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Linking adaptation science to action to build food secure Pacific Island communities

C. Cvitanovic [a,*], S. Crimp [b], A. Fleming [c,d], J. Bell [e,f], M. Howden [b,k], A.J. Hobday [d,g], M. Taylor [h], R. Cunningham [i,j]

[a] Centre for Marine Socioecology and Faculty of Law, University of Tasmania, Battery Point, Tasmania 7004, Australia
[b] Agriculture, CSIRO, GPO Box 1700, Canberra, ACT 2601, Australia
[c] Land and Water, CSIRO, Hobart, Tas 7001, Australia
[d] Centre for Marine Socioecology, University of Tasmania, Battery Point, Tasmania 7004, Australia
[e] Pacific Community, Noumea, New Caledonia
[f] Australian National Centre for Ocean Resources and Security, University of Wollongong, NSW 2522, Australia
[g] Oceans and Atmosphere, CSIRO, Hobart, Tasmania 7001, Australia
[h] Faculty of Science, Health, Education and Engineering, University of the Sunshine Coast, Queensland, Australia
[i] Land and Water, CSIRO, PO Box 883, Kenmore QLD 4069, Australia
[j] Tyndall Centre for Climate Change, University of Manchester, Department of Mechanical, Aerospace and Civil Engineering, M1 4PL, UK
[k] Climate Change Institute, Australian National University, Canberra, ACT, Australia

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ABSTRACT

Climate change is a major threat to food security in Pacific Island countries, with declines in food production and increasing variability in food supplies already evident across the region. Such impacts have already led to observed consequences for human health, safety and economic prosperity. Enhancing the adaptive capacity of Pacific Island communities is one way to reduce vulnerability and is underpinned by the extent to which people can access, understand and use new knowledge to inform their decision-making processes. However, effective engagement of Pacific Island communities in climate adaption remains variable and is an ongoing and significant challenge. Here, we use a qualitative research approach to identify the impediments to engaging Pacific Island communities in the adaptations needed to safeguard food security. The main barriers include cultural differences between western science and cultural knowledge, a lack of trust among local communities and external scientists, inappropriate governance structures, and a lack of political and technical support. We identify the importance of adaptation science, local social networks, key actors (i.e., influential and trusted individuals), and relevant forms of knowledge exchange as being critical to overcoming these barriers. We also identify the importance of co-ordination with existing on-ground activities to effectively leverage, as opposed to duplicating, capacity.

1. Introduction

Anthropogenic climate change is widely regarded as one of the most significant threats to global food security, impacting all dimensions of food production, availability, stability and utilisation (Schmidhuber and Tubiello, 2007; Wheeler and

* Corresponding author. Tel.: +61 (02) 6246 4212.
E-mail address: christopher.cvitanovic@utas.edu.au (C. Cvitanovic).

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Von Braun, 2013; Gbegbelegbe et al., 2014; Tai et al., 2014). For example, climate change has been shown to directly impact food production through changes in agro-ecological conditions, with declines in food production and increasing variability of food supply already attributed to observed warming and changes in regional rainfall patterns (e.g. Parry et al., 2004, 2005; Fischer et al., 2005). Climate change also affects the ability of individuals to access and use food effectively by altering the conditions for food safety and increasing the risks of vector-, water- and food-borne diseases (Githeko et al., 2000; Patz et al., 2005). As a result, it has been projected that the number of undernourished people may increase by up to 26% by 2080 (Fischer et al., 2005). Consequently, achieving food security under the changing climate is a critical public policy problem, particularly given the tendency of climate change to interact with other economic, political, temporal and biophysical drivers (Ericksen et al., 2009).

Although climate change will have significant impacts on food security globally, the vulnerability of individual communities is likely to differ substantially (Allison et al., 2009; IPCC, 2014). Recent studies show that communities in Pacific Island Countries (PICs) are expected to be among the most vulnerable (Barnett, 2011). For example, climate change is projected to have profound impacts on the production of coastal fisheries throughout the Pacific Island region (Bell et al., 2013), and reduce the productivity of coastal aquaculture (reviewed by Bell et al., 2011). Consequently, the ability of Pacific Island communities to access fish will be adversely affected, which is a significant concern given that fish provide between 50% and 90% of animal protein for rural communities in the majority of PICs (Bell et al., 2009). Similarly, agricultural production throughout the Pacific Island region will be adversely affected by climate change through the loss of coastal lands, increased contamination of groundwater and estuaries by saltwater incursion, and losses associated with the increased frequency and severity of events such as cyclones, heat stress and drought. For example, the estimated loss of up to 80% of local food production in Vanuatu due to Tropical Cyclone Pam in 2015 is a recent, potent case in point. The impacts of climate change on food security in PICs are compounded by geographical isolation, high rates of population growth, limited land area, widespread poverty and a very high dependence on subsistence fishing and agriculture for livelihoods (Barnett and Campbell, 2010; Bell et al., 2011; Bell and Taylor, 2015).

Given the significant risk posed by climate change to food security in PICs, adaptation and in particular the enhancement of adaptive capacity, is considered to be a key priority to ensure the long-term sustainability, health and safety of local communities (Barnett and Campbell, 2010). In the broadest sense, adaptive capacity refers to the ability or potential of complex social-ecological systems to respond successfully to climate variability and climate change (Adger et al., 2007). As such, adaptive capacity is a necessary condition for the design and implementation of effective adaptation strategies to reduce the risks posed by climate change (Brooks and Adger, 2005). To this end, adaptive capacity not only encompasses the preconditions required to enable adaption, but also the ability to mobilise and utilise them as required (Nelson et al., 2007; Park et al., 2012). In doing so, adaptive capacity mediates the vulnerability of communities to climate change (Adger et al., 2005; Marshall et al., 2012, 2014).

Adaptive capacity, however, is highly variable across both spatial and temporal scales (Smit and Wandel, 2006). The factors that underpin the development and use of adaptive capacity at the community level include the ability of individuals to access, understand and apply the knowledge needed to inform their decision-making processes. While a range of knowledge types can contribute to developing adaptive capacity (i.e. – both positivist and interpretivist epistemological orientations), it is widely accepted that adaptation science is of critical importance given its ability to facilitate the effective identification and assessment of threats, risks and uncertainties associated with climate change. Adaptation science also generates the information, knowledge and insight required to steer socio-ecological systems towards increased adaptive capacity and performance (Meinke et al., 2009; Howden et al., 2014). In doing so, adaptation science analyses problems without a predefined disciplinary lens, allowing for the inclusion of multiple perspectives and knowledge bases (e.g., cultural knowledge) to generate adaptation pathways to support societal responses to global environmental change (Butler et al., 2014; Wise et al., 2014). As a result, adaptation science is considered to be a specialised form of sustainability science at the boundary between science and society (Meinke et al., 2009).

