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Framework for integrating indigenous and scientific knowledge for disaster risk reduction

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A growing awareness of the value of indigenous knowledge has prompted calls for its use within disaster risk reduction. The use of indigenous knowledge alongside scientific knowledge is increasingly advocated but there is as yet no clearly developed framework demonstrating how the two may be integrated to reduce community vulnerability to environmental hazards. This paper presents such a framework, using a participatory approach in which relevant indigenous and scientific knowledge may be integrated to reduce a community's vulnerability to environmental hazards. Focusing on small island developing states it presents an analysis of the need for such a framework alongside the difficulties of incorporating indigenous knowledge. This is followed by an explanation of the various processes within the framework, drawing on research completed in Papua New Guinea. This framework is an important first step in identifying how indigenous and scientific knowledge may be integrated to reduce community vulnerability to environmental hazards.

Keywords: disaster risk reduction, indigenous knowledge, Papua New Guinea, scientific knowledge, small island developing states

Introduction

Since the 1970s a growing body of literature has emphasised the importance of incorporating local knowledge and practices into development and conservation projects (see Table 1). Increasingly, the importance of local knowledge and practices has also been highlighted in relation to environmental hazards and disasters (Cronin et al., 2004a, 2004b; Dekens, 2007a, 2007b; Haynes, 2005; Howell, 2003; Jigyasu, 2002; Mitchell, 2006). However, while in theory the importance of such work has been recognised within the international community, the practical application generally only occurs on a small scale within communities of developing countries (Dekens, 2007a). For example, indigenous residents of Tikopia Island in the Solomon Islands struck by Cyclone Zoe in December 2002 survived using age-old indigenous practices of traditional housing (some of which survived the cyclone) and taking shelter under overhanging rocks on higher ground as the cyclone struck (Anderson-Berry et al., 2003; Kelman, 2005; Vettori and Stuart, 2004; Yates and Anderson-Berry, 2004). The National Disaster Management Office and associated international agencies helped their post-disaster reconstruction, but only after the people had secured their own survival in the short term. Such stories of survival through indigenous practices have directly contributed to challenging mainstream scientific views, which downplay the potential of indigenous knowledge. This has

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resulted in an increased interest among non-governmental organisations (NGOs) and other organisations working with populations threatened by environmental hazards in the potential for indigenous knowledge to contribute to disaster risk reduction (Mercer et al., 2007).

This interest has been especially highlighted within small island developing states (SIDS), due to their inherent vulnerabilities and propensity to environmental hazards (Lewis, 1999; Pelling and Uitto, 2001). The interaction of new global pressures such as climate change (Van Aalst, 2006) and sea level rise (Rodolfo and Siringan, 2006) with local dynamics has contributed to increased vulnerability to environmental hazards in SIDS (Pelling and Uitto, 2001). Indigenous populations have adjusted their livelihood strategies to adapt to gradual change for centuries, but new global pressures have significantly changed people's social, economic, political and environmental contexts (Dekens, 2007a). In the South Pacific, for example, this has contributed to a dramatic increase in the number of reported disasters and the effects of these upon communities since the 1950s (Bettencourt et al., 2006).

In moving forward with a disaster risk reduction strategy for SIDS it is clear that alongside the physical hazard risk, the interrelated human, societal and cultural factors surrounding this risk also need to be taken into account (Wisner et al., 2004). Disaster risk reduction reflects this need, viewing disasters as socio-economic and political in origin rather than natural (Gaillard et al., 2007; Hewitt, 1983; Torry, 1978, 1979; Wisner et al., 2004). It can be seen as '**the systematic development and application of policies, strategies and practices to minimise vulnerabilities,**

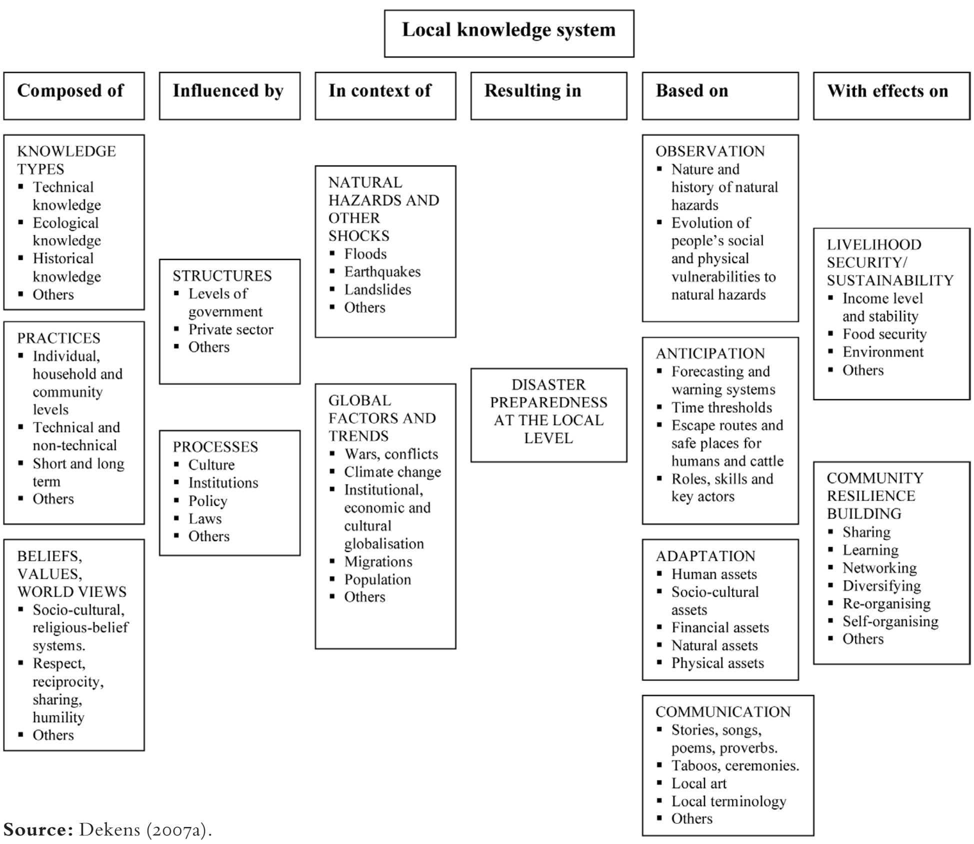
Table 1 Literature identifying the benefits of and the need to incorporate local knowledge (illustrative of examples within the field)

