REPORT

Local Perceptions of Changes in Traditional Ecological Knowledge: A Case Study from Malekula Island, Vanuatu

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Abstract Traditional ecological knowledge (TEK) is a critical global resource that may be eroding amid social and environmental change. Here, we present data on local perceptions of TEK change from three communities on Malekula Island in Vanuatu. Utilizing a structured interview ($n = 120$), we find a common perception of TEK loss. Participants defined two key periods of TEK erosion (roughly 1940–1960 and 1980–present), and noted that TEK decline was driven both external (e.g., church) and internal (e.g., shifting values) processes. Erosion was perceived to more comprehensive in the worldview domain than in aspects of ethnobiological knowledge and practice. These data indicate the perceived fragility of TEK systems and the complexity of TEK change. TEK systems are critical to natural resource management, and data such as these will assist in designing nuanced responses to the ongoing loss of cultural knowledge and practice.

Keywords Traditional ecological knowledge · Cultural change · Trend analysis · Vanuatu · Malekula

INTRODUCTION

The importance of traditional ecological knowledge (TEK) is well established within natural resource management and sustainability science (Zent and Maffi 2009). Defined as the cumulative environmental knowledge, belief, and practice of local and indigenous people, TEK is a product of enduring links between humans and the environment (Berkes 2012). Commentators have noted that TEK is a critical store of ecological knowledge (Johannes 1998), can guide adaptive management practice (Berkes et al. 2000), and underpins resource governance over much of the globe (Singh et al. 2010). Unfortunately, TEK is at risk worldwide, as the

transmission and acquisition of cultural knowledge falters amid social and ecological change (Zent 2001). This erosion of TEK is a serious threat to local-scale resource management capacity (Brosi et al. 2007), and represents the loss of a diverse and contextualized set of responses to global environmental issues (Ford and Martinez 2000).

In response, studies have sought to decipher the drivers and rates of TEK decline. In general, the approach to quantifying these patterns has been to measure participant knowledge within a sub-domain of TEK (e.g., ethnomedical knowledge), and examine inter- or intra-cultural variation according to demographic (e.g., age) and social (e.g., level of education) variables (Godoy et al. 2009). Most data indicate declines in levels of TEK that are associated with social change (e.g., Voeks and Leony 2004), although some studies do show remarkable persistence of TEK over time (e.g., Zarger and Stepp 2004). These studies also tend to note that drivers of TEK erosion are interactive and complex, and can vary across spatial contexts and between domains of TEK (Reyes-Garcia et al. 2007). For example, integration into market economies affects some domains of TEK but not others (Godoy et al. 1998), while educational attainment has been found to associate both positively (Reyes-Garcia et al. 2005) and negatively (Quinlan and Quinlan 2007) with environmental knowledge.

There are a number of opportunities to increase our understanding of the drivers and rates of TEK erosion. For one, the explanatory variables used to examine TEK variation (such as number of visits to a market town) are often designated a priori, based on previous studies. This is problematic: such models tend to be etic in nature (i.e., derived from sources outside the focus community), and may not account for local conditions or unforeseen variables. Moreover, assessment of change in TEK over time is hampered by a lack of longitudinal data. Instead, authors

typically examine associations between knowledge and age in a cross-sectional survey, which can yield spurious conclusions because knowledge accumulates with age, and because it is difficult to account for covariance in explanatory variables (Godoy et al. 2009). TEK also comprises multiple domains and dimensions, and processes of change can vary between the various aspects of local knowledge (Zent and Maffi 2009). Finally, research of this kind displays a significant geographic skew, and studies from Melanesia—a global hotspot of biological and cultural diversity—are lacking (Reyes-Garcia et al. 2007).

In this paper we address these opportunities by examining local perceptions of drivers and rates of TEK change on Malekula Island in the Republic of Vanuatu. We ask three key questions that will be of interest across the globe: (a) when have been the major periods of change in TEK systems; (b) what do participants perceive to be driving TEK change; and (c) how has TEK change impacted across different domains and dimensions of TEK?

