Local knowledge and ecosystem service management: opportunities and challenges

Introduction

Over the past 50 years the ecosystems on which we rely have been rapidly altered directly and indirectly by human action (MEA, 2005). Although these changes have led to unprecedented gains in human welfare, namely through increased food, fuel and fibre production, these gains have come at an ecological cost. Approximately 60% (15 out of 24) of the ecosystem services assessed under the Millennium Ecosystem Assessment (2005) are being degraded or used unsustainably. Considered and effective management is needed to address the inherent trade-offs between meeting current human needs and maintaining the capacity of ecosystems to provide services for future generations (Foley et al., 2005; Turner and Daily, 2008). However, for many ecosystem services scientific data is limited and alternative sources of information need to be considered when making management decisions (Berkes, 1999).

In recent decades, local ecological knowledge has received increasing interest for its potential use as an alternative source of information in the management and conservation of natural resources (Berkes et al., 2000). Local knowledge can be used to improve the management of ecosystems through validating or correcting established assumptions, guiding scientific enquiry and empowering local resource users. However, local knowledge is not inherently valuable to natural resource management and the methods employed by researchers will greatly affect its reliability. Drawing on a number of examples from relevant literature, the following essay discusses the opportunities and challenges of integrating local knowledge into the management of ecosystem services.

What is local ecological knowledge?

There is no universally recognized definition of local ecological knowledge (LEK). This is partly due to its complex nature and diverse range of application (Brook and McLachlan, 2008). For the purposes of this essay the term LEK is defined as the "knowledge held by a specific group of people about their local ecosystems" (Olsson and Folke, 2001:87). It is site specific and may be a combination of practical and scientific knowledge and often includes a component of belief (Olsson and Folke, 2001). Opposed to Traditional Ecological Knowledge

(TEK), LEK is concerned with the current knowledge a group of people possess, be it transmitted through generations or more recently acquired (Berkes, 1999).

Opportunities

The discourse surrounding local knowledge has been one of contention and shifting ideologies. Once considered primitive and a hindrance to development, local knowledge has recently received increasing interest for its potential use in natural resource management (Berkes et al., 2000). Local knowledge and scientific knowledge have largely been viewed in opposition, with one being seen as preferential to the other (Agrawal, 1995; Nygren, 1999; Davis and Ruddle, 2010). This polarized narrative has arguably overlooked the hybrid nature of LEK and opportunities for complementarity between the two. The following examples illustrate how LEK can be used to validate or correct scientific knowledge, progress ecological monitoring and evaluation in data-sparse environments, and improve the management of natural resources through relevant research and local empowerment.

Improving ecological monitoring and assessment

Through living in close association with their environment, local resource users may detect changes in the size and/or distribution of their natural resources that would otherwise go undetected by modern scientific research. Inuit, the indigenous people of Arctic Canada and Greenland, for example, have repeatedly shown extensive knowledge of the seasonal and spatial distribution of their natural resources. In the mid 1990s Inuit from the community of Sanikiuaq reported a regional decline in the population of Common Eider (*Somateria mollissima sedentaria*), a large marine duck harvested for its down (Gilchrist et al., 2005). Subsequent biological surveys confirmed the eider population had indeed declined by 75% since the late 1980s (Robertson and Gilchrist 1998). In addition to identifying a population decline that would have otherwise gone undetected, local Inuit recognised the decline had been caused by extensive sea ice restricting feeding sites in the winter of 1991, and helped identify the most important areas for overwintering eider; locations that have since become formally protected and incorporated into management plans (Mallory and Fontaine, 2004).

