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Integrating local and scientific knowledge for environmental management

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ABSTRACT

This paper evaluates the processes and mechanisms available for integrating different types of knowledge for environmental management. Following a review of the challenges associated with knowledge integration, we present a series of questions for identifying, engaging, evaluating and applying different knowledges during project design and delivery. These questions are used as a basis to compare three environmental management projects that aimed to integrate knowledge from different sources in the United Kingdom, Solomon Islands and Australia. Comparative results indicate that integrating different types of knowledge is inherently complex – classification of knowledge is arbitrary and knowledge integration perspectives are qualitatively very different. We argue that there is no single optimum approach for integrating local and scientific knowledge and encourage a shift in science from the development of knowledge integration products to the development of problem-focussed, knowledge integration processes. These processes need to be systematic, reflexive and cyclic so that multiple views and multiple methods are considered in relation to an environmental management problem. The results have implications for the way in which researchers and environmental managers undertake and evaluate knowledge integration projects.

1. Introduction

To manage the scope, complexity and uncertainty of global environmental problems, it is important to take account of different types and sources of knowledge (Olsson and Folke, 2001; Cash et al., 2003; Reid et al., 2006; Fabricius et al., 2006). Some scientists interested in the interface between social and ecological systems argue that western paradigms and systems of knowledge are currently not able to deal with the full complexity of environmental management (Johannes, 1998; Ludwig et al., 2001), nor sufficiently able to integrate local stakeholder perspectives in the development of environmental management strategies (Olsson and Folke, 2001). The current challenge for researchers is to develop 'user-inspired' and 'user-useful' management approaches whereby local knowledge is considered alongside scientific knowledge (Pullin and Knight, 2001; Reed et al., 2007; Reed 2008; Cowling et al., 2008).

In response to these challenges, there has been a considerable shift in approaches to environmental management, moving from management informed by reductionist ideas (e.g., the modeling of single species) to a post-normal science associated with the erosion of boundaries between different forms of knowledge and rationality (Scoones, 1999; Nowotny et al., 2001) and the coupling of social and ecological systems (Berkes, 2004; Folke et al., 2005). This view is reflected in the approaches of adaptive co-management (Folke et al., 2005; Armitage et al., 2007, 2008, 2009; Berkes, 2009), trans-disciplinary planning (Tress et al., 2006), community-based natural resource management (e.g., Kellert et al., 2000; Blaikie, 2006; Robinson, 2006a,b), transitions management (e.g., Geels, 2002, 2005); sustainability science (e.g., Kates et al., 2001; Clark and Dickson, 2003) and sustainability education (Fazey, in press). Such approaches share a number of similar principles. They:

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1) Recognise the need to integrate knowledge held by academic researchers (often across traditional academic disciplinary boundaries) and non-academic participants, such as land managers and the public;
2) Highlight the need to build on different (and sometimes disparate) knowledges to address a research or applied question by developing shared theory, methods and new knowledge to promote common understanding of environmental management problems;
3) Often utilise participatory research methods and seek to facilitate participatory, multi-level governance processes to both enhance the validity of knowledge elicited in research and to increase inclusiveness of stakeholders in decision-making;
4) Follow iterative processes of knowledge creation, application, reflection, learning and feedback to science or decision-making; and
5) Attempt to integrate knowledge across a variety of spatial and temporal scales.

Despite this shift in thinking, little attention has been paid to how different ontological perspectives (views about the definition and classes of entities) and philosophical or epistemological perspectives (a set of values concerning truth and validity) influence the integration of different types of knowledge for environmental management. Often knowledge integration studies are undertaken with little consideration of what forms of knowing are being used and privileged, and how the epistemological beliefs (beliefs about the nature of knowledge or how individuals come to know something) of researchers constrain or support the engagement of multiple interest groups within environmental planning and management. This tension is reflected in the multiple and often overlapping ways of categorising 'knowledge', the variety of approaches and methods used to integrate knowledges, and ongoing debates about the relative merits of engaging citizens in science (see Agrawal, 1995, 2002; Sillitoe, 1998; Nygren, 1999; Bruckmeier and Tovey, 2008, 2009 for critiques). For example, Huntington et al. (2002) explored the role of workshops in overcoming divisions between participants holding local and scientific knowledge, which highlights the importance of further research into the role of deliberate and facilitative methods for integrating multiple knowledge types.

In this paper, we develop and apply a conceptual framework (also referred to as a process) which may assist project teams to consider and address the challenges associated with integrating different types of knowledge for environmental management. Firstly, we discuss the ontological, epistemological and applied challenges associated with integrating different types of knowledge and then outline four factors and seven questions that should be considered by project teams. We then use this framework to compare three knowledge integration case studies: the United Kingdom Rural Economy and Land Use (RELU) funded Sustainable Uplands Project, the Solomon Islands Livelihoods and Change project and the Otways Region (Victoria, Australia) social values mapping project.

2. The challenges of integrating local and scientific knowledge

There are many different perspectives of what constitutes knowledge or how someone comes to know something. This creates confusion and misunderstanding when attempting to integrate different forms of knowledge. This section therefore reviews: (1) the different ways knowledge has been categorised (ontological challenges to integration); (2) the ways in which different philosophical or epistemological perspectives held by researchers affect knowledge integration (epistemological challenges); and (3) the difficulties of applying integrated knowledge for environmental management (application challenges).

2.1. Different ways knowledge has been categorised (ontological challenges)

Many different forms of knowledge are discussed in the environmental management literature (Table 1). These range from those of a more personal nature, such as personal, lay, tacit or implicit knowledge (Polanyi, 1958, 1997; Fazey et al., 2005, 2006a, b), to those that are embedded in and interact with traditional cultural rules and norms (Berkes, 1993; Healey, 1993; Becker and Ghimire, 2003). Knowledge may also be generated through more formalised processes such as through research and/or applying scientific methods (Gunderson et al., 1995; Turnbull, 1997; Pullin and Knight, 2001; Fazey et al., 2004). Water management is a good case for the comparison of knowledge types. Environmental managers may have implicit or deeper tacit knowledge about the flooding and drying cycles of a wetland but may either have not yet articulated this knowledge or may have found it difficult to explicitly explain why they know what they know. In contrast, explicit knowledge of the managers is that which has been articulated (e.g. in the form of verbal, written, or scientific reports – see Fazey et al., 2006a).