Research area	References
Soils	Gowing et al. (2004); Gray and Morant (2003); Payton et al. (2003); Sandor and Furbee (1996); Scott and Walter (1993)
Fisheries	Mackinson (2001)
Natural resource management	Moller et al. (2004); Rist and Dahdouh-Guebas (2006)
Forestry	Donovan and Puri (2004); Kaschula et al. (2005); Klooster (2002); Singhal (2000); Thapa et al. (1995); Walker et al. (1995); Walker et al. (1999)
Land management	Gobin et al. (2000); Reed et al. (2007)
Health	Giles et al. (2007)
Agricultural research	Rajasekaran (1993)
Marine conservation	Drew (2005)
Climate	Stigter et al. (2005)
Desertification	Gaur and Gaur (2004)
Water	Osti (2005); Roncoli et al. (2002)

hazards and the unfolding of disaster impacts throughout a society, in the broad context of sustainable development' (UNISDR, 2004, p. 3). It should therefore involve the incorporation of indigenous knowledge alongside scientific knowledge. Yet even though research and development organisations have acknowledged the existence and importance of indigenous knowledge and strategies related to disaster risk reduction, in practice, little documentation of its application through official channels exists (Dekens, 2007a). For example, Papua New Guinea, in developing a *National Disaster Risk Reduction and Disaster Management Framework for Action 2005–2015*, identified the need to integrate traditional knowledge into disaster management systems but not how this may be achieved (National Disaster Centre, 2005). It is essential that indigenous knowledge is drawn upon in addressing the accelerated pace of change in today's global world, its impacts upon environmental hazards, and the consequences for indigenous communities situated within hazard prone areas (Mercer et al., 2007). This is especially important for indigenous communities in SIDS.

In a first step towards identifying how indigenous and scientific knowledge in disaster risk reduction can be integrated successfully, Dekens (2007a) has developed a framework for data collection and analysis of local knowledge related to disaster

Figure 1 Framework for local knowledge on disaster preparedness



Source: Dekens (2007a).

preparedness (Figure 1). The framework assists in identifying the linkages and relationships between local knowledge and practices and disaster risk reduction, and the influences upon them (Dekens, 2007a). Dekens' framework enables an analysis of indigenous knowledge and its uses within disaster preparedness. While Dekens uses the term 'disaster preparedness', the authors of this paper use the term 'disaster risk reduction', as defined above, to encompass all applicable methods to reduce vulnerability to disaster, therefore incorporating disaster preparedness. However, it does not account for how this knowledge should be utilised alongside scientific knowledge to reduce community vulnerability to environmental hazards. As Dekens (2007a) herself states the next important step in order to provide further policy recommendations is identifying how indigenous knowledge can be combined with other knowledge bases such as scientific knowledge for disaster risk reduction.

This paper identifies how this may be achieved through the development of a framework identifying how indigenous and scientific knowledge may be integrated to reduce community vulnerability to environmental hazards, specifically in SIDS. The development of the framework emerges from participatory work within three rural communities in Papua New Guinea (PNG), namely Kumalu (population 565), Singas (population 296) and Baliau (population 297). Situated in Morobe and Madang Provinces these communities have been affected, respectively, by landslides and flooding, and by flooding and volcanic eruptions. Rather than a detailed analysis of each case study, data from all three will be used to illustrate the development of the framework that is the focus of this paper.

The challenge of incorporating indigenous knowledge

Knowledge is defined by the Oxford English Dictionary (Trumble, 2007) as 'information and skills acquired through education or experience' or an 'awareness or familiarity gained by experience of a fact or situation'. This can then be divided further into 'scientific knowledge' and 'indigenous knowledge'. While the former is generally understood to involve western technology or techniques, there exists no concise definition of the latter. Indigenous knowledge is referred to in a number of ways including, but not limited to, 'local knowledge', 'traditional knowledge', 'indigenous technical knowledge', 'peasants' knowledge', 'traditional environmental knowledge' and 'folk knowledge' (Sillitoe, 1998). To summarise relevant literature, indigenous knowledge is considered to be a body of knowledge existing within or acquired by local people over a period of time through accumulation of experiences, society-nature relationships, community practices and institutions, and by passing it down through generations (Brokensha et al., 1980; Fernando, 2003; Sillitoe, 2000). Scientific knowledge is global in nature whereas indigenous knowledge is considered local. However, as with scientific knowledge, indigenous knowledge is dynamic in nature, continually influenced both by internal creativity and experimentation, and by contact with external systems (Flavier et al., 1995).

Knowledge, both scientific and indigenous, is intertwined with power and human relationships including social, political, technical and economic elements (as demonstrated in Figure 1). Indigenous knowledge is oppressed in a number of ways as a result of the marginalisation, exploitation, powerlessness, cultural imperialism, violence and denial of existing knowledge placed upon its bearers (Laws, 1994; Young, 1988, 1990). All of these forms of oppression can occur simultaneously or independently of each other, but all contribute to the suppression of indigenous knowledge in a society where the scientific culture is dominant (Laws, 1994; Rist and Dahdouh-Guebas, 2006). Oppressed people, such as many indigenous populations, have largely remained outside the realm of academic discourse even though they are frequently the subject of academic analyses (Laws, 1994). Indigenous knowledge is based on diachronic observations accumulated over generations of detailed observation and interactions with local ecosystems (Dekens, 2007a). Thus, indigenous people are clearly interested in changing social relations and structures, and committed to adapting knowledge to achieve such changes (Laws, 1994). Their knowledge is more qualitative and geographically specific in contrast to scientific knowledge, which is normally based on synchronic observations, tending towards the quantitative and more general in nature (Dekens, 2007a). However, too often indigenous knowledge is hidden and dismissed by the tendency of scientific knowledge to deny the importance of the other (Agrawal, 1995; Davies, 1999; Laws, 1994; Rist and Dahdouh-Guebas, 2006).

Indigenous populations in SIDS face difficult challenges including globalisation, environmental pressures, marginalisation, racism, and economic and health inequity (Edwards and Heinrich, 2006). These processes are external to a community but can impact it internally (intrinsic factors) through, for example, agricultural changes, migration or loss of indigenous knowledge. This could potentially impact upon vulnerability levels of a community to environmental hazard(s) (Mercer et al., 2007). However, the ability of indigenous populations, such as those in Kumalu, Singas and Baliau in PNG, to survive environmental hazards is evidence of the applicability of indigenous knowledge (Anderson-Berry et al., 2003; Kelman, 2005; McAdoo et al., 2006).

In order to engage indigenous knowledge productively in development, Agrawal (1995) argues that there is a need to move beyond the dichotomy of indigenous versus scientific and work towards building bridges across the indigenous and scientific divide. This requires parity and integration between traditional and scientific knowledge systems, demanding a mutual understanding of the cultural, material and epistemological basis of each (Agrawal, 1995). He goes on to suggest that an attempt to create distinctions between indigenous and scientific knowledge is 'potentially ridiculous', and that it makes more sense to discuss multiple domains and types of knowledge with differing logics and epistemologies (Agrawal, 1995). This is observed among indigenous communities in SIDS, who have constantly adapted and developed their knowledge over centuries, intertwining this with outside knowledge where necessary, thus creating multiple forms of knowledge (Campbell, 2006; Raffles, 2002). This is observed with risk communication on Tikopia Island, Solomon Islands, where only a few residents received a Radio Australia transmission warning (scientific method) of the coming cyclone in December 2002 (Anderson-Berry et al., 2003). The local communication system (indigenous method) then took over with local runners taking the message out to other community members in the local language.