Incorporating LEK may present opportunities to improve current biological survey methods. In the late 70s, scientific surveys indicated the Alaskan bowhead whale (*Balaena mysticetus*) population had been severely depleted and that hunting by local whalers was impeding recovery (Freeman, 1989). State managers had estimated the bowhead whale population to be between 600 and 1200 individuals and called for a subsequent whaling ban (Johannes et al., 2000). Local Inuit hunters disputed the validity of the state's findings, claiming the bowhead population to be in the order of 7000 (Freeman, 1989). While the researchers had assumed the whales only migrated in open waters, the hunters argued they were capable of travelling large distances under ice and that the visual observations undertaken had been inadequate (Johannes et al., 2000). Following these criticisms, an alternative survey technique which incorporated Inuit knowledge was developed, and later verified that the bowhead population had been grossly underestimated by previous survey approaches that did not incorporate LEK (Freeman 1989)

Identifying causation

Knowledge of causation is of particular use in natural resource management; knowing the contributing factors to ecosystem degradation can help to identify appropriate solutions and prevent further decline. In the field of environmental change, ecologists are beginning to recognise the potential of local knowledge in explaining why environmental changes have occurred, especially when historical data is limited (Bart, 2006; Kovacs, 2000). Compared to researchers, who often only observe changes after they occur, local people are well positioned to directly observe environmental changes and their underlying causes (Kovacs, 2000).

Recent studies of common reed (*Phragmites australis*) invasions of salt marshes provide an example of how LEK can contribute to the study of environmental change. Through altering nutrient cycling, hydrological regimes, and species composition, *Phragmites* has long been a threat to North American wetland ecosystems and the services they provide (Chambers et al., 1999). Its aggressive spread however remained unexplained (Chambers et al., 1999).

In order to determine the causes of *Phragmites* invasions of US salt marshes, Bart (2006) conducted repeated interviews with farmers who harvest hay from salt-marsh vegetation in New Jersey, US. Farmers stated that the invasion had started in the early 50s following a hurricane that had flooded their fields and washed in *Phragmites* rhizome fragments. In order to protect their fields from further flooding farmers constructed dykes and ditches, unintentionally burying these fragments. Although the farmers had noted the presence of *Phragmites* seeds before the hurricane, establishment only occurred after the hurricane, suggesting rhizome dispersal and burial was to blame. The farmers' observations informed experimental studies which showed *Phragmites* seedlings to experience 100% mortality under the conditions described following the hurricane, confirming rhizome dispersal and burial were necessary for *Phragmites* establishment (Bart, 2003).

Making research relevant

In order for research and development to serve local needs, an understanding of what local people already know, and where their knowledge is limited, is needed. Through experiences, observation and informal experimentation within their environment, local resource users may develop detailed explanatory knowledge of the mechanisms and processes behind environmental phenomena (Sinclair and Walker, 1999). However the possession of certain knowledge may not be evident from observable practices, it is therefore important not to infer what people know from what they do (Sinclair and Joshi, 2000). The formal study of LEK can be used to help determine the extent of people's knowledge.

One such case is that of farmers in the eastern mid-hills of Nepal who base management decisions on a sophisticated understanding of the nutritive value of fodder trees and their effect on soil erosion (Thapa, 1994). In their study of farmers' ecological knowledge, Thapa (1994) found Nepali farmers to have a common understanding of how leaf size determines a trees effect on splash erosion – an effect locally termed *tapkan* and unrecognised by researchers until the early 90s (Hall and Calder, 1993). *Ficus roxburghii* for example was identified as having large leaves and thus a negative *tapkan* effect (Sinclair and Joshi, 2000). Farmers, although aware of this detrimental *tapkan* effect, still chose to grow this tree due to its high fodder value (Thapa et al., 1995).

Before the formal study of their local knowledge, the farmers understanding of *tapkan* had been overlooked by research and extension agents (Sinclair and Joshi, 2000). Once aware of the farmers' knowledge and interest in minimising trade-offs between *tapkan* and fodder production, researchers were able to tailor their research to build on what farmers already knew and their priorities for improving current farming systems (Sinclair and Walker, 1999). The study also meant researchers and extension workers knew the local terminology to effectively communicate their research to farmers (Sinclair and Joshi, 2000).

Empowering local people

A central objective of most LEK research is to empower local people through their inclusion in natural resource management and policy (Davis and Ruddle, 2010). The potential to empower local people through the systematic collection and validation of their LEK is powerfully illustrated by Ruddle (1995) in their depiction of the New Zealand Maori and the return of their traditional fishing rights. Despite being guaranteed under the Treaty of Waitangi 1840, Maori fishing rights had been eroded by subsequent government legislation.

