging a joint understanding of: (i) the current thinking around best practice IKM; (ii) challenges for effective IKM in climate change adaptation; and (iii) the role of IKM for supporting best practice climate change adaptation.

The approach used to collect and consolidate responses to the questionnaire involved the designated climate change IKM officer from Fiji, Tonga and Vanuatu developing a single national response based on review and discussion of the questions internally among stakeholders. This approach for collecting responses to the questionnaire was identified by the participating countries as desirable due to: (i) the relatively low number of stakeholders operating in this area in each country; (ii) the need to foster ownership of IKM challenges and opportunities; (iii) the need for a consolidated national view on the current situation of climate change IKM; and (iv) the need to avoid overburdening the relatively small and often overcommitted climate change teams operating in each country. Collectively, the designated climate change IKM officers in each country consulted over twenty people to consolidate their response.

The questionnaire included both open ended and controlled pick list questions, which provided those consulted with an opportunity to consolidate their perspective on current national climate change IKM practices, the status of national climate change information portals, known national barriers to climate change IKM and opportunities for improving the current situation. An overview of the theme and intent of the questions is provided in Table 1.

The follow-up regional workshop was attended by the designated climate change IKM officers from Fiji, Tonga and Vanuatu who consolidated their national response to the questionnaire, along with director-level government staff responsible for national climate change and some technical staff responsible for managing national climate change Information and Communications Technology (ICT). Overall, eight people from Fiji, Tonga and Vanuatu participated in the workshop, which focused on: (i) verifying the questionnaire findings; (ii) expanding on the questionnaire findings in more detail; and (iii) considering any regional implications of the national findings in terms of common issues and opportunities to share lessons.

5.1. Situation analysis findings

At a strategic level, the situation analysis findings highlighted the governments of Fiji, Tonga and Vanuatu as both users and suppliers of climate change information, with a common intent to ensure IKM practices can support national adaptation and resilience planning efforts. This is evidenced in each country's national-level climate change policy, which reference the importance of climate change information collection, storage, sharing and delivery as key priorities (Government of the Republic of Fiji, 2012; Government of the Republic of Vanuatu, 2016; Kingdom of Tonga, 2010). However, at the time of the analysis, none of the participating countries had a comprehensive framework for guiding actions that would support the realization of their strategic climate change IKM aspirations. A lack of IKM capacity, experience and knowledge was identified by all three countries as a major limitation to converting strategic climate change IKM aspirations into practical actions that support adaptation and resilience planning. In addition, all three countries acknowledged that their general operating environment of limited funding, capacity and resourcing further exacerbated their climate change IKM challenges, and there is a need for support from senior executive champions to help overcome these limitations.

In terms of climate change IKM practice, all three countries identified minimal data sharing between national government departments, with sharing between government and external stakeholders being poor and, in some cases, non-existent. In the case of data sharing among government departments, several factors were continually raised as key limitations, including: (i) the need to meet departmental cost-recovery requirements; (ii) concerns regarding misrepresentation of data; (iii) concerns regarding loss of mandated powers to deliver information; (iv) no clear whole-of-government data sharing obligations (although these are being developed); and

Table 1. The themes and intent of questions asked in the situation analysis questionnaire.

Theme	Intent of Questions
Current National Information Management Practices	To identify: 1. What existing or emerging climate change IKM policy or strategy exists in each country. 2. How current climate change IKM policy or strategy is applied 3. What funding is available for national climate change IKM. 4. What storage infrastructure is used for national climate change data, information and knowledge. 5. Common and uncommon IKM practices within government. 6. The level to which climate change information is shared with internal and external stakeholders, and how this sharing occurs. 7. Common information discovery and access issues and practices. 8. The capacity of national staff to implement good climate change IKM practices.
National Climate Change Portals	To identify: 1. Current practices around developing business case or needs assessment for portal services. 2. The aim and primary audience of the portal 3. What content is currently on the portal and what still needs to be added. 4. How information is added to the portal and any verification processes implemented.
Barriers to National Climate Change IKM	To investigate issues such as: 1. Funding availability and constraints. 2. staff availability or capacity to work on IKM. 3. Skills in content management systems. 4. ICT and network storage limitations. 5. IKM policy and governance. 6. Willingness and capacity to share information. 7. Policy inhibitors i.e. IP or public data cost recovery.
Opportunities to Improve IKM National Practices	To identify: 1. Ways in which national climate change IKM could be improved. 2. National targets that would benefit from better national climate change IKM.