Despite the use of both indigenous and scientific knowledge in such circumstances the dominant view of indigenous knowledge as inferior to scientific knowledge can only increase as the centralisation of indigenous knowledge databases in museums or other academic research institutes disempowers local custodians of indigenous knowledge (Agrawal, 1995; Rist and Dahdouh-Guebas, 2006). Hence, there is a need for a participatory process in which indigenous knowledge is shown to have value and is kept within the community. It is essential that indigenous communities themselves have easy access to relevant research and information that may assist them in reducing their vulnerability to environmental hazards (Sillitoe, 2000). In an attempt to meet these challenges the framework presented below has focused on the use of participatory techniques within a given community to integrate both indigenous and scientific knowledge within disaster risk reduction. It is hoped that this will be a useful tool for identifying how the two sets of knowledge may be successfully integrated within disaster risk reduction for indigenous communities in SIDS.

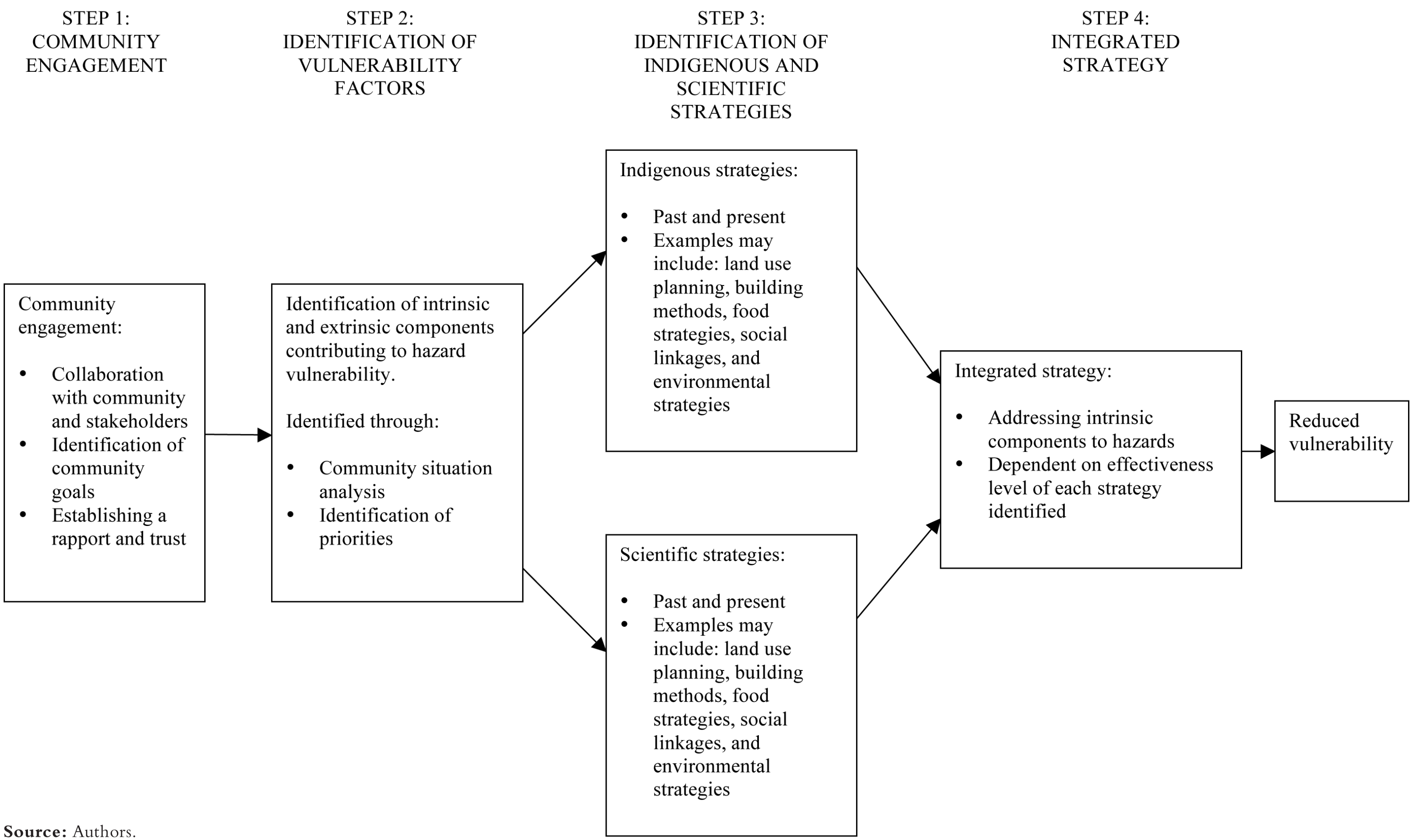
Framework integrating indigenous and scientific knowledge

The proposed framework is a process by which indigenous and scientific knowledge may be integrated to reduce the vulnerability of indigenous communities to environmental hazards. The framework is not identifying new knowledge but rather identifying how existing knowledge can be integrated to enhance the ability of indigenous communities to reduce vulnerability levels to environmental hazards.

A process framework focuses on the process as key to achieving outcomes. However, the process itself should also be considered one of the key outcomes and is critical to achieving a just and sustainable outcome in substantive, emotional and, in the case of this framework, procedural terms (Agius et al., 2004). As Agius et al. (2004) note, in many settings pre-determined processes prescribe the terms of indigenous participation with indigenous people having to conform to the dominant culture. The aim of this framework is to circumvent such a situation, enabling indigenous people to reach a consensus regarding ways to approach their vulnerability to environmental hazards. The framework in its simplified form is illustrated in Figure 2 (each section will be analysed in detail throughout the rest of this paper). The desired outcomes of this process consist of:

a) reduced vulnerability to environmental hazards;
b) increased collaboration among stakeholders; and
c) organised disaster risk reduction planning.

Figure 2 Process framework integrating indigenous and scientific knowledge



Source: Authors.

While outcome b) can be achieved throughout the process, outcomes a) and c) will only be achieved upon implementation of the identified integrated strategy by the community and stakeholders concerned. The framework is a process by which a researcher and community collaborate using participatory techniques to reach a desired result.