Our data are a valuable addition to current knowledge, in at least three ways. First, we are able to draw conclusions directly from local knowledge (rather than relying on a priori variables). This approach may be more sensitive to spatial and temporal complexity, because local people are likely to understand processes of TEK change better than the researcher (Bernard 1998). Previously, little quantitative literature has examined perceptions of TEK change. Second, we utilize trend analysis, a participatory technique that allows historical perspective on TEK change without needing longitudinal data (Kumar 2002). Third, we are able to examine local perceptions of TEK change over multiple domains and dimensions, allowing a more holistic assessment of contemporary cultural change. These advantages are important, given that resource management in many areas hinges on at-risk TEK. Indeed, maintaining resource management capacity may require the design of programs for the revitalization of TEK at a local scale (Zent 2001). Such programs, in turn, will require contextual data on the local perceptions, as well as complete local involvement, to be successful (Maffi and Woodley 2010).

MATERIALS AND METHODS

Location and Study Sites

Vanuatu is an ideal place to examine changes in TEK. Cultural knowledge and practice (collectively termed ‘*kastom*’ in Vanuatu; Bolton 2003) form the basis of daily life for many of the 250 000 inhabitants, 80 % of whom live in rural areas (Regenvanu 2005). Vanuatu is extremely culturally diverse, and inhabitants (known as ni-Vanuatu) collectively speak over 100 languages (Lynch and Crowley

2001). Land on the 80 odd islands is predominantly held under customary ownership and is managed using traditional techniques (such as spatial and temporal refugia), founded on TEK of terrestrial and marine environments (Hickey 2006). As such, TEK is critically important throughout Vanuatu: it forms the basis for conservation actions to manage threatened species (e.g., *Trochus niliticus*; Hickey 2006), encapsulates a large body of ethnomedical practice (Bradacs et al. 2011), and provides a basis for social wellbeing (VNSO 2012).

Social change is proceeding at a rapid pace in Vanuatu (Regenvanu 2005). Since the archipelago obtained independence in 1980, rapid urbanization, linguistic attrition, and the influence of the market economy have shifted cultural norms and methods for cultural transmission (McCarter and Gavin 2011). Preceding this, missionary activity from the late 1800s resulted in widespread internal migration between customary lands in the island interior and the mission stations on the coast (MacClancy 2002). In recent years, widespread land alienation threatens links between ni-Vanuatu and their land (Haccius 2011). In other areas of the planet, such dynamics have been noted to drive TEK change, although this has yet to be quantitatively assessed in Vanuatu.

Our research was located on Malekula Island, the second largest in the group (Fig. 1). Malekula is typical of many islands in Vanuatu, and is a large island comprised of rugged and steep hills up to 800 m high (Tacconi and Bennett 1993). Like much of Vanuatu, Malekula has a wet tropical climate with two distinct seasons, and some areas get over 3000 mm of rain a year. Most Malekulans live in rural communities, and practice subsistence horticulture based on the staples of taro (*Colocasia* sp.) and yam (*Dioscorea* sp.). Commercial opportunities on Malekula are rare, and residents gain cash income from the sale of crops such as kava (*Piper methysticum*), cacao (*Theobroma cacao*), and coconut (*Cocos nucifera*), as well as occasional additions such as wage labor on plantations and small-scale fishing enterprises. Formal education has become widespread only relatively recently: although most pupils now progress at least to year ten, until the mid 1960s education was administered by the church system and usually ran to year three only.

We selected three study communities in consultation with the Vanuatu Cultural Centre (VCC; a national organization that regulates and supports cultural research in Vanuatu), so as to represent diverse ecological and geographical environments in which much of the population of Malekula lives. Uripiv is a small and flat island off the mainland, Unmet is located on a productive coastal plain, and Lorlow is coastal and surrounded by steep hills. On Uripiv we sampled within two communities, Jimes and Tevri, and at Unmet within one community, known as Uri.

Fig. 1 **a** Southwest Pacific, with Vanuatu; **b** Vanuatu, with Malekula; **c** Malekula, with study communities

The focus communities are all relatively small (<150 inhabitants), and each speak a different vernacular language. The focus communities have different settlement histories; while Uripiv was settled before missionary contact, Lorlow was established in 1948 for its proximity to a nearby mission station, and Unmet was established in its current form in the early 1970s then the residents of Amokh migrated from in the interior.