(v) limited awareness of the benefits to be gained from good IKM. Where sharing does occur between government departments or with external stakeholders, it was identified as brokered formally via an memorandum of understanding style agreement or conducted informally based on individual relationships held by staff. The importance of minimal metadata standards to information discoverability and therefore sharing was recognized by all countries, although progress in this area was identified as preliminary, and in some cases seen as hindered by a lack of available open source software.

A need was highlighted by all three countries for effective national climate change IKM and decision support systems to enhance the discoverability, accessibility and usability of climate change data, information and knowledge. Targeted decision support systems in particular were highlighted as a key area where additional support was required to address complex policy or science problems, particularly in the area of adaptation planning. In addition, anecdotal evidence was provided about past decision support systems developed in the region, and why they succeeded and failed. The key points highlighted were that past decision support systems built for the Pacific have: (i) often not considered the regional development context; (ii) failed to effectively build regional capacity in their use and application; (iii) not been managed or maintained in the region; and (iv) not upskilled regional and national staff in the decision support system development process.

Each country identified some progress towards developing a national climate change IKM system. However, limited network storage functionality, ICT infrastructure availability and IKM curation skills were highlighted as constraining capability to effectively store, aggregate and deliver decision-ready content from a central location. Consequently, it was common across the three countries for climate change adaptation related information and resources to be stored in a fragmented way among national data custodians and stakeholders, often using moderate to higher risk infrastructure such as CD-ROM, desktops or external hard drives.

Procedurally, common issues affecting the implementation of good climate change IKM practices were identified across all three countries, with the two predominant issues being intellectual property and limited organizational capacity to undertake IKM user needs assessments and solution-based business cases. In terms of intellectual property, each country was aware of issues around copyright, licensing and appropriately managing sensitive information, but no country was directly addressing these issues in a systematic way. Regarding user needs assessments and business case development, all countries had recent experience in developing climate change IKM systems and recognized the need to transition their focus towards user focused systems that are based on easy to maintain software.

5.2. Framing identified barriers

The definition of a barrier used in this analysis was anything that negatively impacted on the ability of Pacific SIDS to implement effective climate change IKM practices. The questionnaire and regional workshop findings identified a number of such key barriers in Fiji, Tonga and Vanuatu and in Pacific SIDS more generally. Table 2 provides an overview of the commonly identified barriers and their suggested underlying causes. In order to promote a demand-driven approach towards climate change IKM, the barriers identified in Table 2 were grouped and framed based on terminology and processes appropriate to governments in the Pacific region. The framing of identified barriers and underlying causes around the user's way of thinking was deemed the best way to increase understanding of IKM barriers and encourage ownership of action. Barriers were framed as either:

- Policy Barriers – a lack of supportive government or institutional policy or strategy for IKM;
- Institutional Barriers – a lack of institutional champions, key roles or partnerships for IKM;

Table 2. Barriers to good climate change IKM in Pacific SIDS with suggested underlying causes.

Type	Barriers	Suggested Underlying Causes
Policy	1. No government strategies for how climate change information should be managed and shared both within government and externally.	Limited recognition of benefits from good information management. Lack of leadership to progress policy reform.
	2. Lack of clarity on national open data stance, particularly regarding open licensing for information re-use.	Lack of awareness on the potential benefits of open data policies.
Institutional	3. Institutional cultures where sharing climate change information is not normal practice.	No national requirements to implement good information management practices within and across departmental portfolios.
	4. Lack of formal agreements between national institutions that require information sharing.	Poor culture of collaboration and cooperation on data and information management issues.
	5. Institutional cultures where information management is not seen as core business.	Data management seen as a technical rather than policy and productivity issue.
Operational & HR	6. Lack of national guidelines and procedures for climate change information management.	No structured organization and control of information.
	7. Limited funding for national climate change information management staff.	Limited recognition of staff resourcing requirements.
	8. National government staff responsible for climate change information management lack prior experience or formal training.	Limited recognition of staff capacity building requirements.
	9. Limited awareness of national climate change information users and their needs.	No guidelines or resourcing for user engagement.
ICT	10. Lack of reliable networked e-infrastructure to host national climate change portals.	No structured organization and control of information.
	11. High internet costs and slow speeds make uploading and downloading content difficult.	Unavoidable factor in SIDS with current technology.
	12. Limited to no backup for climate change information, risking loss of information.	Limited recognition of information management risks and how to manage them.
	13. Limited national expertise in the development and maintenance of content management systems.	Limited national level capacity and resourcing in many sectors including information management.