Participatory techniques in the context of disaster risk reduction have often been utilised in the form of 'capacities and vulnerabilities' analyses—that is, determining the strengths and weaknesses of a community. While in itself a useful analysis, the process does not seek solutions but rather identifies which strengths need to be built upon. Furthermore, many interventions initiated through participatory techniques within communities only address the hazard concerned rather than the underlying vulnerabilities, the intrinsic factors of which result in hazard vulnerability. It is these intrinsic factors contributing to a community's vulnerability that this framework is concerned with. The term community is itself quite complex, with some arguing that the concept of a local geographic community is a myth and that we each belong to a number of communities that may or may not be geographically situated (see Marsh, 2001, for a broader critique of 'community' in relation to disaster management). However, myth or not, community exists within the rhetoric and mind of citizens, government and non-governmental bodies (Buckle et al., 2003). Whether precisely defined or not, the concept of community is the pillar upon which local and regional programmes are developed to promote sustainable development (Buckle et al., 2003; Cannon, 2007). Hence, for the purposes of this research, community has been defined as a group of people sharing common ideals, resources, environment and aspirations while living in the same geographical location.

For this study, the process framework represents the main processes or steps that are taken in order to reach a point at which the indigenous community concerned can identify an integrated strategy—incorporating indigenous and scientific knowledge—that would best reduce their vulnerability to environmental hazards. As a process framework, guidance to completion is on a step-by-step basis in a linear fashion. However, while it is essential that the first step—initiating community engagement—is completed first, the middle two steps—identification of vulnerability factors and indigenous and scientific knowledge—can be discussed, re-visited and re-defined as deemed necessary by a community before moving on to identify an integrated strategy. This, then, is clearly not the end of the process: irrespective of the presence of an external researcher the community needs to revisit these steps from time to time in order to ensure that all bases are covered and new challenges addressed. It is a cyclic process with the framework designed to be flexible to suit any community, and with no specific guidelines as to how much time should be taken upon each step, thereby enabling the community to control the process. Importantly, this process is not static, because once an integrated strategy has been identified, the framework again allows for flexibility and revision of the process. Indeed, the framework should be utilised in an ongoing process of adaptation as the community continually adjusts to the impact of environmental change. This allows for adjustments both to past, present and future strategies as the community is confronted with and addresses new challenges.

Framework development

Importantly, before developing such a framework and consulting with indigenous communities it is essential to ensure that research is conducted respectfully, following the communities' cultural values and norms, and ensuring that the research contributes to their needs (Louis, 2007). In building an ethical research relationship with the indigenous communities in PNG it was this latter point that was particularly essential, as for the local people 'knowledge for knowledge sake [is] a waste of time' (Meyer cited in Louis, 2007, p. 131): in other words, if research initiated from outside a community does not benefit the community in any way then it should not be carried out (Louis, 2007). The action research approach taken to develop the framework in PNG facilitated the pursuit of particular local goals—that is, to reduce the vulnerability to environmental hazards of the communities concerned (Ivanitz, 1999). The researcher and the community together were able to determine the problems to be worked on and the possibilities for change—in this case an integrated strategy (Ivanitz, 1999).

In taking an action based approach, as will be outlined in the detailed description of the framework, the researcher and the community were able to adapt and develop methods that worked best for a given community or locality (Ivanitz, 1999). This approach attempts to acknowledge that researchers are not always right and that it is the community that knows its own situation best, thus avoiding the traditional power relations between a researcher and his or her subjects (Ivanitz, 1999). It is also an attempt to move away from westernised methodologies and points of view. As Gegeo and Watson-Gegeo (2001, p. 58) state, 'methodologies [that is, interviews and observations] drawing on indigenous cultural knowledge, are imagined, conceptualized, and carried out within the theoretical and methodological frameworks of Anglo-European forms of research, reasoning and interpreting'. By contrast, a participatory approach enables indigenous people to develop and define their own methodologies, drawing on their own conclusions in a strategy that works best for them (Louis, 2007). The researcher is there as the facilitator to guide, assist and learn, but not to teach.

The framework involves a partnership between the community, the researcher and associated stakeholders (for example, NGOs, government bodies) to identify a viable strategy that reduces vulnerability to environmental hazards. It has long been recognised that the top-down, science-centred approach to development has failed to deliver its promises (Fraser et al., 2006; Halani, 2004). The bottom-up participatory approach, advocated a couple of decades ago, has also not yielded the desired results (Halani, 2004). The proposed framework offers a potential solution to this dilemma, utilising and building upon the benefits of both indigenous and scientific knowledge bases.

Understanding the process framework

Step 1: Community engagement

This framework has been developed for use within indigenous communities that have been moderately or severely impacted by an environmental hazard (such as landslides, flooding, earthquake, volcanic eruption). The research for the framework was carried out in a specific location, the small island developing state of PNG, which may or may not preclude its use elsewhere. Research in the past has concentrated on the environmental hazard per se, and how vulnerability levels to this hazard may be reduced using western scientific solutions to mitigate against subsequent consequences (Dekens, 2007a; Wisner et al., 2004). However, in many cases within a community the hazard is also viewed, to a certain extent, as beneficial: for example, flooding can assist with land fertilisation. It is therefore the extent to which a hazard impacts upon a community, often governed by intrinsic factors contributing to vulnerability levels, that should be analysed here.

The essential first step is to initiate community engagement and to determine how, if at all, the community judges their levels of vulnerability to one or more environmental hazards and if they would like to move forward in identifying an integrated strategy to reduce their vulnerability. In initiating such a first step with a community—in this case with Kumalu in Morobe Province, PNG, (affected by landslides and flooding)—and following in line with local cultural traditions, discussions were first held with community elders regarding the proposed project and whether they felt that such a process may assist them in identifying a potential strategy to reduce their vulnerability. The community elders then took the proposal to the community council and a subsequent meeting was called with the majority of community members in attendance. The meeting was an opportunity for villagers to discuss important issues regarding the impact of landslides and flooding concerning both the researcher and various other stakeholders, including the government and NGOs. A large community meeting such as this presented an opportunity not only for a group discussion of the disaster issues and risks of the community but also for the researcher to probe with specific questions such as:

a) Which recent disasters have affected the community?
b) What were the main impacts/consequences?
c) Did the community experience problems in recovering from specific events?

The meeting also enabled a discussion with the villagers regarding the potential research programme, what it would entail and what the expected outcomes were, while allowing villagers to explain their community in detail and point out specific topics/issues that were of concern to them. Having received a detailed outline of the research and discussed issues of concern, this then enabled the community to make an informed decision about participation and therefore to take ownership of the specific project. This decision was made in the absence of the researcher, thus enabling the community to analyse and further discuss in detail the positives and negatives of their involvement with such a project. In the case of Kumalu, the community is impacted by multiple hazards of landslides and flooding. In such a scenario it can later be determined whether the intrinsic factors impacting on the vulnerability to one hazard are the same as those impacting on the other, in which case the two may be combined. If, however, different intrinsic factors are identified for each one then a different integrated strategy for each hazard will need to be developed.