Data Collection and Sample

We conducted fieldwork between February and August of 2008 (between the dry and rainy seasons), and interviewed 120 adults using a structured survey (Table 1). Interviews were conducted in Bislama, a neo-Melanesian pidgin and national language. Participant selection was based on snowball sampling (Bernard 1998), and was stratified by age and gender because these variables commonly pattern TEK within communities (Boster 1986). However, there was a clear gender imbalance in our sample in three communities, which we discuss in more depth below.

Before each interview we discussed our understanding of TEK with participants as knowledge, practice and belief associated with the environment (following Berkes 2012, and translated to Bislama with assistance of the Vanuatu Cultural Center, as ‘*kastom save blong envaeromen*’).

We employed a variety of techniques within the structured interview. *To assess perceptions of the timing of changes in TEK*, we used trend analysis (Kumar 2002). Trend analysis is a participatory technique in which participants are asked to describe the level of a given resource (in this case, TEK) at points through history. We used anchor points (Bernard 1998) based on the immediate family of participants, who were asked to rate how much TEK was present at five time periods (when their grandparents were children; when their parents were children; when they were children; now; and their projection for 20 years in future). The time periods were represented by panels, and participants were asked to place dried beans on each panel to indicate how much TEK they perceived to be present. We adjusted for the age of participants and were able to assign a 10-year window within which each panel fell.

Table 1 Participants in structured interview

Community (area)	<i>n</i>	Male	Female	Median age	Range
Jimes (Uripiv)	24	12	12	57.5	20–80
Tevri (Uripiv)	21	15	6	42	18–80
Lorlow (SW Bay)	34	21	13	46.5	18–80
Uri (Unmet)	41	26	15	48	22–90
Total	120	74	46	48	18–90

Because trend analysis deals with memory and perceptions of past events, it is prone to recall bias (Bernard 1998). In this case, we used the technique as a means for spurring discussion of broad trends in TEK, rather than for eliciting precise ‘amounts’ of TEK. In this context, it was a useful way to get a relative, if admittedly imprecise, measure of perceived rates and drivers of TEK change over time. Due to time constraints, trend analysis was not conducted in all interviews (total $n = 57$).

To assess perceptions of the drivers of TEK erosion, we conducted a freelist exercise with all participants (Quinlan 2005). In this technique participants are asked to list everything they can recall within a given domain, giving a rapid assessment of the most salient responses within and between communities (e.g., Quinlan and Quinlan 2007). In this case, participants were asked to ‘list all the drivers of TEK erosion in this community’. Here, ‘drivers’ were broadly defined, and referred to social processes that interviewees perceived to underlie the changes in TEK that they had described.

To address the perceptions of change across domains and dimensions of TEK, all participants were asked to rate change within ten domains of TEK in their community on a five-point Likert scale (from ‘no change’ to ‘gone’). The subject domains represented knowledge, practice and belief, which are three interconnected dimensions of TEK (Berkes 2012). In ‘knowledge’, we asked participants about three aspects of theoretical knowledge of the surrounding flora and fauna. In ‘practice’, we asked about three practical skills that were likely to be still widely used in the community, notably the use of *tabu* (in this context, spatial and temporal restrictions on resource use; Hickey 2006). In ‘belief’, we asked about belief in the ‘devils’ of the bush. These are spirits that formed a critical part of pre-Christian spirituality, and were especially associated with respect of *tabu* and the maintenance of social norms (Hickey 2006). The ten subject domains were derived with assistance from staff at the VCC, and were checked for salience in each community by the VCC fieldworkers (trained volunteer indigenous anthropologists).

Analysis

Data were entered into SPSS 17.0. We utilized non-parametric statistical tests to account for non-normality, including Kruskal–Wallis (between multiple categories), Mann–Whitney *U* (between two categories), and Friedman’s non-parametric ANOVA. The salience of the cited drivers of TEK change was calculated using Smith’s *S* (which takes into account both rank and citation frequency; Smith 1993) in Anthropac 4.0 (Borgatti 1996).