Knowledge can also be compared on local and traditional grounds. Olsson and Folke (2001) suggest a local fishing association in a Swedish community displayed management practices that enabled the protection of crayfish beyond the local population to the ecosystem, an example of local ecological knowledge. In contrast, traditional ecological knowledge implies a historical and cultural context to knowledge generation and dissemination. For example, the Turkwel Riverine Forest in Kenya has been managed for many years by an indigenous system known as *ekwar* which refers to a parcel of riverine forests whereby the owner and family has exclusive rights to collect building materials, firewood and edible fruits. Outsiders require permission from the *ekwar* owner to graze their livestock in the area (Stave et al., 2007).

Researchers have usually compared knowledge types along different continua. This includes those that represent the extent to which knowledge is: (1) locally specific or generalised across regions; (2) formalised; (3) expresses expertise; (4) is articulated in ways accessible to others; and (5) is embedded in traditional cultural rules and norms derived from longstanding association and feedback with ecological processes (Fig. 1). Examining knowledge in this way highlights that the criteria used to compare knowledge types are often not distinct and that many knowledge types overlap different continua. For example, tacit or local knowledge can be either informal/lay or expert knowledge, and both informal and scientific knowledge can be explicit. Other categories of knowledge are also broad and encompass a number of dimensions, such as 'personal knowledge' (Polanyi, 1958) which represents various degrees of localised, expert, tacit and implicit knowledge which may have been derived through formalised or informal processes.

The variety of ways in which knowledge has been categorised means there is considerable potential for confusion about the meaning of the terms and their relevance for environmental management (Fazey et al., 2006a). To this end, categories have often been simplified and expressed under three broad headings: 'localised, experiential or indigenous' knowledge (referred to herein as 'local knowledge'); more formalised 'scientific' knowledge, and; 'hybrid' knowledge. 'Local knowledge' usually refers to the informal, lay, personal, often implicit or tacit, but possibly expert, knowledge held by land managers involved in environmental decision-making. 'Scientific knowledge' usually refers to the

Table 1
Different definitions of knowledge within the environmental management literature.

Knowledge class	Generated through	Type of knowledge	Definition	References in environmental literature
Experiential/ local	Traditional cultural rules and norms	Indigenous	Local knowledge held by indigenous peoples, or local knowledge unique to a given culture or society (Warren et al., 1995).	Howden, 2001; Davis, 1999, 2006; Becker and Ghimire, 2003
		Traditional ecological (TEK)	Subset of indigenous knowledge that includes knowledge and beliefs handed down through generations by cultural transmission and which is related to human–environment interactions (Berkes, 1993, p. 282).	Berkes, 1989; Johannes, 1989; Berkes, 1993; Healey, 1993; Hunn, 1993; Lewis, 1993; Berkes, 1999; Berkes et al., 2000; Olsson and Folke, 2001; Becker and Ghimire, 2003;
	More recent human–environment interactions	Local ecological	Knowledge held by a specific group of people about their local ecosystems. This includes the interplay between organisms and their environment (Olsson and Folke, 2001, p. 87). 'Local' differs from 'traditional' ecological knowledge in the sense that the former has been derived from more recent human–environment interactions (e.g. a few generations) rather than being embedded in deeper cultural practices.	Olsson and Folke, 2001; Berkes and Folke, 2002; Gadgil et al., 2003; Brosius, 2006; Cleveland and Soleri, 2007; Brosius, 2006; Reid et al., 2006
	Personal experience	Personal	Personal knowledge people hold about something. This is a broad concept that can include tacit, implicit, expert or non-expert knowledge derived through various experiential processes.	Polanyi, 1958; Fazey et al., 2006b
		Lay	Usually refers to some form of non-expert, localised or informal knowledge reflecting people's everyday interpretation of a situation, in contrast to expert knowledge or knowledge derived using a formalised process.	Jones, 1995; Halfacree, 1995
		Local or situated	Knowledge that reflects understanding of local phenomena. Often used as a term that reflects some level of expertise of a local site or issue (e.g. knowing land managers, their opinions and beliefs, or the ecological aspects, such as location of species and their habitat). Often used to make a distinction between the knowledge of external experts who have technical expertise but lack appreciation of the local nuances.	Robertson and McGee, 2003
		Tacit	Unconscious knowledge which is often hidden, abstract, and difficult to articulate but has a significant influence on thinking and behaviour. It cannot be made explicit, such as recognising someone's face but not being able to explain why or how the face was recognised. Often deep, unconscious, and closely tied to worldview, values, personal experience and expertise.	Boiral, 2002; Polanyi, 1958, 1997; Fazey et al., 2006b
		Implicit	Knowledge that an individual is aware of but which they may not have yet articulated in a form accessible to others (orally or in written form). Implicit knowledge is distinct from tacit because it can be articulated.	Fazey et al., 2006b
		Informal	Similar to personal, tacit or lay knowledge. Usually refers to knowledge that is derived from experiencing different phenomena, but which lacks structured processes that regulate the way those experiences affect understanding.	Pasquini and Alexander, 2005; Fernandez-Gimenez et al., 2006; Abay et al., 2008
		Non-expert, Novices	Knowledge that does not reflect the depth of experience and characteristics of expertise demonstrated by experts.	Fazey et al., 2005, 2006a,b
	Personal experience	Expert	Reflects a depth of experience, which may or may not have been derived through structured and formalised processes (e.g. research or explicit use of reflection in practice). Typically, experts have many years of experience and practice. Much of this is tacit knowledge, and some can be made explicit. Experts can often recognise patterns and issues that are not easily recognised by novices, do not necessarily need to consciously think about what they are doing, and can vary in their ability to respond flexibly to new circumstances (adaptive expertise). Considered to be qualitatively very different from 'scientific' knowledge.	Fazey et al., 2005, 2006a,b; Martin et al., 2005
Scientific	Formalised processes		Science is from Latin 'scientia', meaning knowledge. In its broad sense science refers to any systematic recorded knowledge or practice. This gives rise to the scientific method which focuses on agreed principles or process of study, including reliability and validity. What counts as 'evidence' depends on a person's philosophical and epistemological standpoint. It can also depend on the way in which the knowledge is determined. For example, in an 'evidence-based' approach from clinical medicine and public health, greater value is given to randomised, controlled double blind experiments than non-randomised or natural experiments (see Fazey et al., 2004) and informal forms of knowledge are given very little credibility.	Gunderson et al., 1995; Turnbull, 1997; Fazey et al., 2004; Pullin and Knight, 2001
		Explicit	Knowledge that exists in a written (i.e., codified, including numeric or graphical) and categorical form that is widely accessible.	Fazey et al., 2006a; Fabricius et al., 2006
		Formal	Passed through a strict and universally accepted set of rules qualifying it for a particular use	Fabricius et al., 2006