The accumulation of adaption science alone, however, is insufficient for building adaptive capacity to enhance food security (Howden et al., 2013). Rather, adaptive capacity at the community level is dependent on the extent to which the information from adaptation science is accessed and used to precipitate action in response to the changing climate (Van Kerkhoff and Lebel, 2006; Howden et al., 2007; Jacobs et al., 2010). For this reason, it has been argued that adaptation scientists have an ethical responsibility to engage better with end-users to enhance adaptive capacity (Lacey et al., 2015). The engagement of end-users in adaption science, however, remains an ongoing and significant challenge that has resulted in a growing body of literature on climate change communication and stakeholder engagement, most of which is focused in the context of developed countries (e.g., Moser and Dilling, 2007; Nisbet, 2009; O'Neill and Nicholson-Cole, 2009; Cunningham et al., 2015). In contrast, understanding how to engage end-users in climate change science in developing countries, such as in the Pacific region, has received less attention and available studies are largely location specific case-studies with limited application to the Pacific Islands region (reviewed in Moser, 2010 – but see Hay and Mimura, 2006; Dumaru, 2010; McNaught et al., 2014). Thus, climate scientists still have limited resources to assist them in developing improved communication and end-user engagement strategies for PICs. Therefore, the aim of this study was to identify practical strategies for engaging Pacific Island communities in adaptation science to enhance food security. Specifically, we build a narrative that (1) determines the role and importance of adaptation science for contributing to future food security in the Pacific Island region, (2) identifies the primary barriers inhibiting community engagement in adaptation science, and (3) develops recommendations for overcoming these barriers.

2. Methods

The Pacific Island region comprises 22 countries and territories across much of the tropical and subtropical Pacific Ocean (Fig. 1). The area encompassed by the exclusive economic zones of these countries and territories exceeds 27 million km^2, and is divided into three sub-regions: Melanesia, Polynesia and Micronesia. Within the region, key industries include agriculture, forestry, fishing, tourism and aquaculture, all of which are highly susceptible to the impacts of climate change (Bell et al., 2011).

To address the aims of this study we used a qualitative research approach, conducting semi-structured interviews of participants recruited using a purposive snowball sampling technique between September 2013 and March 2014 (Bryman, 2012). Given the geographic size of the Pacific Island region and the distribution and diversity of PICs, it was not feasible to interview a sufficiently diverse cross section of community members to address the aims of this study (Noy, 2008). Therefore, we interviewed a range of people who all have extensive experience working with and among countries across the Pacific region and across multiple sectors to capture a range of experiences and knowledge bases.

Specifically, the initial study participants were selected based on their experience in applying adaptation science related to food security in the Pacific, as nominated by an organisational head with many years of experience in the Pacific. This group was drawn from in-country regional organisations including the Secretariat of the Pacific Community (SPC) and the Secretariat of the Pacific Regional Environment Programme (SPREP). On average, each participant had >20 years of experience working on related topics, including community engagement, in the region. At the completion of these interviews, participants were asked to suggest others they believed would be relevant to the study, with this step being repeated at the completion of each subsequent interview. This process identified 24 participants, however, interviews were only undertaken with 16 of these individuals due to logistical constraints. Interview analyses showed this sample size was sufficient for achieving saturation of ideas and concepts (Fig. 2). The participants represented a range of agencies including SPC, the University of the South Pacific (USP), SPREP and CSIRO.

Prior to starting each interview, the purpose of the research was explained to the participant and formal written consent to participate was obtained (in accordance with Human Research Ethics procedures CSSHREC: 072/13). In general, each interview took between 30 and 45 min and was undertaken by the same member of the research team (CC) for consistency. With only one exception, all interviews were audio recorded and professionally transcribed to ensure accuracy. The remaining interview was transcribed by the interviewer immediately following the interview from notes taken during the interview.

All interview transcripts were analysed using NVIVO 10 qualitative data analysis software (QSR International 2013). The analysis consisted of broad thematic coding against the key project questions:

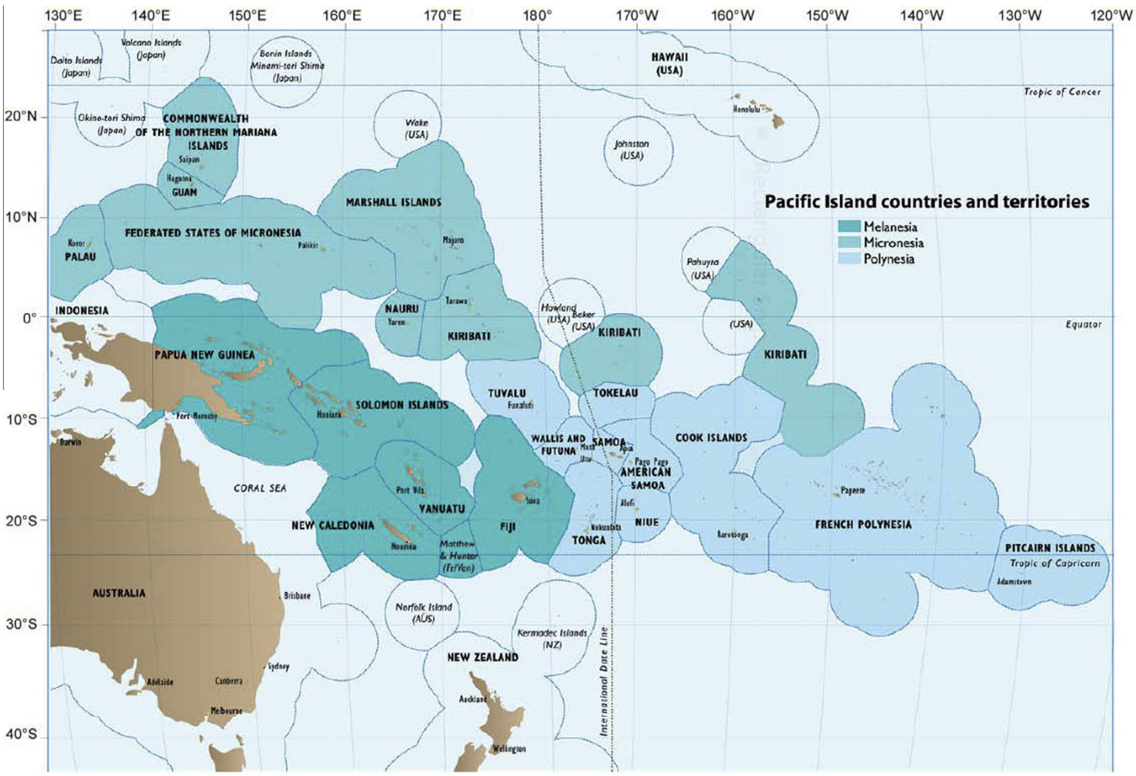

Fig. 1. The exclusive economic zones of Pacific Islands Countries and Territories. The subregions of Melanesia, Micronesia and Polynesia are also shown (as first published in Bell et al. (2011), provided for use by the Secretariat of the Pacific Community).