- Operational or Human Resource Barriers – a lack of formal processes, procedures, guidelines, resourcing or staff capacity in IKM; and
- Information and Communication Technology Barriers – a lack of appropriate digital infrastructure and IT systems for IKM.

6. Overcoming IKM barriers: key lessons and insights

A number of lessons and insights for overcoming climate change IKM barriers in Pacific SIDS have emerged from this analysis, as summarized below.

6.1. Guiding IKM framework and principles

Core to effective climate change IKM is the need for a strong IKM framework to characterize objectives and guide targeted actions (Rubenstein-Montano et al., 2001). The lack of guiding climate change IKM frameworks identified by Pacific SIDS is clearly a major barrier to converting strategic climate change IKM aspirations into practical actions (Brown et al., 2015). The following six guiding principles have been identified as relevant to developing a strong climate change IKM Framework in Pacific SIDS (and possibly SIDS more broadly):

(1) **Recognition of IKM Value**: The need to recognize and value the benefits gained from their effective climate change IKM.
(2) **Strong Information Governance**: The need for strategy and procedures to guide climate change IKM.
(3) **Senior Leadership and Resourcing**: The need for senior officials to support and effectively resource climate change IKM.
(4) **Organization and Control**: The need for quality standards to guide climate change IKM practices.
(5) **Use and Re-use**: The need for systems that enable the use and re-use of climate change information.
(6) **Collaboration and Cooperation**: The need for collaboration on climate change IKM between agencies and across jurisdictions.

6.2. Demand-driven IKM

Although imbalances between the supply and demand of climate change information are well recognized in formal literature, the approach of putting the user at the centre of climate change IKM has only recently started to take shape in Pacific SIDS. For example, once participants in this article's analysis were able to consider user needs more effectively, the outcome was a reframing of IKM barriers in user appropriate language, in recognition of the likely increase to acceptance and ownership of IKM collaboration. In addition, participants of this analysis highlighted the relationship and trust that can be developed by a demand-driven IKM approach, which can provide a good platform to address known user concerns about information uncertainty and misuse.

6.3. Building decision support system capacity in SIDS

Pacific SIDS involved in this article's analysis emphasized the critical need for targeted decision support systems to help bridge clear gaps between climate change science, policy and action. In addition, the anecdotal experiences and lessons of participants highlight that for decision support systems to be effective in Pacific SIDS, regional capacity in user scoping, system development, deployment and maintenance needs to be developed. In some cases, initial steps towards upskilling regional and national climate change officers in various stages of decision support system development are underway, such as those carried out under the Pacific iCLIM project[2] (Griffith University, 2018). The complex and often interdisciplinary nature of many climate change problems, however, means that the demand for decision support systems in Pacific SIDS is only going to grow, making it critical that Pacific SIDS develop capacity in this area.

6.4. Federated systems encourage IKM collaboration

The situation analysis findings suggest that the ICT solutions deployed in Pacific SIDS to date have not been based on appropriate software and ICT architecture to meet identified climate change IKM aspirations. In addition, there is a clear need for any IKM system developed for Pacific SIDS to either dispel or circumvent the common view among government departments in Pacific SIDS that IKM may result in information misuse or loss of mandated powers. A federated IKM system (which is an IKM system where databases are interlinked via metadata, while still being separately managed and often geographically dispersed) can overcome such barriers by: (i) enabling information custodians to maintain direct autonomy over their own content and how it is managed and controlled; and (ii) aggregating metadata about content stored in different locations, so users can at a minimum discover what information exists. This approach has been piloted for the PCCP (SPREP, 2018), in an attempt to increase regional level data sharing and IKM collaboration. In the three years since deployment, over 15,000 separately managed climate change content items have now been made discoverable via the single search interface on the PCCP, during which time the average rate of PCCP content searches, acquisitions and uploads have almost tripled.[3] The key lesson from the PCCP is that a federated IKM system enhances information discoverability without having to directly address IKM barriers relating to sharing.