Table 1 (*continued*)

Knowledge class	Generated through	Type of knowledge	Definition	References in environmental literature
'Hybrid' knowledge	A social learning process		Knowledge types that have, in some way been integrated. The level of integration can occur to different degrees. For example, distinctions are made between multi-disciplinary and interdisciplinary research. In the former, studies from different disciplines are conducted and most knowledge exchange or integration occurs after results of the separate studies become apparent. In the latter, research approaches and methods are more fully integrated from the outset creating new knowledge in ways that are not possible through less integrative methods using mutli-disciplinary approaches. Trans-disciplinary approaches go even further by involving or embedding non-academic participants, such as the public. Some argue that all knowledge comprises a heterogeneous blend of knowledges from different sources as this knowledge is developed through personal experience, interpretation and interaction (even if it is with 'scientific' evidence).	Long and Long, 1992; Murdoch and Clark, 1994; Romig et al., 1995; Clark and Murdoch, 1997; Kleine, 1995; Evely et al., 2008; Fazey et al., 2006a; Tress et al., 2005; Ingram 2008

often explicit knowledge that has been derived from applying more formal methods that aim to increase rigour in relation to different positions on validity and reliability. This includes natural science and social science research. Finally, 'hybrid' knowledge is often referred to as the new understandings which emerge through the integration of different types of knowledge (such as local and scientific) and/or through multi-, inter-, or trans-disciplinary research (see Romig et al., 1995; Walter et al., 1997; Ingram, 2008). The three broad categories roughly encompass the more specific types of knowledge (Table 1).

While these broader categories can be useful, they can still be difficult to separate. For example, while scientific knowledge is often presented in an explicit form (through written reports or presentations), the information presented is always interpreted by individuals (including researchers) who make sense of that information in relation to their existing personal knowledge derived from past experiences (Longino, 1990; Fazey et al., 2006b). This implies that knowledge is inherently personal with different people interpreting the same information in different ways. In addition to interpretation of knowledge, the production of knowledge is also heavily influenced by personal perspectives and ideologies, which are in turn shaped by contextual factors and the values of the society in which a person is embedded (Harré, 1981; Longino, 1990; Nygren, 1999). These factors influence, for example, how research is practiced, which questions are asked or ignored, the selection of the phenomena to be investigated, how data are described, and which research frameworks are accepted or rejected (see Evely et al., 2008).

Categorising knowledge as 'local', 'scientific' or 'hybrid' is therefore overly simplistic and does not sufficiently take into account the way individuals learn, make sense of new information, or the social contexts that influence how people understand something. When attempting to integrate knowledge types much greater focus is therefore required in the early stages of the process to identify and evaluate the different knowledges involved and how they might be relevant. This might involve ensuring that experts engaging in the process have sufficient depth of experience directly relevant to the problem to be addressed (Fazey et al., 2006b). It may also require determining the type of knowledge different stakeholders can bring to the integration table (e.g. indigenous or scientific perspectives), as well as the type of content they have to offer (e.g. whether they have particular expertise, such as ecological or economic that can help to improve understanding of the interrelated human and social aspects of a system or problem).

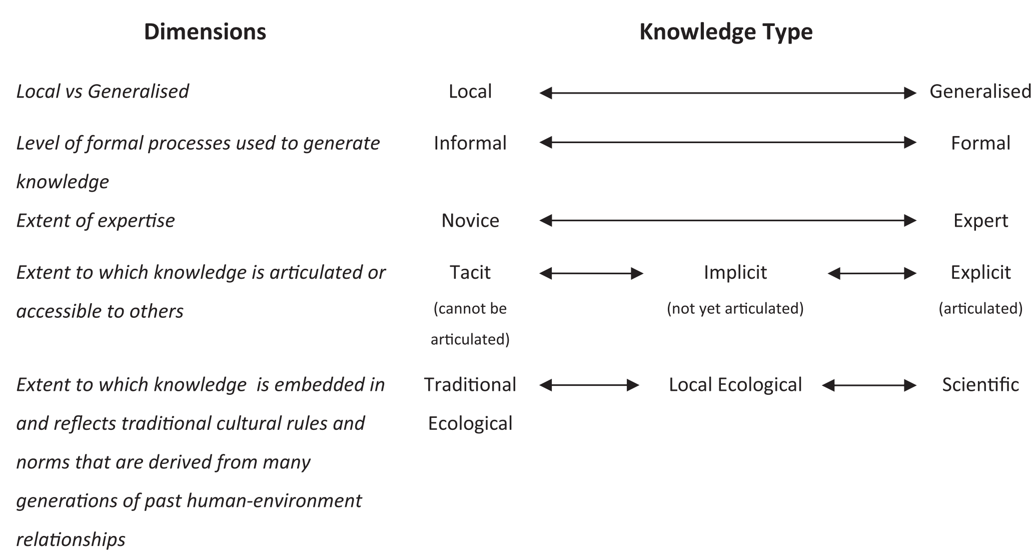

Fig. 1. Dimensions of knowledge types derived from the environmental literature. Some knowledge types may cross different dimensions and others include broader concepts that express multiple aspects (e.g. personal knowledge and lay knowledge might be tacit or implicit, expert or non-expert, but are usually considered to be informal). Note that the types on the left or right do not necessarily group together, so knowledge might be 'expert' and 'tacit' or 'traditional' and 'local'.

