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review

Knowledge management for land degradation monitoring and assessment: an analysis of contemporary thinking¹

Reed MS¹, Fazey I², Stringer LC³, Raymond CM⁴, Akhtar-Schuster M⁵, Begni G⁶, Bigas H⁷, Brehm S⁸, Briggs J⁹, Bryce R¹⁰, Buckmaster S¹¹, Chanda R¹², Davies J¹³, Diez E¹⁴, Essahli W¹⁵, Evely A¹⁰, Geeson N¹⁶, Hartmann I¹⁷, Holden J¹¹, Hubacek K³, Ioris I¹⁸, Kruger B¹⁹, Laureano P²⁰, Phillipson J²¹, Prell C²², Quinn CH³, Reeves AD²³, Seely M²⁴, Thomas R⁷, van der Werff Ten Bosch MJ²⁵, Vergunst P¹⁷, Wagner L²⁶

¹ Aberdeen Centre for Environmental Sustainability and Centre for Planning and Environmental Management, School of Geosciences, University of Aberdeen, St Mary's, Aberdeen AB24 3UF, UK

² School of Geography and Geosciences, Irvine Building, University of St. Andrews, North Street, St. Andrews KY16 9AL, Fife, UK

³ Sustainability Research Institute, School of Earth & Environment, University of Leeds, Leeds, West Yorkshire LS2 9JT, UK

⁴ Centre for Rural Health and Community Development, University of South Australia, and Enviroconnect Pty Ltd. GPO Box 190, Stirling South Australia 5152, Australia

⁵ Secretariat DesertNet International (DNI), c/o Biocentre Klein Flottbek and Botanical Garden, University of Hamburg, Ohnhorststr.18, 22609 Hamburg, Germany

⁶ MEDIAS-FRANCE-CNES, Mediterranean Coordinating Office for START, 18 Avenue Edouard, F-31055 Toulouse, France

⁷ United Nations University, Institute for Water, Environment and Health, Suite 204, 175 Longwood Road South, Hamilton, Ontario, Canada L8P 0A1

⁸ League for Pastoral Peoples and Endogenous Livestock Development, Pragelatostrasse 20, 64372 Ober-Ramstadt, Germany

⁹ Department of Geographical & Earth Sciences and Director of the Glasgow Centre for International Development, University of Glasgow, 10 The Square, University of Glasgow, Glasgow G12 8QQ, UK

¹⁰ Aberdeen Centre for Environmental Sustainability, University of Aberdeen & The Macaulay Institute, School of Biological Sciences, Tillydrone Av., Aberdeen AB24 2TZ, UK

¹¹ School of Geography, University of Leeds, Leeds LS2 9JT, UK

¹² Department of Environmental Science, University of Botswana, Private Bag 00704, Gaborone, Botswana

¹³ IUCN, the International Union for Conservation of Nature, Wasaa Conservation Centre, Mukoma Road, PO Box 68200, 200 Nairobi, Kenya

¹⁴ UNESCO Chair for Spatial Planning and the Environment, Ed. Departamental II Of. 241, Rey Juan Carlos University, 28933 Mostoles, Madrid, Spain

¹⁵ Community of Sahara and Sahel States, BP 4041, Tripoli, Libya

¹⁶ Osservatorio MEDES (Observatory for economic problems associated with desertification in Mediterranean areas), Viale dell'Ateneo Lucano 10, Potenza 85100, Italy

¹⁷ Amoud University, Borama, Somaliland

¹⁸ School of Geosciences, University of Aberdeen, St Mary's, Aberdeen AB24 3UF, UK

¹⁹ Emerging Commercial Farmers' Support Programme, Private Bag 13255, Windhoek, Namibia

²⁰ Via Roma 595, 50012 Bagno a Ripoli, Firenze, Italy

²¹ Centre for Rural Economy, School of Agriculture, Food and Rural Development, Newcastle University, Newcastle NE1 7RU, UK

²² Department of Sociological Studies, University of Sheffield, Sheffield S10 2TU, UK

²³ Geography, School of Social and Environmental Sciences, University of Dundee, Dundee DD1 4HN, UK

²⁴ Desert Research Foundation of Namibia, P.O. Box 20232, Windhoek, Namibia

²⁵ Both ENDS, Nieuwe Keizersgracht 45, 1018 VC Amsterdam, The Netherlands

²⁶ International Institute for Sustainable Development (IISD), Reporting Services Division, 300 East 56th Street #11A, New York, New York 10022, USA