Many Maori fishers were excluded from allocated fishing quotas based on false perceptions that Maori fishing was limited to a few species, confined to inshore locations and largely for subsistence. During a formal tribunal, the systematic collection and validation of Maori ecological knowledge provided persuasive evidence for the return of their traditional fishing rights. Maori fishers showed profound knowledge of their marine resources and were able to name over 94 marine fish species and accurately locate marine fishing grounds that were later verified by historical records and fisheries experts.

The valorization of local knowledge may also encourage environmental stewardship among local communities as illustrated by previous research on the declining bonefish (*Albula glossodonta*) population of Tarawa, an atoll in the small Pacific island nation of Kiribati. The reef and lagoon fisheries of Tarawa depend heavily on bonefish, which spawn in the lagoonal areas of the atoll (Johannes et al., 2000). To gain information on bonefish migration, Johannes and Yeeting (2000) conducted interviews with the local fishers of Tarawa. Despite the number of bonefish having remained high enough to supply 20% of the shallow water fish consumed by the inhabitance of the atoll, Johannes and Yeeting (2000) discovered the population was maintained by only one remaining spawning run and at increasing risk of collapse. Following the collection and reporting of their local knowledge, villagers of Tarawa have taken action to protect their remaining bonefish spawning run with no official sanction or intervention by the Kiribati Fisheries Department (Johannes et al., 2000).

Challenges

As evident from the previously described examples, local knowledge can be a useful resource in the management of ecosystems and their services. However local knowledge is not of inherent value. In some cases local knowledge may prove to be inaccurate and contradictory to what has been shown to be true by scientific approaches. Equally the methods employed by researchers to elicit, analyze and interpret local knowledge will greatly affect its reliability and utility. The following examples illustrate the potential limitations of LEK and the methodological challenges in its collection, analysis and interpretation.

Observability

Local ecological knowledge is largely constrained by the ability of resource users to make observations. Processes that occur at very small scales, invisible to the naked eye, are likely to remain unobserved by those without access to specialised equipment (Bentley, 1989).

Equally, in order to be realised, some processes may require observations over long periods of time or at larger scales than feasibly possible for many resource users (Chalmers and Fabricius, 2007). For example, although the Nepali farmers could identify and describe the mechanisms by which six tree-attributes contributed to the effect of *tapkan,* they showed comparatively little knowledge of belowground tree-crop interactions (Thapa, 1999). This is arguably due to the farmers' knowledge being physically constrained by their inability to observe belowground processes (Sinclair and Walker, 1999). In the case of the Inuit community of Sanikiuaq, although they knew extensive sea ice had limited eider feeding sites the cause of the severe winter, a volcanic eruption in the southern hemisphere, was understandably unknown to them (Gilchrist et al., 2005).

Likewise, local people may present multiple plausible explanations for past environmental change, making it difficult to determine from LEK alone which, if any, caused the observed change. For example, although the farmers of New Jersey correctly identified rhizome dispersal and burial as causes for *Phragmites* establishment, they also presented a number of additional hypotheses that were not validated by experimental studies (Bart, 2006). For instance, they claimed removal of vegetation following the hurricane had removed any plant competition. Experimental results however suggest reduced competition is not required for rhizome establishment (Bart, 2003). While useful in improving explanations of environmental change LEK is likely to be insufficient to determine causation on its own.

Reliability

Although local resource users may often detect ecological changes in data-sparse environments and show detailed explanatory knowledge, this may not always be the case. For example, the hunters of Upernavik in Greenland recognized the population of Thick-billed Murre (*Uria lomvia*), a locally hunted seabird, had declined (Gilchrist et al., 2005). When interviewed 80% of the hunters suggested the murre population had not declined *per se*, but had moved elsewhere due to disturbances from hunting activities (Gilchrist et al., 2005). However boat and aerial surveys confirmed no new colonies had been established within the region (Boertmann et al. 1996).