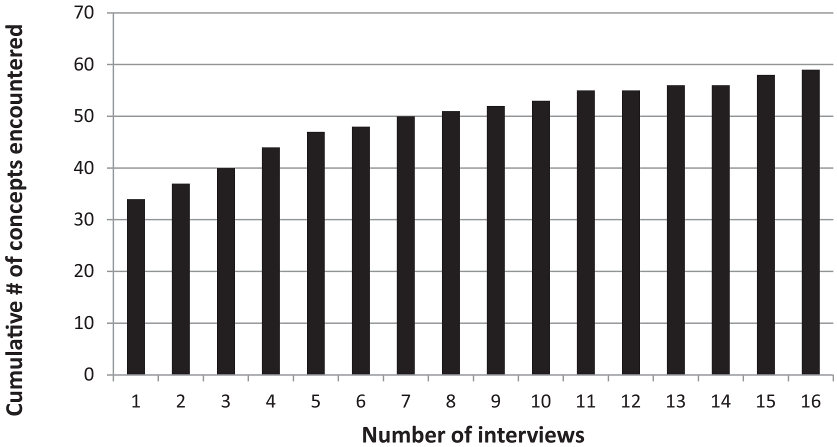

Fig. 2. Cumulative number of concepts encountered with increasing number of interviews, with a plateau after approximately 6 interviews (following Hagerman et al., 2010).

1. What is the role of adaptation science in contributing to future food security in the Pacific?
2. What are the main barriers preventing the uptake of adaptation science by Pacific communities?
3. How can these barriers be overcome?

To ensure themes were relevant and valid, the emerging interpretations were continually checked against the data from which they were derived, following the methods used in a number of previous studies (Strauss and Corbin, 1998; Fleming and Vanclay, 2009; Marshall et al., 2011a,b).

3. Results

The interview coding produced four key themes: '*Barriers*; *Risks*; *the Role of Science*' and '*Trust*'. Although there was some overlap between themes, they contributed to our understanding of the role and importance of adaptation science for future food security, outlined the primary factors inhibiting community engagement, and allowed us to identify and develop recommendations for overcoming these obstacles. '*Barriers*' was the most commonly identified theme, with 168 references across all 16 sources, while *Trust* was the theme mentioned the least, with 88 references across 15 sources (Table 1). Note, however, that the number of references simply indicates how frequently each theme was mentioned in interviews, rather than the importance participants placed on the issues.

3.1. Risks posed to Pacific Island food security as a result of climate change

The theme '*Risks*' was among the most recurring and prominent across the interviews (Table 2). Climate-related risks to food security and human health were most prominent in this theme, with institutional risk and infrastructure risk also

Table 1
Analysis hierarchy of themes and codes (frequency is the number of times coded across all interviews) with the number of interviewees who raised the issue (n = 16).

Theme (frequency)	Code (frequency)	No. of Interviewees
Barriers (168)	Discusses failures of knowledge transfer (56)	16
	Discusses cultural differences (44)	10
	Identifies governance issues (29)	11
	Identifies issues with resources or capacity (39)	12
Risks (93)	Identifies food security risks (62)	16
	Identifies health risks (31)	10
The Role of Science (132)	Identifies useful future pathways (82)	16
	Gives examples of success (44)	13
	Discusses use of technology (6)	3
Trust (88)	Talks about trusted messengers (42)	14
	Discusses particular regions (18)	11
	States years of experience (16)	15
	Talks about the next generation (12)	7

Table 2
Summary of views on recurrent topics across all study participants, where ✓ indicates that this view was stated during interviews. Boxes without any marker indicate the absence of an expressed view for the theme in that column (following Hagerman et al., 2010).

Expert No.	Barriers				Risks		Trust		The Role of Science		
	Culture	Knowledge transfer	Governance	Resources	Food	Health	Next gen	Messengers	Technology	Successes	Future pathways
1	✓	✓		✓	✓	✓		✓		✓	✓
2	✓	✓	✓	✓	✓					✓	✓
3		✓		✓	✓	✓			✓	✓	✓
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5		✓	✓	✓	✓		✓	✓		✓	✓
6		✓	✓	✓	✓	✓		✓		✓	✓
7		✓		✓	✓	✓	✓	✓		✓	✓
8	✓	✓	✓	✓	✓		✓	✓		✓	✓
9	✓	✓	✓	✓	✓		✓	✓		✓	✓
10	✓	✓			✓	✓	✓	✓		✓	✓
11	✓	✓	✓	✓	✓			✓			✓
12	✓	✓	✓		✓	✓		✓			✓
13	✓	✓	✓		✓	✓		✓	✓	✓	✓
14		✓	✓	✓	✓		✓	✓		✓	✓
15	✓	✓	✓		✓	✓		✓		✓	✓
16		✓			✓	✓		✓			✓
Total	10	16	11	11	16	10	7	14	3	13	16

widely discussed. The lack of holistic and longer term planning and agreement at different levels of planning and policy making, and the lack of access to knowledge and the ability to apply the knowledge at the community levels, were identified as the main causes of climate-related food security and human health risks. Specifically, lack of access to knowledge and both technical and political support for growing food locally and improving current productivity levels were seen as the most important contributors to food security and human health risks. These issues also contributed to increasing reliance on imported foods and increasing pressures on the environment, through maladapted farm management practises, simultaneously reducing the capacity for local food production and increasing health problems. Rapidly increasing urbanisation was also linked strongly to discussions around food security, with broad agreement among participants that this was leading to the loss of skilled individuals from rural areas: '*People are moving from rural areas into urban areas. When they get there they don't always have the opportunity to practise their traditional food production methods and so traditional knowledge about how to produce food is being lost*' (ID4).

Intersecting with climate change risk, participants also identified increased reliance on imported foods as a significant risk to people in Pacific Island communities: '*There's too much reliance on imported food so that if anything goes wrong where that food is produced, then Pacific Island countries are stuck - what do they do?*' (ID5). In addition, participants identified that imported food is more likely to be processed, high in sugar, fat and/or salt, and exacerbate the incidence of non-communicable diseases: '*The major risk associated with food security is the increased consumption of fatty and salty foods and the associated health impacts, such as diabetes and heart problems*' (ID16).