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Abstract

It is increasingly recognised that land degradation monitoring and assessment can benefit from incorporating multiple knowledges, using a variety of methods at different scales, including the perspectives of scientists, land managers and other stakeholders. However, the knowledge and methods required to achieve this are often dispersed across individuals and organisations at different levels and locations. Appropriate knowledge management mechanisms are therefore required to more efficiently harness these different sources of knowledge and facilitate their broader dissemination and application. This paper examines what knowledge is, how it is generated, and explores how it may be stored, transferred and exchanged between knowledge producers and users before it is applied to monitor and assess land degradation at the local scale. It suggests that knowledge management can also benefit from the development of mechanisms that promote changes in understanding and efficient means of accessing and/or brokering knowledge. Broadly, these processes for knowledge management can: i) help identify and share good practices and build capacity for land degradation monitoring at different scales and in different contexts; and ii) create knowledge networks to share lessons learned and monitoring data amongst and between different stakeholders, scales and locations.

Keywords: land degradation; environmental management; monitoring and assessment; knowledge management; knowledge exchange; knowledge transfer; knowledge brokers; social learning.

1 Introduction

“Land degradation is in the eye of the beholder” (Reed *et al.*, 2008: 1267): it depends on who is doing the monitoring and assessment, where and when. As a process, and as a concept, land degradation is highly dynamic and unpredictable. Land degradation is a function of the context in which it occurs and the values of those who perceive it. One person’s degradation may be the next person’s opportunity. For example, thorny bush encroachment represents a green desert to cattle but a valuable browse resource for a goat farmer (Reed *et al.*, 2008; Figure 1). For these reasons, there can be no simple, universal system for land degradation monitoring and assessment. Instead, land degradation monitoring and assessment must incorporate multiple knowledges (e.g. local or indigenous knowledge as well as external expertise and scientific knowledge), using a variety of methods and scales. This must include the potentially conflicting

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3 perspectives of those who use the land, and those who may benefit from a wide range of
4 ecosystem services who may be located far away from the places where land degradation is
5 occurring.
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9 Monitoring and assessment of land degradation can be data intensive and may be viewed
10 as a continual process of learning and adaptation (Cundhill and Fabricius, 2009), as different
11 indicators are used at different times in relation to the management goals of the system. Effective
12 monitoring and assessment also requires knowledge of complex socio-ecological systems,
13 operating at a variety of spatial and temporal scales. As different stakeholders involved in
14 monitoring and assessment operate at scales ranging from the local to the international, the
15 knowledge required to develop a more complete picture of environmental change and
16 degradation is often dispersed. Calls for land management and policy decisions to be based on
17 evidence from monitoring at a variety of scales (e.g. UNCCD, 1994; MA, 2005; Reid *et al.*,
18 2006; WOCAT, 2007; Jessop *et al.* 2008) creates an important challenge. This is complicated
19 further by the highly fractured nature of the current knowledge base, combined with structural
20 and procedural barriers that prevent the flow of knowledge between those who are monitoring
21 land degradation at these different scales (Stringer *et al.*, 2007a,b; WOCAT, 2007; Bauer and
22 Stringer, 2009). The capacity for monitoring at each scale also differs markedly from place to
23 place. With little co-ordination or integration between monitoring activities, those working at
24 national and international levels are rarely able to tap into the data and expertise held by those
25 who manage the land. In turn, land managers rarely see the benefits of (often expensive) national
26 and international monitoring programmes (Reed *et al.*, 2006). There is, however, an increasing
27 awareness of the need to break down these barriers and a recognition that knowledge must be
28 merged and managed from wide ranging sources including academic, local, national and
29 international (Raymond *et al.*, in press). If knowledge about land degradation and its monitoring
30 and assessment can be managed more effectively, it may be possible to provide a more robust
31 evidence-base that can support more sustainable land management policies and practices and
32 allow their broader dissemination. This could provide multiple benefits across spatial and
33 temporal scales for a range of different stakeholders and groups.
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53 To understand how we can better manage knowledge for land degradation monitoring and
54 assessment, this paper will identify the different forms of knowledge that we may draw upon to
55 monitor and assess land degradation at local scales, and evaluate the potential advantages of, and
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3 available methods for, sharing and integrating knowledge from different sources and scales. It
4 then proposes a conceptual framework for knowledge management, showing how knowledge is
5 generated, with the potential to store, transfer or exchange knowledge between producers and
6 users of knowledge before it is applied to monitor and assess land degradation. This framework
7 is then explored in the context of local land degradation monitoring and assessment in drylands.
8 In this way, we hope to draw on the widest possible range of relevant knowledge to facilitate
9 more sustainable land management in some of the most food insecure countries of the world.
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19 **2 Different Knowledges for Land Degradation Monitoring and Assessment**