2.2. Engaging different knowledges (epistemological challenges)

Identifying knowledge types using categorisations such as those in Table 1 is an important first step of knowledge integration. But most of the important challenges associated with integration of knowledge are the result of fundamental differences in the way people perceive the nature of knowledge or how they come to know something. These different perceptions influence opinions of the extent to which there is a 'universal truth', what counts as evidence, and ultimately which forms of knowledge are believed to be valid (Kuhn, 1977; Firestone, 1987; Crane, 1999; Dyson and Brown, 2006). For example, different epistemological or philosophical positions lead to different types of research, that in turn have different implications for informing practice (Dyson and Brown, 2006; Evely et al., 2008). Examples of how different perspectives influence research are provided in Online Supporting Material 1. While in-depth integration of the knowledge from some of these disciplinary perspectives is sometimes possible, many of the fundamental differences in perspectives preclude meaningful consensus on how integration of the knowledge outputs generated by the research might occur (Norton, 2005; Miller et al., 2008). Early involvement of researchers from different epistemological or philosophical standpoints is therefore essential in an interdisciplinary research process. However, interdisciplinary research can be time consuming, and may still result in the dominance of one perspective over another, very rarely addressing the fundamental epistemological differences in perspectives held by researchers from different disciplines (Miller et al., 2008). To work towards a more integrated form of research, the broad approach of epistemological pluralism is advocated, which recognises that there may be several valuable ways of knowing, focuses on the social processes and values involved in the production of knowledge and employs a continuous process of negotiation between researchers (Miller et al., 2008).

Any attempt at knowledge integration must therefore provide mechanisms to support mutual learning and deliberation of those examining existing, or providing new knowledge in the integration process. Crucially, these processes need also to actively promote discussion and continual negotiation of the different epistemological beliefs held by participants and their implications for knowledge integration and decision-making (Miller et al., 2008). As such, knowledge claims should be evaluated together, in a structured and decision-oriented environment of collaborative inquiry (Failing et al., 2007). This process allows debate on the basis of knowledge claims, exploration of the reasons for conflicting claims, and an evaluation of their implications for the decision being made. For example, communities affected by land degradation can systematically and critically evaluate both local and scientific knowledges about degradation indicators, using participatory decision-support tools such as multi-attribute evaluation methods (see Keeney and Raiffa (1993) for details) or multi-criteria evaluation (c.f. Ferrarini et al., 2001; Reed et al., 2008). Hence, the question of how was the validity and reliability of different knowledges evaluated is an important question for project teams to ask.

Overall, to address the epistemological challenges, participants need to be much more aware of their own and others' philosophical and epistemological positions, how these positions impact knowledge integration, and that their views are unlikely to be the same as others (Evely et al., 2008). Careful mechanisms need to be developed to provide space and scope for these issues to be made explicit and to be addressed . Specifically, project teams must identify and discuss the different perspectives held by participants on what knowledge is, in addition to the different ways of knowing about the environmental management problem, and the opportunities available for participants to learn about the perspectives of others. Following these earlier steps, project teams need to establish acceptable ways of evaluating the validity and reliability of different forms of knowledge.

2.3. Applying integrated knowledges (challenges to application)

This section reviews factors which should be considered during the application of mechanisms to promote knowledge integration. Knowledge integration processes can be influenced by: (1) differences in world views of project participants and external experts; (2) differences in institutional power or control over access to and management of local resources, and; (3) changes in perception about the benefits generated by the project (Johnson, 2004). Kothari (2001) argues that knowledge integration processes can promote the interests of local elites if attention is not paid to how the outputs will be applied or used by different stakeholders (cf. Stringer et al., 2007).

Participatory monitoring and evaluation (PM&E) has been offered as a way of managing differences in world views and power (see Estrella and Gaventa, 2000 for a review). A key function of PM&E is to create a learning process to strengthen organisational and institutional learning. Stakeholders, including external experts, community members, project staff and facilitators, need to evaluate the objectives and outputs of the project themselves in terms of whether they reflected the needs of stakeholders. This evaluation needs to occur throughout the project cycle, not just at mid-and-end-terms or after the project has been completed (Phillipson and Liddon, 2007). Failure to effectively evaluate the objectives and outputs can lead to 'intellectual robbery' (the taking of local knowledge without providing a benefit in return), and a subsequent loss of trust in the engagement process. Reflections on a recent multi-disciplinary project (Meagher and Lyall, 2007) suggest the importance of taking the time necessary to capture and share the lessons learned from the knowledge integration project across researchers, external actors (e.g., funding bodies) and local participants. Multiple stakeholders are more likely to use the products if they understand the participatory processes involved and how the different forms of knowledge were integrated and can be applied within an environmental management context (Reed and Dougill, 2010). A key indicator of project success is the extent to which the knowledge integration outputs are used by those who input their knowledge.

Finally, the knowledge integration process needs to be sufficiently flexible to take into account changes in perceptions emerging during the project and to deal with new information arising after application. The adaptive co-management literature emphasises the need for environmental management to be embedded in institutions which are flexible to deal with multiple forms of knowledge, across multiple scales and time horizons (e.g., Armitage et al., 2008; Berkes, 2009). Explicit in this approach is that local and scientific knowledge can support learning through dialogue and deliberation (Cook et al., 2004). The approach also stresses the need to draw attention to both slow and fast variables that structure complex social–ecological systems (Gunderson and Holling, 2002). Climate change knowledge and information, for example, is being rapidly updated across different spatial scales. Researchers and local environmental managers will have different perceptions about the validity of the information being presented (Miller et al., 2008). Knowledge integration processes need to be able to reflect upon the validity of this new knowledge and information, and where relevant, have processes in place to integrate into outputs prepared during the course of the project.

3. Comparing the integration of different types of knowledge

The previous sections highlighted some of the ontological, epistemological and application challenges associated with knowledge integration. This raises key questions that need to be addressed when knowledge integration is attempted (Fig. 2). The questions can be framed around four areas including: identifying existing knowledge, engaging different knowledges, evaluating different knowledges and applying integrated knowledges. We view the integration of local and scientific knowledge as a cyclic process of reflection and learning from problem identification to the applications of integrated knowledges.