Establishing trust and rapport with a community is an essential first step prior to moving on to further steps in the framework. It is important that the community understands issues of hazard and vulnerability in their own terms before moving on to the second step and the identification of vulnerability factors if they choose to do so.

Potential problems and limitations

The aim of this first step was not to select the community per se but to initiate community engagement, whereby the proposed project was presented to the community so that its members could make an informed decision regarding their participation. In an ideal situation the community itself would request external facilitation, though for this to occur communities would need to be aware of the options available to them. In PNG, all three communities had requested and in some cases received assistance in response to the impact of the hazard on their lives. In this way the communities, already 'selected' by having suffered from environmental hazards, also had the initiative to approach authorities for relevant assistance. The assistance expected was in the form of hand-outs from government bodies providing material assistance (Mercer et al., 2008). This created the first problem in working towards an effective and applicable disaster risk reduction strategy for indigenous communities in SIDS. Expectations within the communities were raised by the presence of an external researcher who was seen as a potential source of benefit, both financial and material, through his/her linkages with the outside community, both governmental and non-governmental (see Mercer et al., 2008, for further explanation). Such expectations were carefully addressed through detailed and coherent explanations of the research and the potential benefits it could and could not provide the community.

In addition, in undertaking work within indigenous communities the external researcher is very much seen as the 'authoritative figure'. This creates unequal power relations between the researcher and the communities and should be mitigated against from the outset (Mercer et al., 2008). It is essential that the communities themselves take ownership of the research in order for the final result to be successful and implemented by the community (Chambers, 1994a, 1994b; Louis, 2007; Mercer et al., 2008). The researcher or facilitator is there to guide and to listen but not to direct. Ultimately it is important that, in later steps of the framework, the communities identify an appropriate integrated strategy themselves rather than have the researcher interpret the information for them. However, addressing such concerns is easier said than done. To some extent there will always be an unequal exchange of power between the facilitator and the communities (Chambers, 1994a;

Table 2 Identification of extrinsic and intrinsic components contributing to vulnerability

Identified through:
1. Community situation analysis:
a) Community and environment: through social and resource maps and community transects establish a comprehensive understanding of social and physical aspects of village life.
b) Establish history and hazard timelines to identify trends and changes over time within the village.
c) Identify seasonal and daily routines and impacts of hazard upon these, both present and historic.
d) Classify building and construction types, establishing their importance and vulnerability levels.
e) Identify the layout of the community and available service infrastructure and systems.
f) Analyse vulnerabilities and capacities in terms of livelihoods.
g) Identify community assets, services and opportunities, and linkages with external groups and/or institutions.
h) Environmental and social data of the area.
i) Establish general baseline data including information about population and human development, land, livelihood activities, disaster and hazard event history, available community services and supplies, community organisation and programmes, and government organisation and contacts.
2. Identification of priorities:
a) Interpret the situation analysis to identify extrinsic and intrinsic components impacting upon vulnerability.
b) Produce a 'cause-effect' diagram, in consultation with the community, clearly showing extrinsic and intrinsic factors impacting upon their vulnerability to hazards.
c) Identify priorities and key intrinsic factors that need to be addressed in initial stages of vulnerability reduction.
d) Establish the impact of the pre-identified key intrinsic factors upon vulnerability.

Cooke and Kothari, 2001; Mercer et al., 2008). Only through linking participatory approaches to wider and more difficult processes of democratisation and through addressing power relations within and between communities will long-term changes occur (Mohan, 2001).

Step 2: Identification of vulnerability factors

After establishing a rapport and engaging with the community in Step 1, the focus throughout the rest of the framework moves away from the hazard itself. The extent of a hazard's impact is determined by the vulnerability level of a community. It is important then for the community to identify and determine their level of vulnerability, irrespective of the hazard. The identification of vulnerability factors is essentially split into two parts: the extrinsic factors, incorporating anthropogenic and non-anthropogenic processes that are outside the control of a community; and the intrinsic factors resulting from extrinsic ones, which to some extent a community can address (see Table 2). The aim of this part of the process framework is to support and assist a community in identifying the process of vulnerability and how this contributes to exacerbating the impact of an environmental hazard.

What type of information is required to identify the vulnerability factors?

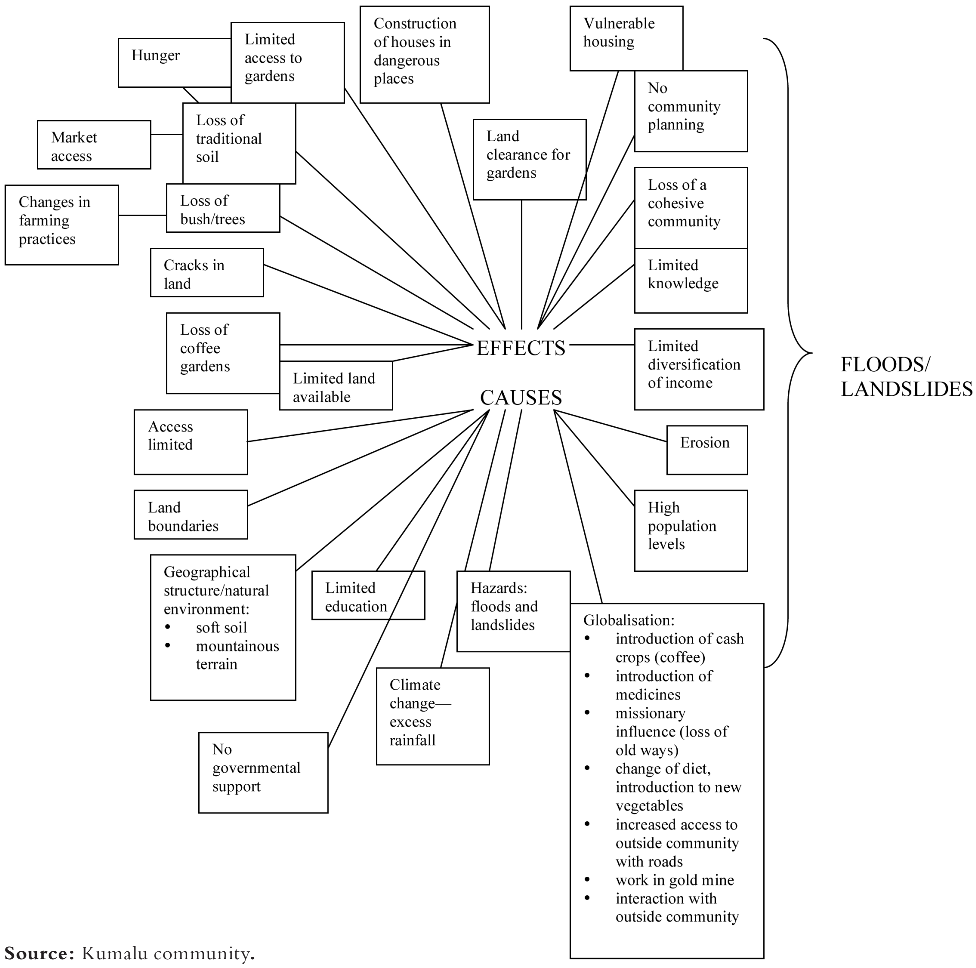
The analysis of extrinsic and intrinsic components impacting upon vulnerability does not have to be exhaustive to be effective. The aim is to identify those intrinsic factors that are of particular importance or have a particular impact upon vulnerability to the hazard. Such an understanding of these factors cannot occur without an adequate understanding of the context in which they exist—that is, the social and physical analysis of the community in question.