Another broad and intersecting risk discussed in terms of food security and climate change was the reliance of many Pacific Islands on external parties to fund activities to support the improvement of agricultural production. This was seen as problematic because many of the funding programs do not reflect the development needs or priorities of island communities. According to one participant: '*Organisations will provide funding for their particular interests at the time but when those interests change, funding can evaporate. This makes it difficult to support the long-term projects needed to establish effective adaptations to climate change*' (ID11). Another confirmed: '*So although First World countries might be willing to offer aid, it's often with strings attached, e.g. that things are done in particular ways, and so it's not always such an easy decision for governments to be able to make*' (ID13). Funding was also seen to be poorly linked with other on-ground activities or strategic planning and was rarely used to co-ordinate science information from different disciplines well. '*I think fragmentation is the biggest problem. Lots of project reports and scientific information are generated but linking that back to communities has been very poorly done*' (ID2).

3.2. The Role of Science in contributing to future food security in the Pacific

The Role of Science theme was focused on filling gaps in knowledge, especially in terms of connecting the otherwise distinct disciplines of climate, health, social and ecological sciences (Table 2). Many of the participants noted that science agencies could do more to connect and work with communities, rather than for the communities – an approach that requires local extension officers to help 'translate' information both ways. Science was regarded as important by all participants, especially if it could be applied and broadened to address the complex issue of food security. As one participant stated: '*I think science enables us to identify the scale of the problem. It also allows us to bring together the multidisciplinary research required to address the food security problem*' (ID2).

All of the interviewees saw a role for science that is comprehensible, integrated, directed at communities and practical. They advocated a more holistic perspective to incorporate science with community needs and decision making at various scales where: '*science is just one part of the equation*' (ID11).

3.3. Barriers to community engagement

In the Barriers theme, participants identified key issues as the lack of public knowledge (failures of knowledge exchange) and cultural differences between Pacific Island people and scientists from western cultures (Table 2). Pacific culture promotes the value of the community, in contrast to the typical Western focus on individuals. Participants suggested that knowledge would be more readily converted into action if the values of community were recognised, and if the messages were kept simple, relevant and easy to apply. As one participant stated: '*It's often hard for the community to understand and put into practice what the science is telling them*' (ID12). Another participant confirmed: '*If we're going to get good science to fishermen, we need to keep the information very simple*' (ID10). How science is communicated was noted as a frequent barrier to the uptake and understanding of information. This included both the format of information delivery, for example presentations at set times, and the complexity of the information presented: '*They came out with some fantastic data and information, but the way it was presented was not particularly digestible to people on the ground, particularly at the community level*' (ID12).

Recommended ways to overcome these barriers were: to include a familiar intermediary or extension worker to help translate the science into relevant information for the audience, and to use different, more attractive formats for delivering messages (e.g., using visual media) at times and locations where community members can discuss the ideas. One participant described how the use of pictograms in information sheets served to overcome language and literacy problems. One-on-one discussions were also identified as a way to allow people to ask questions and clarify information – something that might otherwise be seen as culturally inappropriate.

Cultural differences between generations were also noted as a barrier because the younger generation uses the internet, smart phones etc., and has lost some interest in traditional agriculture: '*Sometimes, people look down on traditional agriculture in the Pacific as being for people who can't get a better job*' (ID1). New technologies, however, may also provide potential ways to target information, especially as they become more widespread. For example, one participant explained how technology can be used to make artisanal fishermen aware of tuna tagging programs. '*The solution is to get the mobile phone numbers for all coastal residents and send them a message once a month encouraging them to look for tags in the tuna they catch (with a picture of tag) and informing them about the reward for tag returns and where to send the tag*' (ID4).

Other barriers discussed by participants were related to risks, and to the lack of consistent frameworks and agreements across Pacific Island nations and at local government levels. '*I think it would make sense to have a common strategy, to address this and other issues*' (ID7). It was acknowledged that overcoming these types of limitations in terms of consistent agreement across nations was more complex. It requires interdisciplinary, holistic science and more input into science policy decision making as a starting point.

3.4. The importance of trust

The theme of '*Trust*' is closely related to cultural differences (a code in the Barriers theme), especially in terms of who were trusted messengers (Table 2). During interviews, participants stated how every community has its gatekeepers, who engender high levels of trust. Examples of gatekeepers included community elders and people in respected positions, such as church leaders. People who are local, who are educated, who participate in the local life and culture (not imposing external values) and who speak the same language (there are up to 800 different languages/dialects in the region) are also trusted. Many participants noted that: '*They may be the pastor or a religious person, or the village chief*' (ID15). A number of participants also noted that trust relied on researchers being genuine and caring about the whole community, rather than just their own research needs: '*If you genuinely have the interest of that country in your heart and in the work that you do, people will feel it*' (ID12).

4. Discussion

Participants identified a range of present and future risks relating to food security and individual health in the Pacific, driven largely by the changing climate but also population growth. A particularly potent example is the increased reliance on energy-dense, nutrient-poor imported foods. Greater consumption of foods with higher sugar, fat and salt content has increased the prevalence of obesity and other non-communicable related health problems in the Pacific Islands (WHO, 2002; Cassels, 2006; Cheng, 2010; Parry, 2010). Reliance on these types of food sources also exposes Pacific Island communities to greater disruption in food supply, given that most of these foods are imported. The increased reliance on imported foods crystallises the issue – increased production of local crops and better access to the region's rich tuna resources for local consumption are needed to provide greater quantities of nutritious food for growing urban populations (Bell and Taylor, 2015; Bell et al., 2015). Participants also identified the importance of adaptation science for building adaptive capacity and alleviating the impacts of climate change and other drivers on food security, notwithstanding the challenges associated with engaging local communities in adaptation science. The application of adaptation science to achieve these goals will also reduce the vulnerability of PICs to the variations in global grain production (which is a key ingredient of much of the imported food now flowing into the region) projected to occur under global warming (Porter et al., 2014).

Overall, most participants found it easier to identify the problems rather than the solutions, presumably due to the difficulties involved in overcoming the range of complex barriers to food security in our changing world. Instead of solutions, participants often talked about successful endeavours from the past, for example, specific, small-scale projects that achieved successful community engagement, or identified useful pathways for how work should be done in the future. A common element among these projects, however, was the importance of clearly identifying local social networks to determine the key players (via tools such as social network analysis), and the most relevant forms of knowledge exchange. Co-ordination with existing on-ground activities to effectively leverage, as opposed to duplicate capacity, and conveying information in the appropriate format among social networks, were also seen as important.