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22 To manage knowledge effectively, we need to understand what knowledge is and how different
23 people define it. To do this, we distinguish between data (raw numbers and facts), information
24 (“useful data” i.e. that has been processed/analysed and interpreted) and knowledge
25 (“information that is known” by an individual or group). Knowledge may include different types
26 of information that an individual holds. This information may have been derived from a range of
27 activities and sources, including personal experience, observations, research results etc. This
28 view of knowledge sits between two extremes: one that sees knowledge as something that has
29 “universal truth”, and another that considers knowledge as entirely dependent on the unique
30 interpretation and reality of each individual (Zermoglio *et al.*, 2005). Raymond *et al.* (in press)
31 further suggest that knowledge is strongly influenced by the personal epistemological beliefs of
32 the individual, and the processes through which these beliefs are shared and redefined.
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42 There are many different kinds of knowledge and ways of knowing (Fazey *et al.* 2006a).
43 “Tacit knowledge” represents the knowledge we hold but of which we are not consciously
44 aware. An example of this is our ability to recognise a face, yet not know why or how we
45 “know” this (Polanyi 1997). Tacit knowledge by definition cannot be made explicit. ‘Implicit’
46 knowledge is that which can, but has not yet been, articulated (Fazey *et al.* 2006a). Such
47 knowledge can be useful for managing complex systems if it can be articulated, for example
48 providing detailed information about how systems work on the basis of many years experience
49 living and working with a system (Olsson *et al.* 2004; Fazey *et al.* 2006b). ‘Explicit knowledge’ is
50 that which has been articulated in written or spoken form (Polanyi, 1962, 1967; Nonaka, 1994).
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3 This includes mechanistic scientific knowledge, which is typically systematised,
4 decontextualised and presented in forms that are widely transferable (Norgaard, 1984; Ingram,
5 2008). Of course, many different forms of knowledge inform and are developed within science,
6 one of the ways science moves forward is by trying to solve disagreements between those who
7 hold different knowledge, informed by different methods and epistemologies (Lane, 2001). What
8 is important is that we are aware of the advantages and limitations of the various approaches and
9 types of knowledge so that they can be managed and utilized. Lundvall and Johnson (1994) refer
10 to scientific knowledge as “know-why”, since scientific knowledge partly attempts to
11 understand the underlying principles and theory behind observable phenomena. They contrast
12 this with the “know-how” of local² knowledge, which is primarily tacit, informal, context-
13 dependent and rooted in experience and practice (Ingram, 2008). During the 1970s international
14 bodies emphasized “science” as a key resource for decision-makers, but since then the value of
15 local knowledge and the practices derived from it have been increasingly recognised by
16 international bodies, notably the UNCCD, and by interpretativist and post-modern researchers
17 seeking alternatives to the top-down “transfer of technology” paradigm (Brokensha *et al.*, 1980;
18 Long Martello, 2004).

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21 Another important distinction between knowledge types is the difference between expert
22 and non-expert knowledge. ‘Expertise’ is a depth of knowledge about a system, process, or issue
23 that is distinctly different from the knowledge of non-experts (and may or may not be associated
24 with formal qualifications or credentials). The characteristics of expertise are varied and do not
25 always easily equate to ‘more robust’ or ‘accurate’ explicit knowledge. This is because much of
26 the knowledge is tacit and context dependent. Experts tend to have a deep understanding of a
27 particular issue or system, and are able to draw on their extensive appreciation of it to tackle
28 complex problems. When using expertise for environmental management, it is crucial to know
29 the extent of the expertise of a person and ensure that it is directly relevant to the issue under
30 consideration (Fazey *et al.* 2006a, b).