6.5. Leverage whole-of-Government IKM

Considering the identified need for guiding IKM frameworks and executive leadership in climate change IKM, the emergence of whole-of-government IKM in Pacific SIDS should be leveraged rather than duplicated. Integration within such an approach will likely provide additional support and means for overcoming key barriers, such as reliable longer term secure infrastructure, garnering higher level support for IKM and encouraging the effective management and sharing of information. Being an early adopter may also provide climate change IKM officers in Pacific SIDS with the opportunity to shape policy approaches towards typically complicated issues such as dealing with information uncertainty and sensitivity.

7. Discussion and conclusion

Although a strong IKM framework is recognized as foundational to supporting the implementation of good IKM practices (Evans & Price, 2012), there is very little research to date on how ICT can be effectively utilized to implement such a framework (Eakin et al., 2015). This gap in knowledge and subsequent capacity remains a major challenge in Pacific SIDS.

Many of the climate change IKM barriers and underlying causes identified in this article are probably generic (du Plessis, 2008; Evans & Price, 2012). This is certainly the case with the identified supply bias in climate change information delivery and a lack of supporting IKM enabling environments (e.g. good policy, technology, capacity and funding). However, any re-application of general IKM knowledge must be cognisant of the specific economic and social development challenges facing Pacific SIDS (Adger, Huq, Brown, Conway, & Hulme, 2003), and promote sustainable development outcomes wherever possible (Hay & Mimura, 2006). This includes integrating within existing mainstreaming efforts (Lebel et al., 2012) and supporting 'no-regrets' approaches (Hallegatte, 2009) where possible.

Given the small land area, low population and isolated nature of many SIDS, they stand to benefit greatly from any increased economies of scale that are generated from regional cooperation with other SIDS on priority issues such as climate change adaptation (UNESCAP, 2010). While various regional cooperation mechanisms among Pacific SIDS are well established, the strong recognition of IKM in the new regional FRDP presents an important new opportunity to formally establish a regional climate change IKM framework that can ensure adaptation and resilience initiatives benefit from good IKM practice (Griffith University & SPREP, 2016). For a regional approach on climate change IKM to be successful, however, it needs to be sensitive to inevitable variation in how countries and communities of practice view intellectual property, open data and metadata standards.

The inclusion of adaptation objectives in the Paris Agreement (Article 7) reflects international consensus on the importance of adaptation, while also formalizing a clear international framework for national actions on adaptation (Lesnikowski et al., 2017). The direct and indirect requirements for IKM set out in the Paris Agreement (Articles 4.2, 7.7 and 7.10), along with the significant amounts of climate finance set for dispersal in regions such as the Pacific over the coming years, provide a significant platform for Pacific SIDS, SIDS in general and funding bodies to improve adaptation and resilience planning through targeted action and support in climate change IKM.

Finally, the case for embedding effective IKM practices within adaptation and resilience initiatives in the Pacific is compelling, including: (1) an international policy environment (The Paris Agreement) that sets out clear IKM guidance for parties to develop, share, manage and deliver climate change knowledge, information and data, as well as IKM requirements in the funding guidelines for major climate finance providers (e.g. the GCF); (2) a new regional climate change and resilience policy (FRDP) that provides for clear and strong IKM actions for both adaptation and disaster risk reduction; and (3) national climate change policies in most Pacific SIDS that have climate change IKM aspirations. This article has made some initial steps towards documenting the climate change IKM barriers facing SIDS, with lessons and insights for overcoming these provided by experiences in Fiji, Tonga and Vanuatu. The findings from this article re-affirm that there remain imbalances between supply and demand for climate change IKM in Pacific SIDS, along with the need to improve information reliability and usability. The lessons and insights provided in this article can assist Pacific SIDS and SIDS in general to approach climate change IKM in ways that generate ownership and collaboration on the policy, technology and organizational change required to overcome climate change IKM barriers in their country.