An understanding of the locality and community is essential for identifying extrinsic and intrinsic components impacting upon a community. This can be achieved through a community situation analysis, an approach often undertaken as part of a community vulnerability analysis (Vrolijks, 1998), as detailed in Table 2. Interactive discussions between the researcher and the community, facilitated by the use of mapping techniques and timelines, enable key baseline data to be generated. This is extremely important as it not only allows the community and researcher to situate themselves but also initiates discussions surrounding community priorities, helping to identify issues of most concern to the community. A community situation analysis can take anywhere from a few days to a few weeks to ensure sufficient data are collected. However, such a process could go on indefinitely depending upon the relationships built up between the researcher and a community. In an anthropological study, for example, a researcher may spend years within a specific community building up relationships and making a significant contribution to the community over a long period of time. However, the aim of this exercise is to move forward quickly with identification of a strategy to reduce vulnerability to environmental hazards. It is therefore preferable to minimise time spent on the situation analysis, while at the same time ensuring that enough time is spent discussing and elaborating on the data identified.

This process culminates in a second stage: the identification of priorities, as detailed in Figure 2. The raw data obtained from a collaborative community situation analysis will enable the researcher to identify extrinsic and intrinsic factors impacting upon the community's vulnerability. The extrinsic factors are identified as causes, thus demonstrating the linkages to the intrinsic factors or effects on a 'cause-effect' tree, thereby enabling a clearer picture of existing interrelationships. This is demonstrated in Figure 3, which details the cause-effect tree established for and developed by Kumalu villagers, PNG. The causes, such as globalisation, hazards, land boundaries and geographical structure, are all extrinsic factors over which the community has no control. These extrinsic factors have culminated in intrinsic effects such as clearance of land, loss of traditional soil, construction of houses in dangerous places, changes in farming practices, which are all components of the vulnerability level within Kumalu village and have contributed to the increased impacts now felt by the community as a result of environmental hazards.

The intrinsic impacts identified then need to be prioritised in order to address those that contribute most to the community's vulnerability to each hazard. To assist the community in identifying the intrinsic impacts that they would like to see addressed, pair-wise ranking could be used, or a process of comparison between each of the intrinsic factors identified (Kumar, 2002). Working with a community on Manam Island, PNG, the simplest way to do this was for the community to construct a grid

Figure 3 Cause-effect tree for Kumalu Village, PNG



Source: Kumalu community.

and nominate a symbol for each intrinsic factor identified (see Table 3).[2] Members of the community then went through the grid comparing two factors at a time (along each axis) and discussing which one of the pair contributed to their vulnerability more. At the end of the exercise the community then added up the symbols in the grid to determine their priority intrinsic factors. The grid, however, was used as a guideline not as an absolute. At the end of pair-wise ranking the community were able to discuss if they agreed with the results and if not why not, and what they should change. Kumalu community, for instance, was unhappy that they had not recognised 'limited knowledge' as a factor in their vulnerability so they decided to change their priorities slightly.

Use of pair-wise ranking enabled all the intrinsic factors to be labelled in terms of their contribution to vulnerability. However, to determine the effectiveness of a subsequent integrated strategy it is necessary to go into more detail. As stated earlier the aim is to identify those intrinsic factors that are of particular importance or

Table 3 Results of pair-wise ranking in Baliau village, Manam Island, PNG

SIGNS	÷	∆	○	⊗	♣	❂	✱	☐	☽	⇧	■	Z
÷	N/A	÷	÷	⊗	÷	❂	✱	☐	☽	⇧	÷	Z
∆	÷	N/A	∆	⊗	∆	❂	✱	☐	☽	⇧	∆	∆
○	÷	∆	N/A	⊗	♣	❂	○	☐	☽	⇧	○	○
⊗	⊗	⊗	⊗	N/A	♣	❂	⊗	⊗	⊗	⊗	⊗	Z
♣	÷	∆	♣	♣	N/A	❂	✱	☐	☽	⇧	♣	Z
❂	❂	❂	❂	❂	❂	N/A	❂	☐	☽	⇧	❂	Z
✱	✱	✱	○	⊗	✱	❂	N/A	✱	☽	⇧	✱	✱
☐	☐	☐	☐	⊗	☐	☐	✱	N/A	☽	☐	☐	☐
☽	☽	☽	☽	⊗	☽	☽	☽	☽	N/A	☽	☽	☽
⇧	⇧	⇧	⇧	⊗	⇧	⇧	⇧	☐	☽	N/A	⇧	⇧
■	÷	∆	○	⊗	♣	❂	✱	☐	☽	⇧	N/A	■
Z	Z	∆	○	Z	Z	Z	✱	☐	☽	⇧	■	N/A
TOTAL	**8**	**8**	**6**	**16**	**6**	**14**	**12**	**16**	**20**	**16**	**2**	**8**

Key:

- ÷ Loss of garden crops
- ∆ Loss of fertile soil
- ○ Hunger
- ⊗ Changes in traditional practices
- ♣ Construction of houses in dangerous places
- ❂ Vulnerable housing
- ✱ Loss of cash crops
- ☐ No disaster plan
- ☽ No community planning
- ⇧ Lack of knowledge
- ■ Changes in farming practices
- Z Business breakdown

Priority list order:

1 No community planning
2 Changes in traditional practices
3 No disaster plan
4 Lack of knowledge
5 Vulnerable housing
6 Loss of cash crops
7 Loss of garden crops
8 Loss of fertile soil
9 Business breakdown
10 Hunger
11 Construction of houses in dangerous places
12 Changes in farming practices

Note: The symbol N/A (non applicable) is used throughout the centre of the grid to avoid two of the same factors being compared against each other.

have a particular impact upon vulnerability to the hazard. It is therefore suggested that these are drawn out relative to their scores on the pair-wise ranking table in order to identify an integrated strategy addressing them. This obviously depends on the community's needs and situation at the time. Further discussion surrounding these factors and their impact is then necessary. For example, in Singas village in PNG they chose to focus on the top five factors and score these on a scale of 1–10 as to their contribution to vulnerability levels of the community and the subsequent impact of an environmental hazard. This then ensured that during the later stages of the framework, when the villagers identify and implement an integrated strategy, they are able to go back to this step to calculate to what extent an integrated strategy has enabled them to reduce these figures.