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33 Different types of knowledge operate at different spatial scales (Wilbanks, 2006), from
34 local knowledge that is generated and applied at the local scale to scientific knowledge that is
35 often more generalized, up to the global scale (Raymond *et al.*, in press). However knowledge
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56 ² This is sometimes referred to as traditional knowledge, endogenous knowledge, appropriate technologies,
57 indigenous techniques, nature-based knowledge, sustainable knowledge, folk knowledge and cultural knowledge
58 (Warren 1993; Tahoun 2003 and UNCCD resolution ICCD/COP(3)/CST/3)
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3 may be produced and applied at multiple scales (see Holling 1992; Brenner 2001). The challenge
4 for knowledge managers is to facilitate two-way interaction between experts, institutions and
5 local interests across these scales. This echoes calls by Ostrom (1990) and more recently by
6 Reynolds *et al.* (2007), for knowledge about human-environmental systems to be hierarchical,
7 nested and networked across multiple scales. Choices of scale also have political implications
8 because they privilege some knowledges over others. For example, choices of geographical scale
9 and boundaries influences decisions about who is a stakeholder (often referred to as the framing
10 of the problem) and hence who's knowledge is considered valid (Brenner 2001; Cox 1998;
11 Meadowcroft 2002; Ostrom 2005). Knowledge management systems must therefore make scale
12 choices transparent and explicit (Lebel, 2006), and recognize the potential for cross-scale
13 linkages between different knowledge systems (Cox 1998; Berkes 2002). While a number of
14 studies provide frameworks for linking institutions and individuals both horizontally across
15 geographic space and vertically across levels of organization (e.g., Berkes, 2002; Dietz *et al.*,
16 2003; Ostrom, 2005; Berkes, 2009), the different ways of managing this knowledge is rarely
17 considered.
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30 Stringer and Reed (2007) argued that by hybridising more explicit scientific knowledges
31 with more implicit local knowledges, it may be possible for scientists and other stakeholders to
32 inform more relevant and effective environmental policy and practice to monitor and tackle land
33 degradation. Sometimes this may be a process of eliciting, combining and building on tacit,
34 implicit and explicit knowledge from different groups to co-generate new knowledge. More
35 often, this is a process of developing the necessary level of shared knowledge necessary to
36 facilitate the exchange of existing explicit knowledge between different groups. However, this is
37 frequently easier said than done. Boyo (2009), for example, traces the tensions between local
38 farmers and agricultural experts in Malawi. Here, farmers' strategies on fertiliser use, mixed
39 cropping and the use of cassava as a nutrient recycling crop are seen as backward, "unmodern"
40 and regressive by external experts, despite the fact that the farmers' strategies offer a manageable
41 approach for them in the context of local environmental and social conditions. Scientific
42 knowledge is often given greater legitimacy than tacit and local knowledge, partly by virtue of it
43 being recorded and made explicit (Jordan and Jones, 1997), and also because of its perceived
44 'power' as being 'objective', 'dispassionate', 'controlled', 'replicable' and 'testable' (Agrawal,
45 1995; Briggs, 2005). Indeed, Mackinson and Nottestad, (1998) suggest that scientific and local
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3 knowledge are “grotesquely unequal” in leverage, particularly with respect to policy formation,
4 where the latter is often entirely overlooked.
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7 In contrast, the approach proposed here (and espoused in the text of the UNCCD) views
8 each form of knowledge as complementary. As such, local knowledge of land degradation
9 indicators may be compared against evidence from research literature (c.f. Reed and Dougill,
10 2002; Stringer and Reed, 2007; Reed *et al.*, 2008). This sort of approach is common in mixed
11 methods research designs, where qualitative research is traditionally used to access local
12 knowledge in an exploratory mode, to generate hypotheses, which are then tested using more
13 quantitative methods (Holland and Campbell, 2005; Morgan, 2007). However, such analyses are
14 problematic due to their implication that scientific knowledge is superior and can be used to
15 “validate” local knowledge. Significantly, the World Bank sought to promote the use of
16 indigenous knowledge in the development effort, but only after it has been tested and legitimised
17 by formal “scientific proof” (World Bank, 1998, p6). As Briggs and Sharp (2004, p667) point
18 out: “... it is still the scientific view, in all its wisdom, that can decide which indigenous
19 knowledge is worthy of serious investigation and dissemination elsewhere”.
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22 Instead, methods are needed that can evaluate, combine and integrate local and scientific
23 knowledge. In response to this need, a growing range of methods and approaches have been
24 developed that can be used for this purpose. These range from participatory, often more
25 qualitative methods where stakeholders and researchers evaluate and co-generate knowledge
26 together to more top-down, often more quantitative methods such as the use of decision-support
27 tools to enhance learning between researchers and stakeholders. For example:
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- 30 • Focus groups and field visits have been used as tools to exchange local knowledge
31 between land managers and researchers from different backgrounds and countries (e.g.
32 Curtin and Western, 2008; Stringer *et al.*, 2008);
- 33 • Affected communities can systematically and critically evaluate local and scientific
34 knowledge of land degradation indicators themselves, using participatory decision-
35 support tools such as multi-criteria evaluation (c.f. Ferrarini *et al.*, 2001). For example,
36 using multi-criteria evaluation, Reed *et al.* (2008) evaluated local knowledge of land
37 degradation indicators with local communities in focus groups, assessed the indicators
38 deemed most robust through field-based research, and then enabled local communities to
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3 evaluate the results of this research through further structured discussions in focus
4 groups;
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7 • Raymond and Brown (2006) and Raymond (2008) used participatory mapping to
8 integrate local and scientific knowledge, expressed as values, for conservation areas in
9 Victoria and South Australia. They were able to measure the level of spatial agreement
10 and disagreement between local and scientific conservation values. The level of spatial
11 overlap of local and scientific knowledge could be used to prioritise investment in
12 environmental management;
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- 14 • “Mediated modeling” and “dynamic systems modeling” provide tools that can build on
15 local knowledge of how complex systems work, basing models of land use systems on a
16 more comprehensive knowledge base relevant to land manager needs and priorities (van
17 den Belt, 2004; Prell *et al.*, 2007; Dougill *et al.*, in press; Fazey *et al.*, 2006b). Dynamic
18 systems models allow users to vary the assumptions upon which the models are built,
19 exploring how sensitive a system is to uncertainties and gaps in knowledge, and
20 identifying potential “tipping points” and “leverage points” in the system where land
21 management or policy decisions may have disproportionate effects. Many of the variables
22 included in such models have the potential to be effective land degradation indicators,
23 and by varying their values it is possible to evaluate the relative sensitivity of indicators
24 that are based upon an integrated knowledge base; and
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- 26 • Computer-based Decision Support Tools (sometimes including simulation models,
27 statistical models, remote sensing or GIS) support decision making by offering
28 functionalities to assess the extent or risk of desertification, to monitor land changes, or to
29 show scenarios of different policy alternatives (e.g. Diouf and Lambin, 2001; Holecz *et*
30 *al.*, 2003; Ochola and Kerkides, 2004). Recent research on the application and usefulness
31 of computer-based decision support tools in desertification policy and management
32 suggests that they play a role in improving communication between stakeholders and in
33 promoting local participation in decision making (Diez, 2008), thereby having the
34 potential to be useful in the integration of local and scientific knowledge. However,
35 current designs have a number of pitfalls that need to be overcome to fully exploit the
36 benefits that computer-based decision support tools may offer in knowledge management
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(e.g. low quality of output information in terms of reliability, relevance and completeness, and the “black-box” nature of their outputs).