Collected LEK may also present contradictions and lack consensus among informants. For instance, following Inuit reported concern of declining Ivory Gull (*Pagophila eburnea*) populations; interviews were conducted with 12 hunters to assess their LEK of the gull (Mallory et al., 2003). The results showed opinions of both abundance and distribution varied greatly among the hunters, providing little information on which to base management decisions (Gilchrist et al., 2005). Drawing on these two previous examples, Gilchrist et al. (2005) therefore call for caution when basing resource management decisions purely on LEK.

As reflected by the lack of consensus in the Ivory Gull case, local knowledge is heterogeneous in nature. It cannot be assumed that all persons in a given community possess the same level of knowledge. A fundamental challenge in LEK research is selecting key informants from which to elicit reliable knowledge (Davis and Wagner, 2003). Similarly, if LEK is to be used in ecosystem management, it is not only necessary to assess its validity, but to determine how wide and evenly knowledge is distributed (Davis and Wagner, 2003; Chalmers and Fabricius, 2007).

The importance of selecting local experts can be illustrated by Johannes and Yeeting's study of LEK on bonefish in Tarawa (Johannes and Yeeting, 2000). Despite having carried out interviews with a larger number of fishers than Johannes and Yeeting's study, the Fisheries Department were unaware of the bonefish population's reliance on a single spawning run (Johannes et al., 2000). Johannes et al. (2000) believe this was due to their use of randomly selected participants and the young age of the majority of local fishers. The most knowledgeable fishers however were the oldest, many of whom had since retired, and were therefore overlooked by the Fisheries Department's study (Johannes et al., 2000).

Methods for eliciting local knowledge commonly use some form of interview. Like all interview-based research, knowledge gained is subject to both the interviewer and interviewee bias. People's responses can be influenced by many factors including the social context of the interview, levels of familiarity and trust, and how interview questions are asked; even the personality and gender of the interviewer can affect a participant's response (Patton, 2002; Shank, 2002). To ensure the credibility of LEK collected great care must be taken to reduce interviewer bias.

Academic integrity

As the collection of local knowledge has increased so has concern over its misuse by researchers (Nadasdy, 1999). Examples include failure of LEK research to directly benefit participating communities (Nadasdy, 1999). In extreme cases local people may become victims of "biopiracy" (Shiva, 1997). Brook and McLachlan (2005:3) state "[a] primary goal of any study that involves the application or collection of LEK should thus be to empower communities to contribute in meaningful ways and ensure the studies are of local benefit". Given these explicit intentions, it is indisputable that local knowledge should be systematically and robustly collected, analysed and interpreted (Agrawal, 1995). However, a number of academics have voiced concerns over the methodologies employed by researchers in their collection and analysis of LEK (Brook and McLachlan, 2008; Davis and Ruddle, 2010). In their examination of the most cited LEK research articles, David and Ruddle (2010) found the majority fail to adequately describe and discuss research design and methodology, calling into question the reliability of their results.

A common criticism of local knowledge research is of the romanticism held by its advocates who portray local knowledge as intrinsically wise and even sacred (Agrawal, 1995; Nygren, 1999; Davis and Ruddle, 2010). Such views have arguably hampered progress in local knowledge research where attempts to examine the validity of LEK are accused of being disrespectful and even racist (Gilchrist et al, 2005; Krech, 2007; Davis and Ruddle, 2010). As with all forms of knowledge, claims of fact should be open to rigours scrutiny no matter how ‘sacred’ they are, LEK is no exception.

Conclusion

As we continue to rapidly alter the ecosystems on which we depend, it is increasingly recognized that the formal study of LEK can provide valuable information for the effective management of ecosystem services and even encourage environmental stewardship among resource users. However, if LEK research is to contribute meaningfully to the progression of our understanding and truly empower local people it must be conducted honestly and transparently, employing rigorous and robust methodologies. It must also be recognised that LEK has its limitations and that scientific approaches will likely be needed to verify and validate LEK claims on which management decisions are to be based.

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