Effective use of social networks has previously been shown to improve collaborative governance processes by facilitating generation, acquisition and diffusion of different types of knowledge, and overcoming many of the traditional barriers associated with knowledge sharing (Crona and Bodin, 2006; Burch et al., 2014; Dowd et al., 2014; Kalafatis et al., 2015). For example, social networks facilitate more flexible engagement compared to most top-down communication and engagement strategies, allowing for messages to be tailored naturally throughout the knowledge dissemination process according to individual or community perceptions and attitudes. Given the observed cultural gap between PICs and western science, this will ensure that scientific knowledge is framed appropriately, and will assist in overcoming the reported barriers associated with different levels of education among communities in PICs (Kuruppu, 2009; Kuruppu and Liverman, 2011). The speed and ease with which information can now be disseminated throughout social networks due to the pervasive use of mobile phones and social media in PICs is also advantageous (e.g. Vroegindewey, 2011; Schroeder et al., 2013).

The availability of rapid communication technology alone will not lead to improved uptake. Participants identified trust as a critical issue to overcome between communities in PICs and western science (see also Eidt et al., 2012). The importance of trust as a key issue affecting the extent to which scientific information is used in decision-making processes is well documented (Cash et al., 2003; Reed et al., 2014), including in relation to climate adaption (Few et al., 2011; Cvitanovic et al., 2014). In this regard, participants highlighted how Pacific communities have a range of 'gatekeepers', that is, trusted and highly connected individuals who disseminate important messages and increase the likelihood of the knowledge being accepted and used. In this study, community elders and Church leaders were identified as key 'gatekeepers' to be actively engaged in adaptation science. Harnessing the assistance of trusted and accepted gatekeepers is known to promote individual and collective action towards building adaptive capacity (Adler, 2001; Pfeffer and Carley, 2012). Social network analysis allows adaptation scientists to describe local knowledge networks, and identify the most connected and influential individuals to achieve this (Dowd et al., 2014; Cunningham et al., 2015).

Our findings also suggest that development of trust among adaptation scientists and Pacific Island communities may be best achieved through participatory research approaches, such as the co-production of knowledge (see Crimp et al., 2010; Daniel et al., 2011; Roudier et al., 2014; Briley et al., 2015). Such approaches involve end-users in all aspects of the design and development of research projects, including data collection, analysis, interpretation and reporting (Cvitanovic et al., 2015a). Participatory approaches also facilitate multi-level governance processes by enhancing the validity of knowledge gained through research involving stakeholders in the decision-making processes (Raymond et al., 2010). Moreover, such approaches provide an avenue for traditional knowledge to be incorporated into research and its implications, further increasing the extent to which the recommendations are trusted and used by the community (Calheiros et al., 2000; Kettle et al., 2014). This is critically important because such knowledge is developed over long time periods (i.e. generations) within the local context and offers a richer perspective than research by 'outsiders' (Gray, 1991).

For adaption science and scientists to fulfil their potential in supporting PICs to build and harness adaptive capacity to enhance food security through participatory research approaches, engagement with local communities must be sustained even after completion of research projects (Reed, 2008). This allows the iterative processes of knowledge creation, application and reflection to occur, enabling learning to take place over time and in response to continually changing environmental and social conditions. However, this is seldom achieved because scientists are often limited by a range of institutional factors, such as lack of funding/support for sustained engagement with end-users. Misaligned scientific reward systems for scientists can also result in them prioritising traditional metrics of science impact (i.e. number of publications, citations, h-index etc.) over end-user engagement (Shanley and López, 2009; Cvitanovic et al., 2015b). Overcoming this barrier will require significant institutional innovation by research agencies and funding bodies to promote a culture whereby sustained engagement is actively supported and rewarded (Lacey et al., 2015). Overcoming this barrier may also be achieved through increased and sustained core funding for regional organisations already operating in these areas.

Participants identified that linking science to action to build food secure and climate adapted Pacific Island communities will require coordinated, strategic decision-making processes at the local, regional, national and global levels (see also Thow et al., 2010; Candel, 2014; Grafton et al., 2015). The need for such institutional arrangements has previously been identified for the management of Pacific resources (Miller, 2000). In response, PICs and their development partners have already launched a range of plans and initiatives to combat some of these issues. These include, but are not limited to, initiatives to increase appropriate local agricultural production (e.g., agroforestry), increasing access to the region's rich tuna resources for local consumption and development of freshwater pond aquaculture (Bell and Taylor, 2015). Furthermore, with support from domestic and international partners, high-level policies on climate change adaptation have been developed to raise awareness of the implications of climate change among communities and to assist them to adapt. Modifications to the ecosystem approach to fisheries management to address climate change have also been advocated (Heenan et al., 2015). However, many communities still lack the practical and proven tools to produce increased quantities of food under a changing climate and gaps in knowledge must be filled before these tools can be applied effectively (Cvitanovic et al., 2013; Bell and Taylor, 2015). Filling these gaps will allow governments in the Pacific to implement a new food systems approach, creating options that balance dependence on imported rice and wheat by increasing the local production of climate resilient crops (Bell and Taylor, 2015). This will require effective partnerships between the producers and users of adaptation science to enhance knowledge exchange and uptake of new approaches.

Finally, participants noted that to be effective, adaptation science for Pacific Island communities must be multidisciplinary, with a particular emphasis on integrating the social sciences to ensure that the end products are practical and meaningful for Pacific Island people. A multidisciplinary approach is a key feature of adaptation science (Meinke et al., 2009), however, the integration of social science with other scientific disciplines remains elusive. Rather, the majority of research has been undertaken within the boundaries of a single discipline, neglecting the relationships between ecological and social systems (Fox et al., 2006). This is clearly no longer tenable for PICs, and greater efforts to incorporate social and economic dimensions into biophysical research are clearly needed (Redman et al., 2004; Aswani and Hamilton, 2004; Granderson, 2014).

In conclusion, this study has identified the barriers undermining the uptake of adaption science among PICs, and practical strategies for overcoming them. Cultural differences between western science and PICs were key barriers preventing the use of the latest information by communities. These differences need to be addressed by concerted efforts to build greater trust between the two groups. The best way to do this is through the implementation of long-term, sustained, participatory research approaches (e.g., knowledge co-production) that engages key actors (i.e., influential and trusted community members or 'gatekeepers' such as church leaders) from the outset. Engagement should be continued throughout the research program and sustained once the research is complete. Community 'gatekeepers' will be vital for disseminating key scientific messages throughout their social networks in ways that increase the likelihood of the knowledge being accepted and used to harness and build adaptive capacity. Drawing on this social capital will also help to ensure that scientific messages are tailored to community perceptions and attitudes. While enacting long-term participatory research approaches and establishing large scale multidisciplinary research projects presents several challenges to western science, requiring institutional innovations by research agencies and funders alike, doing so will improve the uptake of adaption science among PICs, allowing them to build adaptive capacity to climate change and enhance local food security throughout the region.