Notes

1. The Pacific Climate Change Portal is an online repository of climate change data, information and knowledge relevant to the Pacific. It both hosts content, and makes content on other databases discoverable and accessible to end-users.
2. The Pacific iCLIM project is a regional climate change IKM support project being implemented in the Pacific by Griffith University in partnership with SPREP URL:https://www.griffith.edu.au/research/research-excellence/griffith-climate-change-response-program/pacific-iclim.
3. This detail is based on Google analytics for the PCCP during the period April 2014–December 2017; accessed 13 July 2017.

Acknowledgements

The key project implementation partner from the Pacific region is the Secretariat of the Pacific Regional Environment Programme (SPREP). We thank the Governments of Fiji, Tonga and Vanuatu for their participation in project activities and helping to improve the outlook of climate change information and knowledge management outcomes for Pacific SIDS, and SIDS in general.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The analysis undertaken and described in this article was carried out under the Pacific iCLIM project, which is funded by the Australian Government Department of Foreign Affairs and Trade under Grant agreement 68616 and implemented by Griffith University.

ORCID

Rebecca Brown http://orcid.org/0000-0002-9621-9933

References

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*, *3*(3), 179–195.

Ahern, T., Leavy, B., & Byrne, P. J. (2014). Complex project management as complex problem solving: A distributed knowledge management perspective. *International Journal of Project Management*, *32*(8), 1371–1381. doi:10.1016/j.ijproman.2013.06.007

ANDS. (2015). *Better data for Australian research*. Australian National Data Service. Retrieved from http://www.ands.org.au/__data/assets/pdf_file/0006/387843/better-data-for-australian-research.pdf

Archie, K. M., Dilling, L., Milford, J. B., & Pampel, F. C. (2014). Unpacking the 'information barrier': Comparing perspectives on information as a barrier to climate change adaptation in the interior mountain West. *Journal of Environmental Management*, *133*, 397–410. doi:10.1016/j.jenvman.2013.12.015

Barnes, S., & Milton, N. J. (2015). *Designing a successful KM strategy: A guide for the knowledge management professional*. Medford, NJ: Information Today.

Begum, R. A., Sarkar, M. S. K., Jaafar, A. H., & Pereira, J. J. (2014). Toward conceptual frameworks for linking disaster risk reduction and climate change adaptation. *International Journal of Disaster Risk Reduction*, *10*(Part A), 362–373. doi:10.1016/j.ijdrr.2014.10.011

Beldiman, D. (2013). *Access to information and knowledge: 21st century challenges in intellectual property and knowledge governance* (1st ed.). Cheltenham: Edward Elgar.

Bhave, A. G., Conway, D., Dessai, S., & Stainforth, D. A. (2016). Barriers and opportunities for robust decision making approaches to support climate change adaptation in the developing world. *Climate Risk Management*, *14*, 1–10.

Brown, R., & Gonelevu, M. (2015). *Pacific climate change portal topics vocabulary*. Retrieved from https://www.researchgate.net/publication/305402554_Pacific_Climate_Change_Portal_Topics_Vocabulary

Brown, R. A., Gonelevu, M., Mackay, S., McGregor, K., Kocovanua, T., Iaken, R., ... Mackey, B. G. (2015). *Barriers to effective adaptation and resilience planning in the Pacific: An information management perspective*. Brisbane: Griffith University.

Conway, D., & Mustelin, J. (2014). Strategies for improving adaptation practice in developing countries. *Nature Climate Change*, *4*(5), 339–342.

Crowley, J. (2014). *Open data for resilience initiative: Field guide*. Retrieved from https://openknowledge.worldbank.org/handle/10986/17840

Curdt, C., Andrew Cox, D., & Hoffmeister, D. (2015). Research data management services for a multidisciplinary, collaborative research project. *Program*, *49*(4), 494–512. doi:10.1108/prog-02-2015-0016

du Plessis, M. (2008). What bars organisations from managing knowledge successfully? *International Journal of Information Management*, 28(4), 285–292. doi:10.1016/j.ijinfomgt.2008.02.006

Duffy, J. (2001). The tools and technologies needed for knowledge management. *Information Management Journal*, *35*(1), 64.