Ethics

We adhered to a strict ethical protocol, in response to a number of concerns surrounding the collection of ethnobiological data (e.g., Agrawal 2002). Our protocol was based on the Code of Ethics of the International Society for Ethnobiology (ISE 2006), and was approved by the Human Ethics Committee at Victoria University and the Vanuatu National Cultural Council. The protocol included a number of clauses to ensure a fair, equitable, and accurate research program, including prior informed consent from all participants. Notably, all ethnomedical data, including species names and uses, are confidential and will not be published in this or other reports.

RESULTS

The vast majority of participants (96 %) perceived that TEK was eroding on Malekula, and that there was less TEK in their community than in the time of their grandparents. Similarly, most participants noted that TEK was not being effectively transmitted within their community, and that children were not acquiring enough TEK (77 and 86 %, respectively). These values did not vary significantly between communities or gender and age groupings.

Trend analysis indicated that participants perceived erosion of TEK to have happened over two major periods (Fig. 2). The first period roughly coincided with the arrival of the missionaries and the geographic shift of the focus

communities to the coast, which participants noted to have been later in Lorlow and Unmet than in Uripiv. In Lorlow and on Uripiv, this decline was arrested between 1970 and 1990, which participants attributed to the independence movement (independence was gained in 1980). The second period is 1990 until the current day, which participants noted had been characterized by increased influence from of formal education for years 1–6, as well as the consolidation of the role of the Presbyterian and Catholic churches in each community. Notably, the erosion of TEK was perceived to have started earlier on Uripiv (where the first missionaries arrived before 1900) than at Unmet (which was established in 1972).

Participants noted several key, interconnected, drivers of TEK erosion (Table 2). Three key drivers were the most commonly cited and salient within the focus communities: the church, formal education system, and intra-community social change (including loss of respect for, and a lack of attention to, *kastom* and traditional knowledge). Generalized ‘western’ influence (usually phrased as ‘whiteman thinking’ by participants), as well as population growth, were also important and salient factors. Ecological change and language shift were mentioned by only a small proportion of participants.

There was some demographic variation in participants’ perceptions of drivers of TEK change. Participants at Unmet were more likely to cite the church as a driver of TEK change than those on Uripiv (Mann–Whitney U tests, $U = 256.0$, $Z = -2.810$, $p < .01$), and were more concerned about generalized western influence than informants

at Lorlow ($U = 353.0$, $Z = -4.517$, $p < .001$). Other community differences were not significant. Younger participants (between 18 and 30 years of age) were less concerned about the influence of the church than older participants (those aged over 60 years; Kruskal–Wallis non-parametric ranking between age cohorts, $\chi^2(2) = 9.22$, $p = .01$; differences confirmed via post hoc Mann–Whitney U tests).

The erosion of TEK was perceived to have taken place to differing degrees in different domains and dimensions of knowledge (Fig. 3). Some domains of knowledge, such as medicinal plant knowledge, were perceived to have only undergone a small amount of change since when the grandparents of interviewees were children. However others, such as belief in the devils of the bush, were perceived to have undergone major changes or to have disappeared altogether. In general, ‘knowledge’ and ‘practice’ dimensions of TEK were perceived to be significantly more intact than those of the ‘worldview’ dimension (Friedman’s non-parametric ANOVA, $\chi^2(2) = 33.91$, $p < .001$; confirmed with post hoc Wilcoxon signed-rank tests).

Participants at Unmet noted that medicinal knowledge and belief in the devils of the bush were more intact than participants at all other study locales (both $p < .01$), though there were no other differences between communities. Older participants (aged 61+ years) perceived a greater degree of change in the ‘practice’ dimension than younger participants (18–59 years; $p < .01$). There was no significant variation in perceived change between dimensions of TEK according to education, gender, or commercial occupation.

Fig. 2 Perceived loss of TEK on Malekula, utilizing trend analysis technique. Dashed line indicates date of study. Y-axis represents number of units placed by participants on time period to represent the amount of TEK at that time. $n = 120$

Table 2 Salience of commonly cited drivers of TEK change on Malekula

Driver	Citation frequency	Average rank	Smith's <i>S</i>
Church	48	1.5	0.35
Formal education	44	1.8	0.29
Internal social change	47	2.0	0.26
'Western' influence	37	1.7	0.25
Population growth	30	1.3	0.24
Market influence	6	1.8	0.04
Language shift	4	2.0	0.03
Ecological change	2	2.0	0.01

DISCUSSION

TEK erosion was perceived to be a past and current reality by the vast majority of participants, thus corroborating the fears of authors from Vanuatu (e.g., Hickey 2006), the Pacific (e.g., Case et al. 2005; Brosi et al. 2007), and around the world (e.g., Voeks and Leony 2004; Quinlan and Quinlan 2007). Participants noted that traditional knowledge and practice—or *kastom*—now play a reduced role in everyday contemporary life, driven by a variety of factors that are nested at local, national, and international scales.