In this section we conduct a comparative analysis of three case studies that encountered the challenges and opportunities of knowledge integration, using the questions presented in Fig. 2 as a guide. Case studies include: the Sustainable Uplands Project (UK); the sustainable development project in Kahua, Solomon Islands; and the mapping landscape values for conservation and tourism planning project in the Otways region of Victoria, Australia. These projects were chosen because they demonstrate different methods for integrating local and scientific knowledge for environmental management. The Sustainable Uplands Project relied on mixed methods to integrate different types of knowledge into the design and application of decision-support tools; the Solomon Island Project was an exploratory study to promote discussion, reflection and learning for three tiers of community members, local people trained as research assistants, and western researchers, around environmental problems in their area; and the Otways study is an example of an explanatory, Public Participation Geographic Information System (PPGIS) approach, whereby different types of knowledge were identified and integrated using GIS map interfaces.

3.1. Case study 1 – Sustainable Uplands project (UK)

The Sustainable Uplands project is funded by the UK Research Councils' Rural Economy and Land Use (RELU) program. The aim of the project is to better anticipate, monitor and adapt to future environmental changes in three UK upland sites: (1) the Dark Peak of the Peak District National Park; (2) Nidderdale Area of Outstanding Natural Beauty in the Yorkshire Dales, North Pennines; and (3) Cairnsmore of Fleet and the Luce, Bladnoch, Cree, Dee and Ken catchments in Galloway, Scotland. Upland areas are subject to a range of significant environmental, socio-cultural and economic drivers which, on top of historic trends, may affect their capacity to respond and adapt to future pressures. In light of these challenges, this project recognises that it is vital to better understand and prepare for the future of the uplands.

The project engages different types of knowledges through an iterative combination of qualitative and quantitative methods. To date, the project has conducted around 45 semi-structured interviews, 100 structured questionnaires, seven workshops and eight site visits with land managers. Local knowledge was elicited from a wide range of land managers in each study site (e.g. farmers, game keepers, grouse moor owners, water companies, recreationalists and government officials) elicited via semi-structured interviews and site visits, analysed using grounded theory analysis and incorporated into conceptual models of the upland socio-ecological system. Scientific knowledge was incorporated from a wide range of relevant disciplines (e.g. ecology, anthropology, sociology, hydrology, environmental modeling, ecological economics) through a literature review and quantitative socio-ecological modeling (coupling an agent-based model with physically based hydrological, ecological and carbon models) within a participatory research design. Most of the local knowledge that informed the work was collected over a series of 10–30 semi-structured interviews and 1–3 site visits per site. Although these were then supplemented with questionnaires to understand people's interactions via social networks and their decision rules to inform an agent-based model, these were primarily designed to answer research questions rather than to collect local knowledge for integration with scientific knowledge.

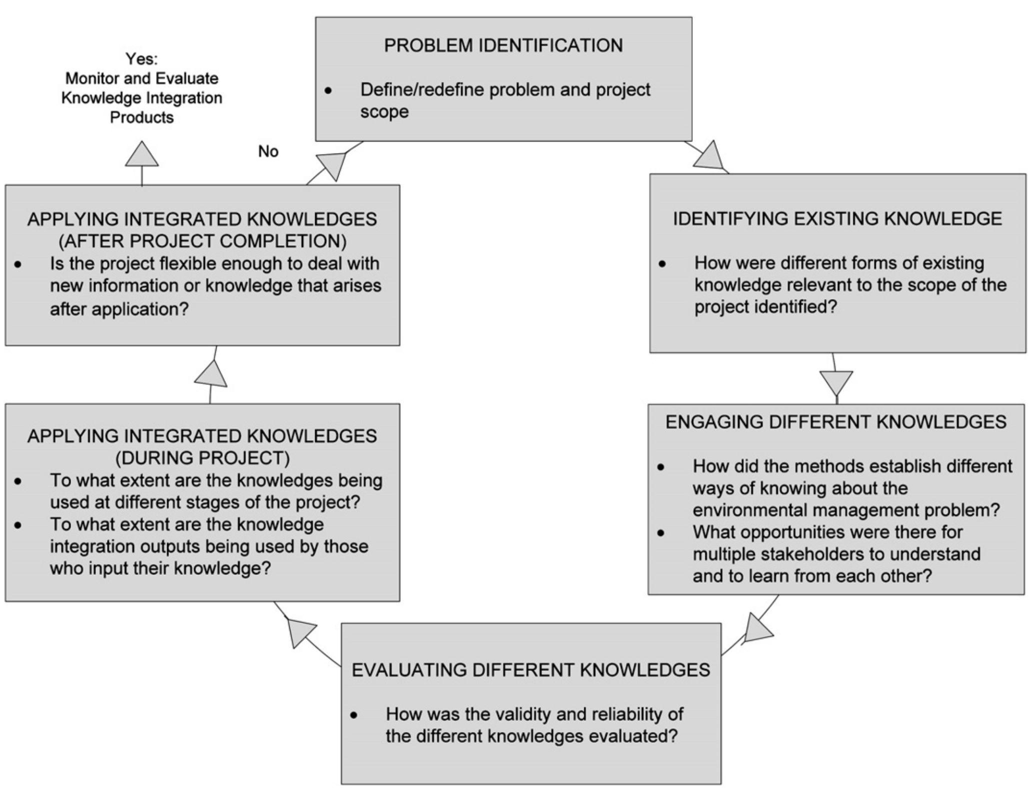

Fig. 2. Questions to be asked when integrating different types of knowledge for environmental management.

3.2. Case study 2 – Sustainable Development in Kahua, Solomon Islands

The Sustainable Development in Kahua, Solomon Islands, project is a partnership between researchers at St. Andrews University, UK, and the Kahua Association, Solomon Islands. The aim of the project is to improve the livelihoods and wellbeing of local communities in ways that do not have negative social and environmental consequences. The study area consists of 40 communities (4500 people) at the eastern end of Makira Island, in the southeastern end of the Solomon Islands. Land use is characterised by subsistence agriculture and low income. Communities have traditionally had access to sufficient food resources and materials for construction of buildings (Bourke et al., 2006). However, population growth is creating significant problems, reducing food security and increasing disputes over land ownership and lack of building materials (Fazey et al., 2007). In recognition of the need for a more sustainable approach to development, community leaders have established the Kahua Association (KA) which has a flat hierarchical structure and aims to provide an overarching governance structure across communities. This process requires application of both local indigenous knowledge and research-led processes that assist decision-making and promote adaptive governance.