Dunn, M. R. (2015). *User and provider perspectives on the supply and demand of future climate change information for adaptation decision making: A case study of the wine grape sector in Australia* (Dissertation/Thesis). ProQuest Dissertations Publishing.

Eakin, H., Wightman, P. M., Hsu, D., Gil Ramón, V. R., Fuentes-Contreras, E., Cox, M. P., … Kammen, D. M. (2015). Information and communication technologies and climate change adaptation in Latin America and the Caribbean: A framework for action. *Climate and Development*, *7*(3), 208–222. doi:10.1080/17565529.2014.951021

Eisenack, K., Moser, S. C., Hoffmann, E., Klein, R. J., Oberlack, C., Pechan, A., … Termeer, C. J. (2014). Explaining and overcoming barriers to climate change adaptation. *Nature Climate Change*, *4*(10), 867–872.

Evans, N., & Price, J. (2012). Barriers to the effective deployment of information assets: An executive management perspective. *Interdisciplinary Journal of Information, Knowledge, and Management*, *7*, 177–199.

Feldman, D. L., & Ingram, H. M. (2009). Making science useful to decision makers: Climate forecasts, water management, and knowledge networks. *Weather, Climate, and Society*, *1*(1), 9–21. doi:10.1175/2009wcas1007.1

Ford, J. D., & Berrang-Ford, L. (2016). The 4Cs of adaptation tracking: Consistency, comparability, comprehensiveness, coherency. *Mitigation and Adaptation Strategies for Global Change*, *21*(6), 839–859. doi:10.1007/s11027-014-9627-7

GCF. (2017a). *Accessing the GCF readiness and preparatory support programme: An introduction and how-to guide*. Retrieved from http://www.greenclimate.fund/documents/20182/104167/Readiness_and_Preparatory_Support_Guidebook.pdf/9eea580f-a109-4d90-b281-c54695114772

GCF. (2017b). *Status of Pledges and contributions made to the green climate fund*. Retrieved from https://www.greenclimate.fund/documents/20182/24868/Status_of_Pledges.pdf/eef538d3-2987-4659-8c7c-5566ed6afd19

Geisler, E., & Wickramasinghe, N. (2009). *Principles of knowledge management: Theory, practices, and cases*. Armonk, NY: M.E. Sharpe.

Government of the Republic of Fiji. (2012). *Republic of Fiji national climate change policy*. Government of the Republic of Fiji and Secretariat of the Pacific Community.

Government of the Republic of Vanuatu. (2016). *Vanuatu climate change and disaster risk reduction policy 2016-2030*. Suva: Government of the Republic of Vanuatu and Secretariat of the Pacific Community.

Griffith University. (2018). *Pacific iCLIM project*. Retrieved from https://www2.griffith.edu.au/research/research-excellence/griffith-climate-change-response-program/pacific-iclim

Griffith University, & SPREP. (2016). *Information and knowledge management for climate change (IKM4CC) strategic framework: Guidelines for the Pacific region*. Brisbane: Griffith University.

Hallegatte, S. (2009). Strategies to adapt to an uncertain climate change. *Global Environmental Change*, *19*(2), 240–247.

Hanger, S., Pfenninger, S., Dreyfus, M., & Patt, A. (2013). Knowledge and information needs of adaptation policy-makers: A European study. *Regional Environmental Change*, *13*(1), 91–101. doi:10.1007/s10113-012-0317-2

Hay, J., & Mimura, N. (2006). Supporting climate change vulnerability and adaptation assessments in the Asia-Pacific region: An example of sustainability science. *Sustainability Science*, *1*(1), 23–35.