The historical perspective offered by the trend analysis exercise provides a useful starting point for understanding TEK change. Participants noted that the first major period of change coincided with the arrival of the missionaries. The perceived erosion of TEK in this period may have been

driven by a number of factors, including the widespread depopulation caused by disease (estimated at 90 % in some areas of Vanuatu, and recalled on Malekula in Deacon 1934); the changes in cosmology brought with Christianity, which some commentators claim was accompanied by 'psychological warfare' to persuade local inhabitants to abandon traditional practices (Regenvanu 2005); and, in Unmet and Lorlow, the geographic shift of communities to the coast. In the latter case, the influence of the different environmental conditions on the coast is likely to be important: cultural transmission of TEK is tightly linked to the ecological knowledge in which it is generated, and significant changing in the surroundings would be likely to have spurred the rapid adaptation of knowledge systems (Greenfield et al. 2000).

Interestingly, participants at Lorlow and Uripiv noted a brief period around 1980 when TEK erosion slowed. This period coincided with the independence of Vanuatu from France and Britain, spurred by a nationalist movement whose rhetoric centered on the importance of *kastom* and tradition (Tonkinson 1982). This soon ended, however, and participants noted a major new period of TEK loss from 1990 to the present day.

The spread of formal education at a primary school level (years 1–6) was perceived to be a key driver during this period, corroborating the findings of quantitative ethnobiological work in other areas of the world (e.g., Quinlan and Quinlan 2007). Such studies note that formal schooling can introduce competing knowledge systems, disrupt traditional systems of knowledge transmission, and interrupt acquisition of experiential and tacit environmental knowledge (Zent and Maffi

Fig. 3 Perceived changes across domains and dimensions of TEK for all age classes. Note that five-point likert scale collapsed here to three. *White bars* indicate no change (1 on likert scale); *gray* indicate some change (2–4 on likert scale); *black* indicate complete change (5 on likert scale)

2009). In Vanuatu, a number of characteristics of the formal education system—most notably, the lack of recognition of vernacular languages—have been alleged to foster the attrition of traditional knowledge (Niroa 2004). These findings add weight to calls for the contextualization and re-direction of Vanuatu's education system, a process that has begun through work by the VCC (Baeraleo 2010) and an ongoing review of the national curriculum (Vanuatu Ministry of Education 2010). Moves to integrate TEK and formal schooling may provide several opportunities for the revitalization of TEK, however, a number of challenges (e.g., lack of teacher time, epistemological differences) will need to be overcome for it to be successful (McCarter and Gavin 2011).

Participants also emphasized the influence of internal social change in the focus communities. There were typically two aspects to this. First, participants were concerned by the loss of 'respect' within the younger generations, both to the natural environment and to other members of the community. Second, interviewees noted that the attrition of TEK and other *kastom* had only happened because of the inattention by the community at large, and that a lack of awareness and appreciation for the value of traditional knowledge and practice was only developing in hindsight. Of course, the drivers discussed by participants are interlinked and are both proximate and ultimate factors in TEK erosion. For example, the social changes described by interviewees may be the result of more widespread formal education. Nevertheless, participants who noted this driver of TEK change emphasized that the *responsibility* for the erosion of TEK lay within the community; and, by implication, that efforts to address TEK erosion would require internally driven efforts.

These data emphasize the importance of broadening the range of explanatory variables that are used to model TEK variation. Very few quantitative studies have considered religious affiliation or integration as a factor in TEK variation (cf., Voeks and Leony 2004), and we are aware of none that measure intra-community factors (such as individual attitudes toward TEK) in relation to variation of ethnobiological knowledge. In particular, this finding highlights that erosion of TEK is not a process driven entirely by outside actors and influences; rather, that erosion of TEK may represent active choices and changing values amongst younger community members (Zent and Maffi 2009). Future studies should explicitly measure both the influence of the church and of individual level attitudes and behaviors on the variation and erosion of TEK.