Potential problems and limitations

The greatest problem at this stage of developing the framework was the translation between English and local languages, which often changed meanings, interpretations and connotations (Mercer et al., 2008). While communities are clearly aware of the risks they face from environmental hazards, their awareness is often embedded within their cultural and/or livelihood settings and in many cases not linked to the specific hazard impacting upon them. It was necessary to test and interpret carefully the language used by the communities before undertaking research there in order to avoid potential misunderstandings (Mercer et al., 2008).

The significance of the vulnerability factors identified could also potentially differ by hazard and by their impact upon livelihoods, individuals or communities. This could be circumvented by identifying a different integrated strategy for each potential hazard, in which different vulnerability factors are identified. In addition, the significance of the vulnerability factors is carefully considered by the whole community prior to selection. While this could reduce the significance of a specific impact upon an individual, for such a strategy to be successful a cohesive approach is required in which those factors most affecting the whole community are taken into account. This leaves room to address potential individual concerns at a later date.

In utilising a non-hazard-specific approach in which the hazard was largely removed from the discussion, communities were able successfully to identify vulnerability factors. However, as the hazard is clearly the main concern for each community it is impossible to completely remove this from the discussion: instead, communities needed to identify the link between the hazard and the vulnerability factor. This may have reduced the effectiveness of the approach in cases where the community only identified those factors that presented an obvious link. This brings us back to the problem of language and the translation of different concepts. Ideally, such an approach should be adopted 'in-country' and carried out by a local person familiar with the communities and their cultural background (Mercer et al., 2008).

Step 3: Identification of indigenous and scientific strategies

Step 3 involves identifying both indigenous and scientific strategies used both in the past and in the present to cope with intrinsic factors affecting vulnerability. It is essential that strategies and/or knowledge used in the past are identified alongside present day strategies because an earlier strategy may emerge as relevant and beneficial. For example, the villagers in Kumalu identified that their indigenous land management strategies used in the past had helped reduce their vulnerability, whereas the strategies implemented today have contributed to their vulnerability. This is especially true with regards to landslides, as implementation of the 'western scientific' way has contributed to destabilising the ground and the soil, resulting in further landslides.

What type of information is required to identify indigenous and scientific strategies?

To find such information involves careful, in-depth analysis with the community concerned, especially as much indigenous knowledge is embedded within a community

Table 4 Identification of indigenous and scientific strategies

Identification of indigenous strategies:

1. Community to establish groups consisting of a balanced representation of elders, youths, women, minorities (e.g. ethnic minorities) and disabled to look at indigenous strategies used to deal with the hazard in both the past and present. Groups to consider different knowledge areas such as land use planning, building methods, environmental strategies, food strategies, social linkages, and other areas identified in collaboration with the community.
2. Triangulate data with whole community and with associated stakeholders to establish/identify strategies that may be used, of which the community may have been unaware.

Identification of scientific strategies:

1. Community to establish groups consisting of a balanced representation elders, youths, women, minorities (e.g. ethnic minorities) and disabled to look at scientific strategies used to deal with the hazard in both the past and present. Groups to consider different knowledge areas such as land use planning, building methods, environmental strategies, food strategies, social linkages, and other areas identified in collaboration with the community.
2. Triangulate data with whole community and with associated stakeholders to establish/identify strategies that may be used, of which the community may have been unaware.

and not necessarily linked to its ability to reduce vulnerability. Careful consideration needs to be taken of all facets of the community and how the knowledge it uses, both scientific and indigenous, contributes to reducing vulnerability. For example, the researcher may see a particular strategy as adequately assisting in reducing vulnerability levels, whereas the community sees it as an everyday process not considered in the context of a hazard.

As there is a large body of indigenous and scientific knowledge to identify, it was found that the best approach in PNG was for the community to divide itself into groups according to community specifications, with each group taking a certain area of knowledge—such as land use planning—and looking at both indigenous and scientific strategies used in the past and present (see Table 4). Essential in this process is working alongside community elders who are often highly respected for the knowledge they hold of indigenous strategies used in the past—of which the younger generation may know very little. This was especially important in all three communities in PNG where the villagers took the initiative to ensure that there were village elders alongside youths in each of the groups discussing indigenous and scientific strategies. Depending on the cultural background of the community concerned it may also be beneficial to divide groups by gender or by minority groups (such as ethnic minorities) to ensure that everyone is represented and feels able to speak freely. This, alongside further triangulation of data with the whole community in discussion together, ensured that all knowledge bases were covered in relation to the different research areas.

Potential problems and limitations

In many cases the communities in PNG discussed the impact of past events rather than what could happen or change in the future. Considering that the strategy ultimately aims to reduce the vulnerability of indigenous communities to potential future hazards it is necessary to ensure that they discuss both past events and how these may be changed in the future. This relates back to Step 1 where the researcher needs to ensure that communities have a clear understanding of the process and what is required before their agreement (or refusal) to participate. It is a process of 'guided discovery' whereby the communities are facilitated to identify solutions to potential problems through drawing on existing knowledge and past experiences to discover facts, relationships and new truths (Bruner, 1961; Mercer et al., 2008). However, difficulties occurred in some cases in accessing past indigenous knowledge and in drawing out strategies embedded within the daily lives of the communities. Limited knowledge retrieval presents particular problems in moving forward with the development of an integrated strategy. As an outsider the researcher must accept, to a large extent, the depth of knowledge offered by community members, but it is also essential to probe and ask questions to draw out further relevant knowledge. Especially important is the involvement of both young and old community members to ensure depth of past and present knowledge (Mercer et al., 2008).

Step 4: Development of an integrated strategy

This is the final step of the framework. It involves an analysis of the data in Steps 2 and 3 in order to negotiate and develop an integrated strategy to reduce vulnerability to environmental hazards. This is a participatory process facilitated by the researcher that enables a community to analyse their vulnerability level, specific strategies identified to deal with this, and how they may move forward with an integrated strategy to reduce their vulnerability to environmental hazards. At this stage new knowledge can be developed leading to a new strategy. The knowledge is kept within the community, with the community developing strategies rather than the researcher suggesting solutions. However, while this is the end of the framework it should not be considered the end of the process. It is a necessary first step but not sufficient in itself to ensure permanent vulnerability reduction among indigenous communities to environmental hazards. There needs to be constant revision and evaluation in light of changing circumstances to ensure that relevant intrinsic factors are targetted and overall vulnerability is reduced. This should also entail collaboration with relevant governmental and non-governmental organisations in order that the community is kept up-to-date with applicable strategies and approaches that may be beneficial to them.