Head, B. W. (2014). Evidence, uncertainty, and wicked problems in climate change decision making in Australia. *Environment and Planning C: Government and Policy*, *32*(4), 663–679. doi:10.1068/c1240

Head, L., Gibson, C., Gill, N., Carr, C., & Waitt, G. (2016). A meta-ethnography to synthesise household cultural research for climate change response. *Local Environment*, *21*(12), 1467–1481.

Innocenti, D., & Albrito, P. (2011). Reducing the risks posed by natural hazards and climate change: The need for a participatory dialogue between the scientific community and policy makers. *Environmental Science & Policy*, *14*(7), 730–733. doi:10.1016/j.envsci.2010.12.010

Jones, L., Dougill, A., Jones, R. G., Steynor, A., Watkiss, P., Kane, C., … Vincent, K. (2015). Ensuring climate information guides long-term development. *Nature Climate Change*, *5*(9), 812–814. doi:10.1038/nclimate2701

Kalafatis, S. E., Lemos, M. C., Lo, Y.-J., & Frank, K. A. (2015). Increasing information usability for climate adaptation: The role of knowledge networks and communities of practice. *Global Environmental Change*, *32*, 30–39. doi:10.1016/j.gloenvcha.2015.02.007

Kingdom of Tonga. (2010). *Joint national action plan on climate change adaptation and disaster risk management 2010–2015 second national communication project*. Tonga.

Lebel, L., Li, L., Krittasudthacheewa, C., Juntopas, M., Vijitpan, T., Uchiyama, T., & Krawanchid, D. (2012). *Mainstreaming climate change adaptation into development planning* (p. 8). Bangkok: Adaptation Knowledge Platform and Stockholm Environment Institute.

Lee, C., & Samuel, L. (2017). Knowledge management ecological approach: A cross-discipline case study. *Journal of Knowledge Management*, *21*(4), 839–856. doi:10.1108/JKM-11-2016-0492

Lemos, M. C., Kirchhoff, C. J., & Ramprasad, V. (2012). Narrowing the climate information usability gap. *Nature Climate Change*, *2*, 789–794. Retrieved from https://www.nature.com/articles/nclimate1614#supplementary-information. doi:10.1038/nclimate1614

Lesnikowski, A., Ford, J., Biesbroek, R., Berrang-Ford, L., Maillet, M., Araos, M., & Austin, S. E. (2017). What does the Paris agreement mean for adaptation? *Climate Policy*, *17*(7), 825–831. doi:10.1080/14693062.2016.1248889

Liew, A. (2007). Understanding data, information, knowledge and their inter-relationships. *Journal of Knowledge Management Practice*, *8*(2), 1–16.

Lynch, A. H., Tryhorn, L., & Abramson, R. (2008). Working at the boundary: Facilitating interdisciplinarity in climate change adaptation research. *Bulletin of the American Meteorological Society*, *89*(2), 169–179.

Maru, Y. T., & Stafford Smith, M. (2014). GEC special edition – reframing adaptation pathways. *Global Environmental Change*, *28*(Supplement C), 322–324. doi:10.1016/j.gloenvcha.2014.07.004

McIver, D., Lengnick-Hall, C. A., Lengnick-Hall, M. L., & Ramachandran, I. (2013). Understanding work and knowledge management from a knowledge-in-practice perspective. *Academy of Management Review*, *38*(4), 597–620.

McNie, E. C. (2013). Delivering climate services: Organizational strategies and approaches for producing useful climate-science information. *Weather, Climate, and Society*, *5*(1), 14–26. doi:10.1175/wcas-d-11-00034.1

Molloy, J. C. (2011). The open knowledge foundation: Open data means better science. *PLoS Biology*, *9*(12), e1001195. doi:10.1371/journal.pbio.1001195

Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences*, *107*(51), 22026–22031.

Mullan, M., Kingsmill, N., Agrawala, S., & Matus Kramer, A. (2013). *National adaptation planning: Lessons from OECD countries*. OECD environment working papers, No. 54. OECD Publishing. doi:10.1787/5k483jpfpsq1-en

Nurse, L. A., McLean, R. F., Agard, J., Briguglio, L. P., Duvat-Magnan, V., Pelesikoti, N., … Webb, A. (2014). *Small Islands 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. Cambridge University Press.