These findings also stress the complexity of TEK change across space and time and (Zent and Maffi 2009). Participants emphasized two major facets to this. First, interviewees perceived that the drivers of TEK change themselves shift over time. In this regard, the significant differences between old and young participants in their emphasis on the role of the church are telling. Particularly

at Unmet, older participants would have seen the church arrive and would have first hand experience of the conversion process. None of the younger generation (<30 years) would have this experience, and the church is now a fundamental and embedded pillar of daily life in all the study communities. As such, the younger participants may have focused more on comparatively recent sources of 'outside' influence, particularly formal schooling.

Second, TEK erosion was perceived to have occurred differently across different domains. For example, the beliefs and spirituality that formerly underpinned empirical knowledge on Malekula were perceived to have largely disappeared by a large proportion of respondents. Because TEK is a nested body of knowledge, practice and belief (cf., Berkes 2012), this is likely to have changed the nature of the knowledge itself. However, medicinal plant knowledge was perceived to have remained relatively constant over time, reflecting the relative ubiquity of ethnomedical knowledge in the focus communities and across Vanuatu (cf., Bradacs et al. 2011). This corroborates evidence suggesting that ethnomedical knowledge often remains highly salient in rural communities, even amid widespread social and ecological change (Zarger and Stepp 2004). It is worth noting that these findings also varied spatially: participants at Unmet perceived that the medicinal and belief dimensions of TEK had changed less over time than in other communities. This may reflect the relatively recent history of conversion and settlement establishment at Unmet (the village was established in the early 1970s), and speaks to the need to consider spatial complexity in future analyses of TEK change.

Future work could improve on our study in a number of ways. For one, we surveyed more men than women, which may have resulted in a gender bias in our data. In our case, this bias was a relic of the snowball sampling method (which favors the social networks of the original informants, who were male) and the fact that women were often uncomfortable with the interview process (as has been noted in other work in Melanesia, cf., Case et al. 2005). While this is potentially significant because TEK is always gendered (Pfeiffer and Butz 2005), we were able to detect no differences between the perceptions of men and women, and were not attempting to empirically describe TEK. Undoubtedly, however, efforts to resolve this bias (e.g., by working with local female research assistants) would strengthen future work. Second, future work should expect emergent drivers of change, in addition to those suggested here. In particular, it is interesting that language shift was not a salient driver for most participants. Language loss, both globally (Nettle and Romaine 2000) and in Vanuatu (Vari-Bogiri 2005), is likely to be a critical threat to TEK in future, as vernacular languages are a key vehicle for TEK transmission. Future research that seeks to evaluate the relationship of linguistic loss to the transmission and acquisition of TEK will be a valuable addition to the literature.

CONCLUSION

This study presents local perceptions of TEK erosion from Malekula Island, Vanuatu. Given the importance of TEK to resource management, both globally and within Vanuatu, these data offer critical clues to how we might proceed with efforts to maintain and revitalize TEK. These data indicate three key lessons for future work in the area.

First, TEK change and erosion is complex, and the adaptation of knowledge systems to changing social and ecological environments has different impacts on the various domains and dimensions of TEK. As such, spatial and temporal complexity should be integrated into the design of studies aimed at examining these trends. Second, quantitative studies of TEK change should seek to understand and account for locally relevant factors in the erosion of TEK, rather than exclusively drawing on etic, a priori variables. In this case, models that seek to understand TEK changes on Malekula would need to consider participant religion, as well as attitudes and norms toward *kastom* and traditional knowledge, in order to accurately explain variation in the data. More broadly, participatory methods such as trend analysis may be an appropriate means of assessing change in TEK over time when longitudinal data are not available (Godoy et al. 2009). Third, practice and policy aimed at maintaining TEK on Malekula must focus on examining the impact of formal education and the church, and facilitating their considerable leverage within the communities for the revitalization of TEK. Moreover, the importance of intra-community factors emphasizes that TEK maintenance is only likely to succeed if genuinely driven from within the community. TEK is critical to natural resource governance the world over, and further investigation into the conditions that are likely to hinder or promote the maintenance of TEK will be a productive area for future research.