Initial research in 2007 was specifically designed to promote discussion, reflection and learning for the three tiers of community members, local people trained as research assistants, and western researchers (Fazey et al., in press). In the initial programme, indigenous local knowledge was used to guide question formulation and understanding about the complex issues and dynamics facing the communities. This has been used to help build understanding of the potential drivers of change in the region, and more recently to identify key research questions that need to be addressed to improve decision-making. External knowledge, in the form of the expertise of western researchers, is being used to provide a different epistemological perspective on the problem allowing triangulation of the results. Additional traditional research projects are now coming online, some of which will include eliciting indigenous ecological knowledge and some using more quantitative research of bio-physical processes. Research includes remote sensing of vegetation change (Garonna et al., 2009), analysis of longer term historical ecological change, understanding local values of biodiversity, projects that will include local monitoring of marine resource management, and ethnographic approaches to understand aspects of early childhood development in the communities (Burton, 2008).

3.3. Case study 3 – mapping landscape values for conservation and tourism planning in Victoria, Australia

The mapping of landscape values for a conservation and tourism planning project was a partnership between the University of South Australia, Parks Victoria, and the Department of Sustainability and Environment, funded by the Cooperative Research Centre for Sustainable Tourism, Australia. The aim of the project was to identify, map and compare the landscape values and development preferences assigned by local stakeholders (residents, visitors) and Victorian Government representatives to the Otways region of Victoria, Australia (Raymond and Brown, 2006, 2007). Part 6 of the survey asked participants to identify places on a map of the Otways region which they valued for different reasons, such as places of aesthetic value, biodiversity value and wilderness value. In addition, respondents were asked to identify places which were acceptable and inappropriate for tourism accommodation and service development. By adding place-specific perceptions of landscape values to land-suitability assessment, planners can systematically address competing values and goals for land management.

In 2005, a mail-based sample was administered to a random sample of 1500 Otways region households. After completion of survey administration and data entry, scientific knowledge about tourism development and protected area management zones were overlaid with local values and development preferences. The level of spatial overlap between local values and expert-derived conservation zones was illustrated using a series of maps to enable place-specific management. The project is largely based upon the experiential knowledge of local residents, with minimal exploration or examination of the reasons why particular areas were important to environmental or tourism agency staff.

3.4. Comparative analysis of knowledge integration methods

This section compares and contrasts the three different methods for integrating different types of knowledge for environmental management using the seven questions (Fig. 2).

3.4.1. Identification of existing knowledges

The first question in the knowledge integration framework addresses the types of existing knowledge defined and identified during the project. All three projects considered knowledge based upon the representation of the participant (e.g., farmer, resident, visitor) rather than the specific forms of knowledge they held or shared. The fact that individuals do not hold merely one type of knowledge is one reason for this classification approach. Although the Sustainable Uplands project tried to explicitly differentiate local and scientific knowledge, some local stakeholders had scientific training. Indeed, Ingram (2008) notes the increasing convergence between the local knowledge of farmers and scientific knowledge in Western cultures due to formal training and learning via extension advice. For other stakeholders in the Sustainable Uplands project, scientific training was a pre-requisite of the professional position; for example Natural England Area Officers and water company catchment managers. Whilst the Solomon Islands case study did not explicitly define different knowledge types, processes were established to promote discussion, reflection and learning across multiple stakeholder groups. Continuous interaction was encouraged between researchers and community members. The Otways study focused largely on the values of residents and visitors to the Otways region. No attempt was made to stratify the resident and visitor samples into different knowledges pre-survey. However, both groups were asked about their perceived knowledge of the Otways region. Moderate positive relationships were found between perceived knowledge of the Otways region and tourism development and protected area management preferences, such as the number of tourism accommodation service preference dots assigned to a map of the region. The knowledge of government representatives was only brought in after survey administration.

3.4.2. Engagement of different knowledge types and epistemological influences on knowledge integration

The second question asks researchers to evaluate how the knowledge integration methods established different ways of knowing. The Solomon Islands case study was highly effective at engaging different types of knowledge relevant to its purpose. Local knowledge was used to guide question formulation and build understanding of potential drivers of change in contrast to the Otways Study where survey questions were prepared by researchers in partnership with the project funder – the Victorian Government. The goal of the Solomon Islands project was to empower local actors to be involved in environmental decision-making and land-use change, whereas the goal of the Otways study was to explain how local values aligned with the land-use designations proposed by state government. In this particular context, the Solomon Islands project adopted a subjectivist view whereby indigenous knowledge was relied on initially as a starting point to understand the complex problems occurring in the area. It focused on social learning and developing a dialogue between indigenous people, government representatives and researchers and invited local communities to collect and interpret data and their own local knowledge. This was motivated by a need to reverse trends of external experts coming in to tell communities what to do and to increase confidence in the ability of local people to think about and work through their own problems using their own knowledge (as there was little else available). Their knowledge was continuously contested through deliberative and participatory approaches, and by the researchers who asked pointed questions about the validity of the ideas presented by the local people. Researchers involved in the Otways project adopted a positivistic stance where the goal was to explain the distribution and intensity of social values relative to government-derived planning boundaries. It focused on residents' map-based knowledge of the Otways region by asking residents to map the distribution and intensity of their social values and development preferences.

In contrast, researchers involved in the Sustainable Uplands project supported a critical realist perspective – a perspective which embraces both qualitative and quantitative research methods. Researchers used qualitative enquiry such as interviews and focus groups to explore and understand different rural futures preferred by upland farmers. Site visits were conducted by both local stakeholders and scientists. This local knowledge was distilled into scenarios and short films which were presented to scientists and other local stakeholders. After each short film, the workshop facilitator asked a series of questions about the upland futures presented in order to encourage local stakeholders and scientists to share their different epistemological beliefs. In addition, there were opportunities for local land managers to influence the development of models prepared by researchers.