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References

Adger, W.N., Arnell, N.W., Tomkins, E.L., 2005. Adapting to climate change: perspectives across scales. Global Environ. Change 15, 75–76.
Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, D., Takahashi, K., 2007. Assessment of adaptation practices, options, constraints and capacity. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 717–743.
Adler, P., 2001. Market, hierarchy and trust: the knowledge economy and the future of capitalism. Organ. Sci. 12, 214–235.
Allison, E.H., Perry, A.L., Badjeck, M.-C., Adger, N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L., Dulvy, N.K., 2009. Vulnerability of national economies to the impacts of climate change on fisheries. Fish Fish. 10 (2), 173–196.
Aswani, S., Hamilton, R.J., 2004. Integrating indigenous ecological knowledge and customary sea-tenure with marine and social science for conservation of bumphead parrotfish (*Bolbometapon muricatum*) in the Roviana Lagoon, Solomon Islands. Environ. Conserv. 31, 69–83.
Barnett, J., 2011. Dangerous climate change in the Pacific Islands: food production and food security. Reg. Environ. Change 11, 229–237.
Barnett, J., Campbell, J., 2010. Climate Change and Small Island States: Power, Knowledge, and the South Pacific. Earthscan Ltd., London, UK.
Bell J., Taylor M., 2015. Building climate-resilient food systems for Pacific Islands. Penang, Malaysia, WorldFish. Program Report 2015–15.
Bell, J.D., Kronen, M., Vunisea, A., Nash, W.J., Keeble, G., Demmke, A., Pontifex, S., Andréfouët, S., 2009. Planning the use of fish for food security in the Pacific. Mar. Policy 33, 64–76.
Bell, J.D., Johnson, J.E., Hobday, A.J. (Eds.), 2011. Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change. New Caledonia, Secretariat of the Pacific Community, Noumea.
Bell, J.D., Ganachaud, A., Gehrke, P.C., Griffiths, S.P., Hobday, A.J., Hoegh-Guldberg, O., Johnson, J.E., Le Borgne, R., Lehodey, P., Lough, J.M., Matear, R.J., Pickering, T.D., Pratchett, M.S., Sen Gupta, A., Senina, I., Waycott, M., 2013. Mixed responses of tropical Pacific fisheries and aquaculture to climate change. Nat. Clim. Change 3, 591–599.
Bell, J.D., Allain, V., Allison, E.H., Andréfouët, S., Andrew, N.L., Batty, M.J., Blanc, M., Dambacher, J.M., Hampton, J., Hanich, Q., Harley, S., Lorrain, A., McCoy, M., McTurk, N., Nicol, S., Pilling, G., Point, D., Sharp, M.K., Vivili, P., Williams, P., 2015. Diversifying the use of tuna to improve food security and public health in Pacific Island countries and territories. Mar. Policy 51, 584–591.
Briley, L., Brown, D., Kalafatis, S.E., 2015. Overcoming barriers during the co-production of climate information for decision-making. Clim. Risk Manage. 9, 41–49.
Brooks, N., Adger, W.N., 2005. Assessing and enhancing adaptive capacity. In: Lim, B., Spanger-Siegfried, E. (Eds.), Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. Cambridge University Press, UNDP-GEF, pp. 165–181.