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REFERENCES

- Agrawal, A. 2002. Indigenous knowledge and the politics of classification. *International Social Science Journal* 54: 287–298.
- Baeraleo, S. 2010. *Teaching indigenous knowledge and resource management in the primary school*. Port Vila: The Vanuatu National Cultural Council.
- Berkes, F. 2012. *Sacred ecology: Traditional ecological knowledge and resource management*, 3rd ed. London: Taylor and Francis.
- Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10: 1251–1262.
- Bernard, H.R. 1998. *Handbook of methods in cultural anthropology*. Walnut Creek: AltaMira Press.
- Bolton, L. 2003. *Unfolding the Moon: Enacting Women's Kastom in Vanuatu*. Honolulu: University of Hawaii Press.
- Borgatti, S. 1996. *Anthropac 4*. Natick: Analytic Technologies.
- Boster, J. 1986. Exchange of varieties and information between Aguaruna Manioc cultivators. *American Anthropologist* 88: 429–436.
- Bradacs, G., J. Heilmann, and C. Weckerle. 2011. Medicinal plant use in Vanuatu: A comparative ethnobotanical study of three islands. *Journal of Ethnopharmacology* 137: 434–448.
- Brosi, B., M. Balick, R. Wolkow, R. Lee, M. Kostka, W. Raynor, R. Gallen, A. Raynor, et al. 2007. Cultural erosion and biodiversity: Canoe-making knowledge in Pohnpei, Micronesia. *Conservation Biology* 21: 875–879.
- Case, R.J., G.E. Pauli, and D. Soejarto. 2005. Factors in maintaining indigenous knowledge among ethnic communities of Manus Island. *Economic Botany* 59: 356–365.
- Deacon, A.B. 1934. *Malekula: A vanishing people in the New Hebrides*. London: George Routledge.
- Ford, J., and D. Martinez. 2000. Traditional ecological knowledge, ecosystem science, and environmental management. *Ecological Applications* 10: 1249–1250.
- Godoy, R., N. Brokaw, D. Wilkie, D. Colon, A. Palermo, S. Lye, S. Sei, et al. 1998. Of trade and cognition: Markets and the loss of folk knowledge among the Tawahka Indians of the Honduran Rainforest. *Journal of Anthropological Research* 54: 219–234.
- Godoy, R., V. Reyes-Garcia, J. Broesch, I. Fitzpatrick, P. Giovanninni, M. Rodriguez, T. Huanca, et al. 2009. Long-term (secular) change of ethnobotanical knowledge of useful plants: Separating cohort and age effects. *Journal of Anthropological Research* 65: 51–67.
- Greenfield, P.M., A.E. Maynard, and C.P. Childs. 2000. History, culture, learning, and development. *Cross-Cultural Research* 34: 351–374.
- Haccius, J. 2011. *The interaction of modern and custom land tenure systems in Vanuatu. State, society and governance in Melanesia: Discussion Paper 2011/1*. Canberra: ANU School of International, Political, and Strategic Studies.
- Hickey, F.R. 2006. Traditional marine resource management in Vanuatu: Acknowledging, supporting and strengthening indigenous management systems. *SPC Traditional Marine Resource Management* 11–23. <http://www.sprep.org/att/irc/ecopies/countries/vanuatu/92.pdf>.
- International Society of Ethnobiology. 2006. ISE Code of Ethics (with 2008 Additions). <http://ethnobiology.net/code-of-ethics/code-in-english/>.
- Johannes, R. 1998. The case for data-less marine resource management: Examples from tropical nearshore finfisheries. *Trends in Ecology & Evolution* 13: 243–246.
- Kumar, S. 2002. *Methods for community participation: A complete guide for practitioners*. Warwickshire: Intermediate Technology Publications Ltd.
- Lynch, J., and T. Crowley. 2001. *Languages of Vanuatu*. Canberra: Pacific Linguists.
- MacClancy, J. 2002. *To kill a bird with two stones*. Port Vila: Vanuatu Cultural Centre.
- Maffi, L., and E. Woodley. 2010. *Biocultural diversity conservation: A global sourcebook*. London: Earthscan.
- McCarter, J., and M.C. Gavin. 2011. Perceptions of the value of traditional ecological knowledge to formal school curricula: Opportunities and challenges from Malekula Island, Vanuatu. *Journal of Ethnobiology and Ethnomedicine* 7: 38.