The third question addresses the mechanisms and opportunities for multiple stakeholders to understand and learn from each other. In the Sustainable Uplands project, there were repeated calls by local stakeholders for the researchers to provide evidence to support different standpoints, suggesting that many of these actors shared a positivist philosophy with the natural scientists on the project. However, the natural science components of the work were embedded in a social science, participatory research framework. This framework was more subjectivist, allowing competing knowledge claims to be considered side-by-side and valued for their different merits in alternative scenarios. In the Otways project, methods allowed no interaction between land managers and researchers and no learning. Contact between researchers and people was not face-to-face and communication was not (for the most part) two-way. Methods involved local people but as a result of a lack of discussion, personal contact and co-learning, the methods used showed weak engagement of multiple interest groups. However, there was opportunity for government to learn from local values and reorient their policies accordingly.

In the Solomon Islands there was much more emphasis on bottom-up methods that are grounded in the local development tradition. This included facilitated processes and structured method to promote reflective learning for the three tiers of community members, local people trained as research assistants, and western researchers. The impact of this is reflected into the key input local people had in shaping the direction of the project and to evaluate each other's findings at multiple stages of the research and development process.

3.4.3. Opportunities for participants to evaluate different knowledges

The fourth question focuses on the extent to which each project allowed for evaluation of the validity and reliability of knowledge. Scientific knowledge was integral to the Sustainable Uplands Project; however, there was little formal evaluation of the validity and reliability of the local stakeholder knowledge by the researchers. Some informal evaluation was conducted during site visits, which were professionally facilitated and designed by a steering group of stakeholder representatives who selected the issues to be covered and the most appropriate sites to stimulate discussion. The steering group suggested the development of information sheets about each issue to ensure all participants had similar levels of information about each issue and could engage in debate at a similar level with one another. The scope of each information sheet was decided through discussion with local stakeholders, and drafts were peer-reviewed by them prior to distribution. Site visits were designed to bring stakeholders with different interests and backgrounds together with researchers as equal partners to discuss the upland management issues that were perceived to be most important. The outdoor context and facilitation style significantly reduced the discrepancies in power that had been witnessed in previous workshops, as site visits were led by the land users themselves rather than the researchers. This enabled the land users to present the elements they considered important, helping all participants to feel comfortable engaging in discussion.

In the Solomon Islands project, mechanisms to test the validity and reliability of knowledge were a key part of the project. The programme relied on the continual discussion and deliberation about the validity of the knowledge by engaging local people in the process of doing research. Knowledge and data derived from their research and that of researchers was continually analysed and contested. Researchers also facilitated discussion that included asking local participants pointed questions about their assumptions and understandings. In the Otways case study, there was little opportunity for survey participants and project partners to share and evaluate the values and preferences generated through the process. However, the representativeness of the sample frame was tested using regional Australian Bureau of Statistics data, and the external and convergent validities of values and preference results were tested using comparable findings and methods from the United States. For example, the researchers used factor analysis to examine the external validity of a place attachment scale developed in the United States (see Brown and Raymond, 2007).

3.4.4. Application of the integrated knowledge to the environmental management problem

In the next step of the knowledge integration framework, researchers are encouraged to evaluate the extent to which the knowledges are being used at different stages of the project. Both the Sustainable Uplands and Solomons Island projects integrated different types of knowledge at multiple stages of the project. The UK Research Councils request that knowledge integration be documented in annual reports, but these different stages are also implicit within the Solomons Island study. Because traditional models of report writing and dissemination were unlikely to be effective (e.g. due to low literacy rates and resources for dissemination) the research data collected by local communities and researchers were analysed, deliberated and interpreted by community members themselves. This deliberation then enabled better understanding by local stakeholders and ensured that the outcomes were embedded in the policies of the grass roots organisation. In the Sustainable Uplands project, ongoing integration was partly facilitated by regular meetings of a Stakeholder Advisory Panel, which guided the development of the project. It was also facilitated via seed-corn funding of a scoping study that enabled researchers to establish relationships with stakeholders early on, and co-develop the funding proposal for the full project. Further, funding and project milestones were tied to non-scientific outputs. A variety of extension documents have been developed such as policy briefs, and education tool-kits for schools and the general public. In the final phase communication materials will be prepared for project partners, interview participants and survey participants. In the Otways study, local knowledge was integrated with scientific knowledge after survey administration.

The final two questions examine the extent to which the knowledge integration outputs are being used by those who input their knowledge, and the level of flexibility of the knowledge integration process in terms of dealing with new information or knowledges that arise after application. Although research is ongoing, outputs from the Sustainable Uplands project are already being used at high levels within Government. For example, the team was commissioned to provide an assessment of the “future of the uplands” (Reed et al., 2009) by the Government Office for Science’s Foresight Land Use Futures project, in which they presented scenarios that were a product of integrated knowledges. The team was also commissioned by the Commission for Rural Communities to provide a think-piece for their forthcoming Inquiry into the Future of England’s Upland Communities, which reports directly to the UK’s Prime Minister. This work was based on an exploration of ideas that originated from interviews with stakeholders and were elaborated through modeling research. The team has also submitted a number of responses to Government policy consultations based on a combination of knowledges (sometimes including quotations from stakeholders). Yorkshire Water funded the team to conduct additional research to apply outputs of the project to their catchments, and explore the possibility of paying land managers to change management practices in order to improve water quality at source. The team has now employed a full-time knowledge broker who will be further translating project outputs into forms that can be disseminated to a wide audience. The project also allowed new knowledge to be incorporated at several stages throughout, and thus can be viewed as flexible to new knowledge that arises after first application.

In the Solomon Islands project, the research was effectively embedded in application through the way it engaged local communities in the research process and worked with the local grass roots organisation. As a result, communities are beginning to implement their own programmes which are partly based on the results of the ongoing research in the region but which are also a legacy of the way the research process engaged communities in thinking about their understanding and building confidence in their own knowledge and capacities. Unlike the Sustainable Uplands and Otways studies, the learnings from this project principally relate to the process of engaging different knowledges rather than material outputs (e.g., reports) generated through the process. New knowledge and norms continually evolve in this project and are expected to endure when the project is over.

The application of results emerging from the Otways study has been more challenging. Results were presented to committees responsible for developing the Otways Forest Amendment Act (2006) and the Otway Hinterland Tourism Plan. However, it is unclear how they informed their decision-making in terms of identifying priority sites for nature conservation and tourism development. New spatially referenced information can be overlaid with the local values after survey administration, but it is relatively costly and time consuming to solicit new spatially referenced values and preference data.