Bryman, A., 2012. Social Research Methods. Oxford University Press, Oxford.
Burch, S., Shaw, A., Dale, A., Robinson, J., 2014. Triggering transformative change: a development path approach to climate change response in communities. Clim. Policy 14, 467–487.
Butler, J.R.A., Suadnya, W., Puspadi, K., Sutaryono, Y., Wise, R.M., Skewes, T.D., Kirono, D., Bohensky, E.L., Handayani, T., Habibi, P., Kisman, M., Suharto, I., Hanartani, Supartarningsih S., Ripaldi, A., Fachry, A., Yanuartati, Y., Abbas, G., Duggan, K., Ash, A., 2014. Framing the application of adaptation pathways for rural livelihoods and global change in eastern Indonesian islands. Global Environm. Change 28, 368–382.
Calheiros, D.F., Seidl, A.F., Ferreira, C.J.A., 2000. Participatory research methods in environmental science: local and scientific knowledge of a limnological phenomenon in the Pantanal wetland of Brazil. J. Appl. Ecol. 37, 684–696.
Candel, J.J.L., 2014. Food security governance: a systematic literature review. Food Secur. 6, 585–601.
Cash, D.W., Clark, W.C., Alcock, F., Dickson, N.M., Eckley, N., Guston, D.H., Jager, J., Mitchell, R.B., 2003. Knowledge systems for sustainable development. Proc. Nat. Acad. Sci. 100, 8086–8091.
Cassels, S., 2006. Overweight in the Pacific: links between foreign dependence, global food trade, and obesity in the Federated States of Micronesia. Globalization Health 2. http://dx.doi.org/10.1186/1744-8603-2-10.
Cheng, M.H., 2010. Asia-Pacific faces diabetes challenge. Lancet 375, 2207–2210.
Crimp S., Laing A., Gaydon D., Brown P.R., Poulton P., Khimashia N., 2010. A participatory approach to developing climate change adaptation options for NSW Farming Systems. Final Report to NSW Department of Environment, Climate Change and Water, Climate Action Grant – T07/CAG/004. CSIRO Climate Adaptation Flagship, Canberra.
Crona, B.I., Bodin, O., 2006. What you know is who you know? Communication patterns among resources extractors as a prerequisite for co-management. Ecol. Soc. 11, 7.
Cunningham, R., Cvitanovic, C., Measham, T., Jacobs, B., Dowd, A.M., Harman, B., 2015. Engaging communities in climate adaptation: the potential of social networks. Clim. Policy. http://dx.doi.org/10.1080/14693062.2015.1052955.
Cvitanovic, C., Wilson, S.K., Fulton, C.J., Almany, G.R., Anderson, P., Babcock, R.C., Ban, N.C., Beedon, R., Beger, M., Cinner, J., Dobbs, K., Evans, L.S., Farnham, A., Friedman, K., Gale, K., Gladstone, W., Grafton, Q., Graham, N.A.J., Gudge, S., Harrison, P., Holmes, T.H., Johnstone, N., Jones, G.P., Jordan, A., Kendrick, A., Klein, C.J., Little, L.R., Malcolm, H., Morris, D., Possingham, H.P., Prescott, J., Pressey, R.L., Skilleter, G.A., Simpson, C., Waples, K., Wilson, D., Williamson, D. H., 2013. Critical research needs for managing coral reef marine protected areas: perspectives of academics and managers. J. Environ. Manage. 114, 84–91.
Cvitanovic, C., Marshall, N., Wilson, S.K., Dobbs, K., Hobday, A., 2014. Perceptions of Australian marine protected managers regarding the role, importance, and achievability of adaptation for managing the risks of climate change. Ecol. Soc. 19 (4), 33.
Cvitanovic, C., Hobday, A.J., van Kerkhoff, L., Wilson, S.K., Dobbs, K., Marshall, N.A., 2015a. Improving knowledge exchange among scientists and decision-makers to facilitate the adaptive governance of marine resources: a review of knowledge and research needs. Ocean Coast. Manag. 112, 25–35.
Cvitanovic, C., Hobday, A.J., van Kerkhoff, L., Marshall, N.A., 2015b. Overcoming barriers to knowledge exchange; the perspectives of Australian marine scientists. Mar. Policy 52, 38–44.
Daniel, R., Konam, J.K., Saul-Maora, J.Y., Kamuso, A., Namaliu, Y., Vano, J.T., Wenani, R., N'nelau, P., Palinrungi, R., Guest, D.I., 2011. Knowledge through participation: the triumphs and challenges of transferring Integrated Pest and Disease Management (IPDM) technology to cocoa farmers in Papua New Guinea. Food Secur. 3, 65–79.
Dowd, A.M., Marshall, N., Fleming, A., Jakku, E., Gaillard, E., Howden, M., 2014. The role of networks in transforming Australian agriculture. Nat. Clim. Change 4, 558–563.
Dumaru, P., 2010. Community-based adaptation: enhancing community adaptive capacity in Druadrua Island, Fiji. Wiley Interdisciplinary Reviews. Clim. Change 1 (5), 751–763.
Eidt, C.M., Hickey, G.M., Curtis, M.A., 2012. Knowledge integration and the adoption of new agricultural technologies: kenyan perspectives. Food Secur. 4, 355–367.
Ericksen, P.J., Ingram, J.S.I., Liverman, D.M., 2009. Food security and global environmental change: emerging challenges. Environ. Sci. Policy 12, 373–377.
Few, R., Brown, K., Tompkins, E.L., 2011. Public participation and climate change adaptation: avoiding the illusion of inclusion. Clim. Policy 7, 46–59.
Fischer, G., Shah, M., Tubiello, F.N., van Velhuizen, H., 2005. Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. Philos. Trans. R. B Soc. 360, 2067–2083.
Fleming, A., Vanclay, F., 2009. Using discourse analysis to better inform the practice of extension. Extension Farming Syst. J. 5 (1), 1–10.
Fox, H.E., Christian, C., Nordby, C.N., Pergams, W., Peterson, G.D., Pyke, C.R., 2006. Perceived barrier to integrating social science and conservation. Conserv. Biol. 20, 1817–1820.
Gbegbelegbe, S., Chung, U., Shiferaw, B., Msangi, S., Tesfaye, K., 2014. Quantifying the impact of weather extremes on global food security: a spatial bio-economic approach. Weather Clim. Extremes 4, 96–108.
Githeko, A.K., Lindsay, S.W., Confalonieri, U.E., Patz, J.A., 2000. Climate change and vector-borne diseases: a regional analysis. Bull. World Health Organ. 78, 1136–1147.
Grafton, R.Q., Daugbjerg, C., Qureshi, M.E., 2015. Towards food security by 2050. Food Secur. 7, 179–183.
Granderson, A.A., 2014. Making sense of climate change risks and responses at the community level: a cultural-political lens. Clim. Risk Manage. 3, 55–64.
Gray, A., 1991. The impact of biodiversity conservation on indigenous peoples. In: Shiva, V. (Ed.), Biodiversity: Social and Ecological Perspectives. Zed Books, London, UK.
Hagerman, S., Dowlatabadi, H., Satterfield, T., McDaniels, T., 2010. Expert views on biodiversity conservation in an era of climate change. Global Environ. Change 20, 192–207.
Hay, J., Mimura, N., 2006. Supporting climate change vulnerability and adaptation assessments in the Asia-Pacific region: an example of sustainability science. Sustain. Sci. 1, 23–35.
Heenan, A., Pomeroy, R., Bell, J., Munday, P.L., Cheung, W., Logal, C., Brainard, R., Yang Amri, A., Aliño, P., Armada, N., David, L., Guieb, R., Green, S., Jompa, J., Leonardo, T., Mamauag, S., Parker, B., Shackeroff, J., Yasin, Z., 2015. A climate-informed, ecosystem approach to fisheries management. Mar. Policy 57, 182–192.
Howden, S.M., Soussana, J.-F., Tubiello, F.N., Chhetri, N., Dunlop, M., Meinke, H., 2007. Adapting agriculture to climate change. Proc. Natl. Acad. Sci. 104, 19691–19696.
Howden, M., Nelson, R.A., Crimp, S., 2013. Food security under a changing climate. In: Palutikof, J., Boulter, S.L., Ash, A.J., Smith, M.S., Parry, M., Waschka, M., Guitart, D. (Eds.), Climate Adaptation Futures. John Wiley & Sons, Oxford. http://dx.doi.org/10.1002/9781118529577.ch4.
Howden, M., Schroeter, S., Crimp, S., Hanigan, I., 2014. The changing roles of science in managing australian droughts: an agricultural perspective. Weather Clim. Extremes 3, 80–89.
IPCC, 2014. Summary for policymakers. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–32.
Jacobs, K., Lebel, L., Buizer, J., Addams, L., Matson, P., McCullough, E., Garden, P., Saliba, G., Finan, T., 2010. Linking knowledge with action in the pursuit of sustainable water-resources management. Proc. Natl. Acad. Sci. http://dx.doi.org/10.1073/pnas.0813125107.
Kalafatis, S.E., Grace, A., Gibbons, E., 2015. Making climate science accessible in Toledo: the linked boundary chain approach. Clim. Risk Manage., doi: http://dxdoi.org/10.1016/j.crm..
Kettle, N.P., Dow, K., Tuler, S., Webler, T., Whitehead, J., Miller, K.M., 2014. Integrating scientific and local knowledge to inform risk-based management approaches for climate adaptation. Clim. Risk Manage. 4–5, 17–31.