Finally, it should be noted that despite the growing range of methods available for integrating different types of knowledge, a number of recent studies are questioning whether it is possible (or advisable) to distinguish between different types of knowledge. For example, Bruckmeier and Tovey (2009) suggest that local and scientific categories are social constructions and are difficult to classify into separate systems of knowledge at the local scale (c.f. Berger and Luckmann, 1967). As such, the merit of categorizing, comparing and contrasting local and scientific knowledge can be debated. Indeed, most producers and users of local knowledge do not distinguish between scientific and local knowledge in everyday practice. For example, Briggs *et al.* (2007) have shown how Bedouin in the Eastern Desert of Egypt incorporate environmental knowledge from all sorts of sources. If it makes sense and can be used within prevailing socio-economic and physical environments, then it is adopted, replacing previous (and now often redundant) ideas. The binary of local and scientific knowledge is irrelevant for these Bedouin in everyday practice.

While some argue that knowledge cannot be categorized on local and scientific grounds (e.g. Bruckmeier and Tovey 2009; Raymond *et al.*, in press), others acknowledge differences, but contend that the two (or more) perspectives viewed in unison produce a more balanced understanding of environmental problems (Sillitoe 1998; Stringer and Reed, 2007). Raymond *et al.* (in press) summarise this as a series of overlapping continua that represent the extent to which knowledge is: (1) locally specific or generalised across regions; (2) formalised; (3) expresses expertise; (4) 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 (Figure 2).