A key application challenge which has emerged through this comparative analysis is addressing the question of power and equality in integration. Since these case study projects all have external funding (be it scientific or through an NGO) the local knowledge framing problem identification largely sits in the hands of the scientific knowledge holders and thus application of the results ultimately rests with them. While varying efforts have been made throughout the case studies to address this balance, the scientific dominance nevertheless remains in at least the Uplands and Otways projects.

4. Discussion

The aims of this paper were to design a conceptual framework which may assist project teams to consider and address the challenges associated with integrating different types of knowledge for environmental management and then apply this framework to three knowledge integration projects. Our review of the literature unearthed a number of knowledge integration challenges. Firstly, the classification of knowledge is arbitrary and there are multiple, overlapping ways of defining local and scientific knowledge which impede the identification of existing knowledge (Table 1, Fig. 2). Secondly, there are multiple philosophies of social science that underpin the personal epistemological beliefs of researchers and stakeholders and their choice of methods for engaging and evaluating different knowledge. Thirdly, there are social and political challenges associated with the application of integrated knowledges in terms of how the results are used by those who input their knowledge. Based on these three arguments we encourage a shift in science from the development of knowledge integration products to the development of knowledge integration processes enabling multiple views and multiple methods to be considered in relation to an environmental management problem.

We then presented a framework (Fig. 2) which may assist researchers to improve the integration of multiple knowledge types in an environmental management project. We suggest attention needs to be paid to the identification of existing knowledge, the engagement of different knowledges, the evaluation of different knowledges and the application of integrated knowledges. Cundill and Fabricius (2009) identify other factors to consider such as the socio-ecological context of the system (e.g., the system’s parameters) and the institutional structure for management, including the goals, strategies, ideas and skills of participants. We add to their process by highlighting the epistemological dimension of social learning which needs to be considered alongside the institutional structures for management and the capacities of individuals involved in the project. Epistemological pluralism must be supported as part of these knowledge integration processes. This finding is supported by Eigenbrode et al. (2007) who assert that the philosophical dimension has largely been overlooked in the knowledge integration literature.

The identification of existing knowledge is one of the first factors which needs to be considered in any new knowledge integration project. All three case studies espoused the integration of local and scientific knowledge without systematically identifying the forms of knowledge to be integrated at project commencement. Knowledge was defined based upon the representation of the actors involved (e.g., farmer, resident and visitor); researchers did not consider the multiple factors and philosophies that influence knowledge claims (see Fig. 1 and Online Supporting Material 1). Without such a check, it is difficult to understand whether different ways of knowing are being incorporated into the project, or whether actors are being selected to represent the interests of those responsible for managing or delivering the project.

Secondly, researchers need to pay more attention to engaging different knowledges, particularly how the methods established different ways of knowing, and the level of opportunity for participants to learn from one another. We found that those projects which adopted a more positivistic stance selected methods whereby outsiders (usually scientists) had a leading role in knowledge integration product development. In the Sustainable Uplands project, predominantly natural science models of the UK Uplands region were prepared by scientists and then refined based upon the knowledge of local stakeholders. In the Otways project, the project objectives and methods were led by scientists – there was little opportunity for multiple stakeholders to learn from one another. In contrast, the Solomons Island project adopted a more subjectivist stance and developed knowledge integration processes which were more culturally relevant and more easily applied by those who shared their knowledge. Indigenous people were guided through an iterative process of identifying shared resource management futures. Much greater emphasis was placed on a deliberative process whereby the research data collected by local communities and researchers were analysed, deliberated and interpreted by local community members themselves, instead of external experts.

A third theme which emerges is that processes need to be established for examining the validity and reliability of different knowledge claims. The Sustainable Uplands and Solomon Islands projects did not have explicit methods for checking validity and reliability of different knowledge claims. The Otways study examined convergent and external validity questions by comparing spatial and survey results to similar studies in the United States. However, one may question who controls what knowledge is valid in knowledge integration projects and the procedures for examining it? If the knowledge integration outputs are culturally relevant, as suggested in the Solomons Island study, then is this an adequate indicator of validity? Again, the answer to these questions depends upon the epistemological beliefs of the project team, and reiterates the importance of sharing these beliefs early in the project. The methods adopted for examining validity and reliability will ultimately depend upon the proposed outcomes of the study, and the shared views of the project team.

The fourth theme relates to the application of integrated knowledges during and after project completion. The philosophical perspective chosen by the project team not only influences the method of knowledge integration, but the level of uptake of the results by different audiences. In the Solomons project, the uptake of the knowledge integration products by local communities and local stakeholders has been more effective in this project to date than the Sustainable Uplands project because it included local community members in the whole process of developing questions, collecting data, preliminary analysis, and feeding this back through workshops in communities and with representatives from development NGOs and government representatives (See Fazey et al., in press for full details). In contrast, there appears to be much greater uptake of the knowledge integration products by technical experts and outsiders (e.g., government representatives) in the Sustainable Uplands project.

5. Conclusion

A variety of ontological, epistemological and application challenges exist when integrating multiple knowledge types for environmental management. This study proposes a framework comprising of four themes and seven questions which may assist researchers and environmental managers consider and address these challenges. We then show how this framework could be applied to three knowledge integration case studies located in the United Kingdom, Solomon Islands and Australia. A comparative analysis of the three case studies indicated that there are multiple methods available for integrating different knowledge types; some of these methods favour scientific knowledge over local knowledge, whereas other methods actively encourage the sharing of knowledge between local stakeholders and scientists. We argue that knowledge integration project teams need to assign more effort to: 1) the identification of the different epistemological beliefs which underpin knowledge claims; 2) the engagement of different knowledges, including how the knowledge integration methods established different ways of knowing, 3) the evaluation of how the knowledge integration mechanisms and processes supported learning and shared understanding, and; 4) the level of application of knowledge integration outputs by multiple stakeholders during the project and after project completion. Based on theoretical insights and case study findings, we conclude that there is no single optimum approach for integrating local and scientific knowledge and encourage a shift in science from the development of knowledge integration products to the development of problem-focussed, knowledge integration processes.

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Appendix A. Supporting material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jenvman.2010.03.023.

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