Kuruppu, N., 2009. Adapting water resources to climate change in Kiribati: the importance of cultural values and meanings. Environ. Sci. Policy 12, 799–809.
Kuruppu, N., Liverman, D., 2011. Mental preparation for climate adaptation: the role of cognition and culture in enhancing adaptive capacity of water management in Kiribati. Global Environ. Change 21, 657–669.
Lacey, J., Howden, M., Cvitanovic, C., Dowd, A.M., 2015. Informed adaptation: ethical considerations for adaptation researchers and decision-makers. Global Environ. Change 32, 200–210.
Marshall, N.A., Friedel, M., Van Klinken, R.D., Grice, A.C., 2011a. Considering the social dimension of contentious species: the case of buffel grass. Environ. Sci. Policy 14 (3), 327–338.
Marshall, N.A., Gordon, I.J., Ash, A.J., 2011b. The reluctance of resource-users to adopt seasonal climate forecasts that can enhance their resilience to climate variability. Clim. Change 107 (3), 511–529.
Marshall, N.A., Park, S.E., Adger, W.N., Brown, K., Howden, S.M., 2012. Transformational capacity and the influence of place and identity. Environ. Res. Lett. 7 (3), 034022.
Marshall, N.A., Dowd, A.M., Fleming, A., Gambley, C., Howden, M., Jakku, E., Larsen, C., Marshall, P.A., Moon, K., Park, S., Thorburn, P.F., 2014. Transformational capacity in Australian peanut farmers for better climate adaptation. Agron. Sustainable Dev. 34, 583–591.
McNaught, R., Warrick, O., Cooper, A., 2014. Communicating climate change for adaptation in rural communities: a Pacific study. Reg. Environ. Change 14, 1491–1503.
Meinke, H., Howden, S.M., Struik, P.C., Nelson, R., Rodriguez, D., Chapman, S.C., 2009. Adaptation science for agriculture and natural resource management-urgency and theoretical basis. Curr. Opin. Environ. Sustainability 1, 69–76.
Miller, K.A., 2000. Pacific salmon fisheries: climate, information and adaptation in a conflict-ridden context. Clim. Change 45, 37–61.
Moser, S., 2010. Communicating climate change: history, challenges, processes and future directions. WIREs Clim. Change 1, 31–53.
Moser, S., Dilling, L., 2007. Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change. Cambridge University Press, Cambridge, UK.
Nelson, D.R., Adger, W.N., Brown, K., 2007. Adaptation to environmental change: contributions of a resilience framework. Ann. Rev. Environ. Resour. 32, 395–419.
Nisbet, M.C., 2009. Communicating climate change: why frames matter for public engagement. Environ. Sci. Policy Sustainable Dev. 51, 12–23.
Noy, C., 2008. Sampling knowledge: the hermeneutics of snowball sampling in qualitative research. Int. J. Soc. Res. Methodol. 11, 327–344.
O'Neill, S., Nicholson-Cole, S., 2009. 'Fear won't do it': promoting positive engagement with claimte change through imagery and icons. Sci. Commun. 30, 355–379.
Park, S.E., Marshall, N.A., Jakku, E., Dowd, A.M., Howden, S.M., Mendham, E., Fleming, A., 2012. Informing adaptation responses to climate change through theories of transformation. Global Environ. Change 22, 115–126.
Parry, J., 2010. Pacific islanders pay heavy price for abandoning traditional diet. Bull. World Health Organ. 88 (7), 481–560.
Parry, M.L., Rosenzweig, C., Iglesias, A., Livermore, M., Fischer, G., 2004. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environ. Change 14, 53–67.
Parry, M., Rosenzweig, C., Livermore, M., 2005. Climate change, global food supply and risk of hunger. Philos. Trans. R. B Soc. 360, 2125–2138.
Patz, J.A., Campbell-Lendrum, D., Holloway, T., Foley, J.A., 2005. Impact of regional climate change on human health. Nature 438, 310–317.
Pfeffer, J., Carley, K., 2012. Social Network, Social Media, Social Change. In: Henning, M., Brandes, U., Pfeffer, J., Mergel, I. (Eds.), Studying Social Networks: A Guide to Empirical Research. Campus Verlag/University of Chicago Press, Frankfurt/Chicago.
Porter J.R., Xie L., Challinor A., Cochrane K., Howden M., Iqbal M.M., Lobell D., Travasso M.I. 2014. Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. <http://www.ipcc-wg2.gov>.
Raymond, C.M., Fazey, I., Reed, M.S., Stringer, L.C., Robinson, G.M., Evely, A.C., 2010. Integrating local and scientific knowledge for environmental management. J. Environ. Manage. 91, 1766–1777.
Redman, C.L., Grove, J.M., Kuby, L.H., 2004. Integrating social science into the long-term ecological research (LTER) network: social dimensions of ecological change and ecological dimensions of social change. Ecosystems 7, 161–171.
Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141, 2417–2431.
Reed, M.S., Stringer, L.C., Fazey, I., Evely, A.C., Kruijsen, J.H.J., 2014. Five principals for the practice of knowledge exchange on environmental management. J. Environ. Manage. 146, 337–345.
Roudier, P., Muller, B., d'Aquino, P., Roncoli, C., Soumaré, M.A., Batté, L., Sultan, B., 2014. The role of climate forecasts in smallholder agriculture: lessons from participatory research in two communities in Senegal. Clim. Risk Manage. 2, 42–55.
Schmidhuber, J., Tubiello, F.N., 2007. Global food security under climate change. Proc. Natl. Acad. Sci. 104, 19703–19708.
Schroeder, A., Pennington-Gray, L., Donohoe, H., Kiousis, S., 2013. Using social media in times of crisis. J. Travel Tourism Market. 30, 126–143.
Shanley, P., López, C., 2009. Out of the loop: why research rarely reaches policy makers and the public and what can be done. Biotropica 41 (5), 535–544.
Smit, B., Wandel, J., 2006. Adaptation, adaptive capacity and vulnerability. Global Environ. Change 16, 282–292.
Strauss, A., Corbin, J., 1998. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. Sage Publications, Thousand Oaks.
Tai, A.P.K., Martin, M.V., Heald, C.L., 2014. Threat to future global food security from climate change and ozone air pollution. Nat. Clim. Change 4, 817–821.
Thow, A.M., Swinburn, B., Colagiuri, S., Diligolevu, M., Quested, C., Vivili, P., Leeder, S., 2010. Trade and food policy: case studies from three Pacific Island countries. Food Policy 32, 556–564.
Van Kerkhoff, L., Lebel, L., 2006. Linking knowledge and action for sustainable development. Ann. Rev. Environ. Resour. 31, 445–477.
Vroegindewey, G.V., 2011. Social media and social networks in disaster management: the haiti model. Prehospital Disaster Med. 26 (S1), s26.
Wheeler, T., Von Braun, J., 2013. Climate change impacts on global food security. Science 341, 508–513.
WHO, 2002. Workshop on obesity prevention and control strategies in the Pacific. Workshop Report. Workshop Convened by World Health Organization regional office for the Western Pacific.
Wise, R.M., Fazey, I., Stafford Smith, M., Park, S.E., Eakin, H.C., Archer Van Garderen, E.R.M., Campbell, B., 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Global Environ. Change 28, 325–336.