3 A Conceptual Framework for Knowledge Management

3.1 Moving from knowledge transfer to knowledge management: a conceptual framework

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3 Building on the discussion of types of knowledge in the previous section, we define knowledge
4 management as a process of generating, storing and circulating *new* knowledge, and identifying,
5 bringing together, and applying *existing* knowledge to achieve specific objectives (in this case
6 land degradation monitoring) (c.f. von Krogh 1998; Alavi and Leidner, 2001). In some contexts,
7 knowledge management may also include building the capacity of different stakeholders to
8 articulate, share and use knowledge.
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14 Early knowledge management literature focussed on “knowledge transfer” from the
15 producers of knowledge (in the field of land degradation, typically scientists) to those who use it
16 (typically policy makers and land managers) (Polanyi, 1962, 1967). In the context of land
17 degradation, this was embodied in the “transfer of technology” paradigm, which reached its
18 height during the so-called “green revolution” of the 1960s, where mechanised agricultural
19 intensification led to the polarisation of rich and poor, and economic/technological dependence
20 on donor countries (Martin and Sherington, 1997). The transfer of knowledge may well involve
21 its codification or packaging within new technologies, policies, guidelines and protocols. As a
22 result, what was once explicit knowledge may well become ‘black boxed’ and hence implicit,
23 and harder to transfer beyond the context for which it has been designed.
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32 More recently, there has been a shift in emphasis within knowledge management
33 literature and practice towards:
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- i) Two-way knowledge exchange through partnerships between knowledge producers and users (including academics, policy makers, businesses, practitioners and communities). Recognition of multiple bases of expertise suggests a need to move from linear models of *knowledge transfer* to more iterative models of *knowledge exchange* between these groups (Phillipson and Liddon, 2008). Knowledge exchange is also increasingly focusing on south-south and south-north knowledge sharing, as opposed to traditional north-south flows (Stringer *et al.*, 2008);
 - ii) Knowledge generation, where knowledge users can become knowledge producers, potentially collaborating with those who traditionally generate knowledge (scientists) to co-generate knowledge (e.g. Phillipson and Liddon, 2008; Berkes, 2009).

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There are contexts where one-way knowledge transfer is the most appropriate mode of knowledge management. There are also cases in which existing knowledge is sufficient and there

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3 is no need to generate new knowledge. In such cases there may nevertheless be a pressing need
4 to exchange, transfer and/or transform existing knowledge so that it can be put to most effective
5 use (perhaps at other scales or in other locations).
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9 Figure 3 illustrates this view of knowledge management, showing how knowledge is
10 generated, with the potential to store, transfer or exchange knowledge between producers and
11 users of knowledge before it is applied. Knowledge users are a very diverse and dynamic group.
12 As such, people and organisations (e.g. scientists and members of policy and wider stakeholder
13 community) may take on different roles in different parts of the knowledge management cycle.
14 Hence knowledge producers can become knowledge users, and knowledge users can become
15 knowledge producers, thus providing the potential for different actors to co-generate knowledge.
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19 As new knowledge is generated, it may be stored in a variety of ways, for example using
20 memory and mimicry from person to person through generations, or through documentation of
21 knowledge from transcripts of interviews to hierarchical documentation systems (e.g. Enting *et*
22 *al.*, 1999). Preventing the erosion or complete loss of knowledge is a key challenge for
23 maintaining knowledge management systems in the long term. For example, the internet
24 provides a valuable medium to store, transfer and exchange knowledge around the world
25 between those who have access. However, the information on many websites is lost when project
26 funding runs out.
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39 *3.2 Knowledge management mechanisms*

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42 Individuals gain knowledge through a process of changing the way they understand something or
43 the way in which they relate to the world (Fazey and Marton, 2002). This process is generally
44 termed 'learning'. Thus to understand the mechanisms through which knowledge spreads and
45 can be managed, it is necessary to understand the conditions, processes, and sorts of practices
46 that influence how people learn, and through what channels and sources they increase their
47 knowledge.
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53 Learning may occur at the scale of individuals, groups, organisations, "communities of
54 practice" or societies, and a vast literature has developed to understand how learning occurs at
55 these different scales (Blackmore, 2007). Learning may also occur between these scales. For
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3 example, there is evidence that local knowledge can pertain to ecological, biological,
4 geographical or physical processes well beyond their immediate environment (Juma 1989;
5 Norgaard 1984). Berger and Luckmann (1967) argue that informal institutions (in which
6 attitudes and worldviews are embedded) or “norms” guide people’s behaviour. These informal
7 institutions are a product of a specific local context (place, time and shared by a specific group of
8 people), and may gradually change over time e.g. as a result of external influences (Vergunst,
9 2008, 2009).