What type of information is required to identify an integrated strategy?

To move forward with an integrated strategy the previous steps in the framework need to be analysed and reviewed by the community. As identified in Table 5 the community needs to go back to the top priority intrinsic factors they identified as contributing to their vulnerability and establish all the indigenous and scientific strategies both past and present that address each one. For example, Kumalu identified vulnerable housing as a major vulnerability factor to which they then matched indigenous knowledge—such as the use of bush materials—with scientific knowledge—such as the use of alternative modern materials—employed in both the past and present to mitigate against this factor. However, identifying these strategies is necessary but not enough on its own for moving ahead to work out how they may be integrated, if at all. The individual merits of each strategy need to be assessed in order to determine its future viability in reducing community vulnerability.

Such a process should be discussed with and directed by the communities themselves. In PNG, in collaboration with the communities, four factors were utilised to assess the viability of each strategy both past and present. These included; a) sustainability—whether the option could be maintained or continue to be useful in a changing environment; b) cost—does the proposed strategy make effective use of available resources; c) equitability—will the option be accessible to all community members or will some members benefit more; and d) stability—will the option bring change in an incremental and systematic way that causes a minimum level of disruption in the ecology, social structure and livelihoods of the community. The communities chose to score each of the strategies out of five in the above mentioned criteria with five valued as strongly agreeing and one as disagreeing. The community then ended up with a list of vulnerability factors with the correlating knowledge used to mitigate against each one scored on the above criteria. This enabled the communities to identify the most beneficial strategies in dealing with each individual intrinsic component.

Each intrinsic factor was then taken and discussed in turn. While the highest scoring mitigating factors were analysed first, the community were able to pick and choose those they thought would be more efficient at reducing their vulnerability if integrated into the strategy. For example the highest scoring mitigating factors may not have been compatible but if one of these were to be removed and the other combined with a lower scoring mitigating factor the combination of the two may help reduce vulnerability more than the initial top scoring approaches. Important here is to remember that it is the community who are most aware of their situation and therefore the community who are best able to make the decisions about an appropriate strategy. This then results in an integration of the most successful indigenous and scientific strategies to reduce community vulnerability to environmental hazards.

There will clearly be conflict or incompatibility between some strategies, in which case these cannot be integrated. Rather, the community is able to identify those that can be integrated and that will further increase their ability to reduce their vulnerability levels, thereby minimising the impact of environmental hazards. When this strategy is implemented by the community in collaboration with external stakeholders the community's vulnerability to intrinsic factors and, subsequently, to environmental hazard(s) will be reduced. An essential part of the process is constant revision and monitoring, as indigenous communities are beset by new challenges or environmental changes. After addressing the priority intrinsic components the community can then identify and analyse ways to deal with other intrinsic components not addressed in the initial stages of the framework, thus further contributing to a reduction in vulnerability.

Table 5 Developing an integrated strategy

1. Review the priority intrinsic components identified and establish all the indigenous and scientific strategies that address each one.
2. Negotiate with the community about how to analyse the effectiveness of each strategy both past and present for future use—for example, through a scoring system.
3. Based on the effectiveness levels determined above develop an integrated strategy addressing each intrinsic component and subsequently reducing vulnerability to environmental hazards.

Potential problems and limitations

Knowledge is constantly evolving and in some cases indigenous communities have already integrated indigenous and scientific knowledge, which may or may not have been to their benefit. If this is the case then the process framework can only reiterate previous successful strategies or else present a new, far more beneficial approach previously not considered by the community concerned.

It is necessary throughout the framework and especially in this final stage to involve relevant governmental and non-governmental organisations to provide the supportive back-up and motivation for such communities to implement, monitor and evaluate such a strategy. Without motivation in the form of follow-up activities and the presence of support such a strategy would potentially be difficult to implement, not because the communities are incapable but rather due to an ingrained 'hand-out' culture where support is expected (Mercer et al., 2008). However, this process could contribute to moving away from such a culture as it involves the practical application of a strategy that is ultimately the responsibility of the community concerned.

Conclusion

This framework has been developed in response to increased calls by both the international community and indigenous people to recognise the value of indigenous knowledge. To date, this has mainly been in the area of natural resource management. However, the applicability of indigenous knowledge within disaster risk reduction is increasingly being recognised. Indigenous communities in SIDS are seen to be at a particular disadvantage because of the vulnerability of their island homes to environmental hazards (Lewis, 1999; Pelling and Uitto, 2001). In light of this vulnerability and the limited resource base of SIDS it would be advantageous to build upon the capabilities already in existence in order to reduce vulnerability to environmental hazards.

This framework has demonstrated a new approach within disaster risk reduction that enables communities to establish potential solutions to their vulnerability to environmental hazards. While the framework has been developed in consultation with indigenous communities in PNG, its conceptual form does not adequately demonstrate the usefulness or the potential solutions it could lead to within an indigenous community elsewhere. The challenge now is to identify how the process of implementation can occur. This challenge is a potential project in itself, moving away from the traditional oppression of indigenous knowledge towards a culture of acceptance and realisation of the potential contributions indigenous knowledge systems have to offer (Laws, 1994).

The first step towards implementation of the strategy within SIDS is recognition by associated stakeholders that indigenous knowledge is a crucial component of a potential strategy reducing vulnerability to environmental hazards. Without this important first step, implementation of such a framework is a meaningless exercise that will result in top-down implementation and direction as some stakeholders dismiss relevant indigenous knowledge, preferring instead to direct and impose their own solutions. The gulf between indigenous and western scientific world views needs to be narrowed, thereby establishing a 'common ground for communication' (Marincioni, 2007) through collaboration between and integration of knowledge bases. The implementation of such a framework and development of an integrated strategy within a community can only occur through a dialogue based on respect and communication between associated stakeholders and the community (Cronin et al., 2004a; Haynes et al., 2008). A relationship based on trust and communication is conducive to the implementation of such a framework and to the subsequent initiation of the participatory process enabling communities to identify the benefits of indigenous and scientific knowledge, and how they may be integrated to reduce vulnerability.

The framework facilitates a process whereby successful integration of the two knowledge bases may occur at the community level. The process is neither top-down nor bottom-up but rather a collaborative effort within and between the community and associated stakeholders. This process has built upon previous efforts in the field that have sought to identify with the value of indigenous knowledge but not how it may be effectively integrated with scientific knowledge to benefit communities. To proceed further there now needs to be a detailed analysis of the case studies in question in PNG to determine the effectiveness of the framework in identifying an integrated strategy reducing community vulnerability to environmental hazards.

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2 Original symbols were chosen by the community but these have been changed for ease of depiction in Table 3.

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