Nurse, L., Sem, G., Hay, J., Suarez, A., Wong, P., Briguglio, L., & Ragoonaden, S. (2001). Small island states in: Climate change 2001: Impacts, adaptation, and vulnerability. In J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, & K. S. White (Ed.), *Contribution of working group II to the third assessment report of the intergovernmental panel on climate change* (pp. 844–875). Cambridge: Cambridge University Press.

Overpeck, J. T., Meehl, G. A., Bony, S., & Easterling, D. R. (2011). Climate data challenges in the 21st century. *Science*, *331*(6018), 700–702. doi:10.1126/science.1197869

Pahl-Wostl, C., Giupponi, C., Richards, K., Binder, C., de Sherbinin, A., Sprinz, D., … van Bers, C. (2013). Transition towards a new global change science: Requirements for methodologies, methods, data and knowledge. *Environmental Science & Policy*, *28*(Supplement C), 36–47. doi:10.1016/j.envsci.2012.11.009

Petr, M., Boerboom, L. G. J., Ray, D., & van der Veen, A. (2016). New climate change information modifies frames and decisions of decision makers: An exploratory study in forest planning. *Regional Environmental Change*, *16*(4), 1161–1170. doi:10.1007/s10113-015-0827-9

Ramesh, P., Vivekavardhan, J., & Bharathi, K. (2015). Metadata diversity, interoperability and resource discovery issues and challenges. *DESIDOC Journal of Library & Information Technology*, *35*(3), 193–199. doi:10.14429/djlit.35.3.8074

Rowley, J. (2007). The wisdom hierarchy: Representations of the DIKW hierarchy. *Journal of Information Science*, *33*(2), 163–180. doi:10.1177/0165551506070706

Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B., Rebeck, K., & Knowledge Management Methodology, T. (2001). A systems thinking framework for knowledge management. *Decision Support Systems*, *31*(1), 5–16. doi:10.1016/S0167-9236(00)00116-0

Scott-Parker, B., Nunn, P. D., Mulgrew, K., Hine, D., Marks, A., Mahar, D., & Tiko, L. (2017). Pacific islanders' understanding of climate change: Where do they source information and to what extent do they trust it? *Regional Environmental Change*, *17*(4), 1005–1015. doi:10.1007/s10113-016-1001-8

Secretariat Pacific Community, Secretariat of the Pacific Regional Environment Programme, Pacific Islands Forum Secretariat, United Nations Development Programme, United Nations Office for Disaster Risk Reduction, & University of the South Pacific. (2016). *Framework for resilient development in the Pacific: An integrated approach to address climate change and disaster risk management [FRDP] 2017–2030*. Suva.

SPREP. (2018). *Pacific climate change portal*. Retrieved from https://pacificclimatechange.net

Street, R., Sanderson, H., & Clare, D. (2015). *Overview of climate change adaptation platforms/services in Europe* (Technical report 5/2015). European Environment Agency.

UNESCAP. (2010). *Sustainable development in the Pacific- progress and challenges*. Pacific regional report, Fiji.

UNFCCC. (2015). *Adoption of the Paris agreement, 21st conference of the parties*. Paris: United Nations.

Van den Eynden, V., Corti, L., Woollard, M., Bishop, L., & Horton, L. (2011). *Managing and sharing data*. A best practice guide for researchers. UK data archive.

Wilby, R. L., Troni, J., Biot, Y., Tedd, L., Hewitson, B. C., Smith, D. M., & Sutton, R. T. (2009). A review of climate risk information for adaptation and development planning. *International Journal of Climatology*, *29*(9), 1193–1215. doi:10.1002/joc.1839

World Bank. (2013a). *Acting on climate change and disaster risk for the Pacific(English)*. Washington, DC: World Bank. Retrieved from http://documents.worldbank.org/curated/en/354821468098054153/Acting-on-climate-change-and-disaster-risk-for-the-Pacific.

World Bank. (2013b). *Better risk information for smarter investments: Catastrophe risk assessment methodology*. Washington, DC: The World Bank. Retrieved from http://siteresources.worldbank.org/EXTDISASTER/Resources/8308420134253126565 7/PCRAFI_REPORT_WEB_Final.pdf