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11 Of particular interest in the context of global land degradation are mechanisms that can
12 facilitate learning at community or societal scales, from person to person through social networks
13 – “social learning” (Reed *et al.*, in press, Fazey *et al.*, in press). Knowledge exchange and
14 transfer often take place through informal networks as well as through formalised and
15 depersonalised forms of communication such as the mass media. Therefore, a key challenge in
16 knowledge management is to stimulate new exchanges and networks where links are
17 undeveloped (such as the local to national level) and to tap into networks that already exist. In
18 this context, social learning is presented as a way to facilitate shared understanding among and
19 between different types of knowledge through peer-to-peer interactions within social networks
20 (Armitage *et al.*, 2008; Reed *et al.*, in press). By stimulating social learning about land
21 degradation monitoring, it is argued that it may be possible to facilitate the adoption of
22 monitoring tools and approaches, and possibly change attitudes, behaviour and underlying world
23 views towards sustainable land management, at a far greater scale than could otherwise be
24 achieved. Despite this, it should be noted that some knowledge may be traditionally ‘patented’
25 and thus kept confidential by specialized knowledge holders e.g. herbalists/traditional doctors,
26 rainmakers, water prospecting and seasonal predictors. Linked to this, social learning processes
27 may infringe intellectual property if not conducted sensitively³.

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29 Linked to this, there is a great deal of literature and research on the role of social
30 networks, “knowledge brokers” of “intermediaries” and their role in the diffusion of information
31 and knowledge (Hargadon, 2002; Howells, 2006; Klerkx and Leeuwis, 2008; Klerkx *et al.*,
32 2009). There is a rapidly growing literature describing and explaining the way knowledge flows
33 between individuals through social networks, and how this may influence natural resource
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57 ³ This point was made by the Holy See and Brazilian delegations during questions at the first CST Scientific
58 Conference, UNCCD COP-9
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3 management (e.g. applications of Social Network Analysis by Prell *et al.*, 2008, 2009). These
4 methods can be used to explain and potentially predict how knowledge is likely to flow through
5 social networks, depending on the characteristics of the individuals through which it flows. This
6 flow may lead to knowledge “clumps” in certain areas where knowledgeable groups of
7 individuals fail to pass on their knowledge to others (Nissen and Levitt, 2004). By understanding
8 knowledge dynamics in this way, it may be possible to predict how interventions designed to
9 facilitate grass-roots monitoring are likely to play out, and hence to design better interventions.
10 Linked to this, researchers are now coupling agent-based models with models of land
11 management systems to explore how the likely behaviour of land managers may affect
12 ecological functioning and agricultural productivity (Chapman *et al.*, 2009), and to better
13 understand the role of knowledge brokers (Dobbins *et al.*, 2009) and boundary (or bridging)
14 organisations (Cash *et al.*, 2003) in knowledge exchange.

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16 Knowledge brokers and boundary (or bridging) organisations are individuals or
17 institutions that rest between people, groups or institutions that are not connected to each other in
18 any way, facilitating knowledge transfer and exchange between those in their networks. In this
19 position, knowledge brokers and boundary organisations can play both positive and negative
20 roles in the spread of knowledge. For example, they can bring together pieces of information that
21 are scattered throughout a network or at different spatial scales to develop new ideas and
22 applications for existing knowledge that could not have been developed by those holding partial
23 information (Ostrom, 2005; Prell *et al.*, 2008; forthcoming). They may also customise
24 knowledge and technologies for particular end users (Howells, 2006). Their position in the
25 network enables them to diffuse this information and knowledge to parts of social networks that
26 it may otherwise not reach (c.f. Rogers, 1995). Researchers and extension workers can often play
27 this brokering role, documenting and then sharing local knowledge among communities, and
28 potentially adapting this knowledge to new contexts and purposes. For example, Reed and
29 Dougill (2009) developed a decision-support system for Kalahari pastoralists in which they
30 brought together stakeholders who were known as innovators within their communities to
31 evaluate local knowledge from different communities alongside scientific knowledge, to develop
32 new strategies to tackle land degradation. However, a broker may strategically decide to keep
33 certain pieces of information to themselves rather than pass on all information. In a similar
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3 fashion, a broker could potentially distort information as they pass it on to a different individual
4 or group (Burt, 1992; Freeman, 1978; Gould and Fernandez, 1989; 1994).
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7 The role of knowledge broker and boundary organisation may be carried out by a range
8 of organisations and individuals, including think-tanks, consultancies, skills development
9 agencies, knowledge networks and advisers. Knowledge brokers and boundary organisations
10 working at the local level can help local communities articulate their opinions and preferences,
11 transforming implicit knowledge into a form of knowledge upon which monitoring programmes
12 can be based. At the inter-organisational level, those working within a common area must also
13 aim for cooperation as a means to achieve better data exchange and data sharing. For example,
14 Drynet is performing the role of boundary organisation between NGOs, CBOs, scientists and
15 policy-makers working in the field of land degradation and sustainable land management (Box
16 1). Similarly in Namibia, the Forum for Integrated Resource Management (FIRM) works with
17 farmers associations to create a boundary organisation where farmers and service providers get
18 together at grassroots level to exchange information and knowledge on a regular basis (Box 2).
19 As such, NGOs and CBOs may have the capacity to communicate monitoring information from
20 the local level upwards.
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32 Thus, from the preceding discussion, the following could be distilled as the key principles
33 of knowledge management for land degradation monitoring:
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- 35 1. Knowledge is contextual and usually comprises both tacit and explicit elements;
- 36 2. The flow of knowledge can be either inter-level/inter-scale (i.e. vertical) or intra-
37 level/intra-scale (i.e. horizontal) in nature. Commonly there would be co-occurrence
38 of the two flow patterns;
- 39 3. Instrumental (i.e. applied) knowledge (e.g. for land degradation monitoring) flows in
40 multiple directions, consisting of knowledge transfer (uni-directional) and knowledge
41 exchange (bi- or multi-directional). The predominant mode would be determined by
42 context; and
- 43 4. Knowledge management requires sustainable and efficient means of knowledge
44 storage, access and/or brokerage.
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57 **4 Knowledge Management for Local Land Degradation Monitoring and Assessment**