- Nettle, D., and S. Romaine. 2000. *Vanishing voices: The extinction of the world's languages*. Oxford: Oxford University Press.
- Niroa, J. 2004. Why we need to re-think Vanuatu education. In *Re-thinking Vanuatu education together*, ed. K. Sanga, J. Niroa, K. Matai, and L. Crowl. Port Vila: University of the South Pacific.
- Pfeiffer, J.M., and R.J. Butz. 2005. Assessing cultural and ecological variation in ethnobiological research: The importance of gender. *Journal of Ethnobiology* 25: 240–278.
- Quinlan, M. 2005. Considerations for collecting freelists in the field: Examples from ethnobotany. *Field Methods* 17: 219–237.
- Quinlan, M., and R. Quinlan. 2007. Modernization and medicinal plant knowledge in a Caribbean horticultural village. *Medicinal Anthropology Quarterly* 21: 169–192.
- Regenvanu, R. 2005. The changing face of 'Custom' in Vanuatu. *People and Culture in Oceania* 20.
- Reyes-Garcia, V., V. Vadez, E. Byron, L. Apaza, W. Leonard, E. Perez, and D. Wilkie. 2005. Market economy and the loss of folk knowledge of plant uses: Estimates from the Tsimane' of the Bolivian Amazon. *Current Anthropology* 46: 651–656.
- Reyes-Garcia, V., N. Marti, T. McDade, S. Tanner, V. Vadez, and N. Marti. 2007. Concepts and methods in studies measuring individual ethnobotanical knowledge. *Journal of Ethnobiology* 27: 182–203.
- Singh, R.K., J. Pretty, and S. Pilgrim. 2010. Traditional knowledge and biocultural diversity: Learning from tribal communities for sustainable development in Northeast India. *Journal of Environmental Planning and Management* 53: 511–533.
- Smith, J. 1993. Using ANTHROPAC 3.5 and a Spreadsheet to Compute a Freelist Salience Index. *Cultural Anthropology Methods Letter* 5: 1–3.
- Tacconi, L., and J. Bennett. 1993. *The forests of Vanuatu: An overview of their environmental and economic status*. Sydney: Vanuatu Forest Conservation Research Reports: University of New South Wales.
- Tonkinson, R. 1982. National identity and the problem of Kastom in Vanuatu. *Mankind* 13: 306–315.
- Vanuatu Ministry of Education. 2010. *Vanuatu National Curriculum Statement (Edited Draft)*. Port Vila: Ministry of Education.
- Vari-Bogiri, H. 2005. A sociolinguistic survey of Araki: A dying language in Vanuatu. *Journal of Multilingual Multicultural Development* 26: 52–66.
- VNSO (Vanuatu National Statistics Office). 2012. *Alternative indicators of well-being for Melanesia: Vanuatu Pilot Study Report*. Port Vila, Vanuatu: Malvatumauri National Council of Chiefs.
- Voeks, R.A., and A. Leony. 2004. Forgetting the forest: Assessing medicinal plant erosion in Eastern Brazil. *Economic Botany* 58: S294–S306.
- Zarger, R.K., and J.R. Stepp. 2004. Persistence of botanical knowledge among Tzeltal Maya Children. *Current Anthropology* 45: 413–418.
- Zent, S. 2001. Acculturation and ethnobotanical knowledge loss among the Piaroa of Venezuela: Demonstration of a quantitative method for the empirical study of TEK change. In *On biocultural diversity: Linking language, knowledge, and the environment*, ed. L. Maffi. Washington: Smithsonian Institution Press.
- Zent, S., and L. Maffi. 2009. Final Report on Indicator No. 2: Methodology for developing a vitality index of traditional environmental knowledge (VITEK) for the project "Global Indicators of the Status and Trends of Linguistic Diversity and Traditional Knowledge", Terralingua. Retrieved 3 March, 2009, from http://terralingua.org/projects/vitek/VITEK_Report.pdf.

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