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5 Local knowledge, both current and historic, is essential to monitor land degradation, as it is
6 uniquely adapted to the contexts in which it has been developed and applied, and so can diagnose
7 the sorts of land degradation issues most relevant in any given locale. In addition, indicators⁴
8 based on local knowledge are more likely to be used by land managers, as they are already likely
9 to be familiar and are less likely to require specialist training or equipment (Reed *et al.*, 2006,
10 2008). Thus, development and use of grassroots indicators may help to reduce barriers to more
11 widespread uptake of land degradation monitoring. If clear links are also made between
12 monitoring and land management, it may be possible to create incentives that could facilitate
13 more widespread monitoring by affected communities (Reed and Dougill, 2009). However, the
14 dynamic and context-dependant nature of land degradation means that monitoring needs and
15 relevant indicators may change over time.
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24 Although no evidence exists to assess the current capacity for land degradation
25 monitoring among affected communities, there is evidence that land managers have a
26 comprehensive and nuanced capacity for monitoring, even in recently established agricultural
27 systems. For example, Maasai in Kenya monitor livestock condition to inform their rangeland
28 management (Kipuri, 1996). Similarly, Oba and Kaitira (2006) document how pastoralists
29 characterize semi-arid rangelands in Tanzania as degradable or non-degradable in response to
30 grazing pressure, with reference to soils and vegetation type, and use this information to regulate
31 seasonal grazing across heterogeneous landscapes. Pastoralists in the Sahel monitor grazing
32 pressure and rangeland condition to inform decisions about rotating or relocating livestock
33 (Niamir-Fuller, 1998). Ngugi and Conant (2008) mapped key resource areas in Kenyan semi-arid
34 rangelands with pastoralists, ranchers, scientists and government officials, relying on
35 accessibility and ecological indicators. Similarly, Raymond *et al.* (2009) mapped threats to
36 ecosystem services with Australian land managers and community representatives, and
37 prioritized areas where action was needed by assessing the value of the services under threat.
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49 To fully harness local knowledge for land degradation monitoring and assessment,
50 institutional reform may also be necessary. For example, there has been considerable research on
51 understanding the conditions necessary for long-term monitoring and assessment of natural
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57 ⁴ We define an indicator as a physical, chemical, biological or socio-economic measurement, statistic or value that
58 can be used to assess natural resources and environmental quality.
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3 resources under common property regimes (Baland and Platteau 1996; Ostrom 1990). From this,
4 two general lessons are evident. Firstly, reasonably small commons with clear boundaries on
5 resources and resource users allow individuals to continually monitor conditions as part of their
6 daily activities, by keeping the transaction costs of monitoring low (Quinn *et al.*, 2007).
7 Secondly, traditional institutions tend to have high levels of social capital and facilitate
8 community empowerment and actions. Such mechanisms are built on trust and a history of
9 negotiation and decision making that can overcome the problems of free-riding or the absence of
10 well-defined property rights (Katz, 2000). That is not to say that traditional common property
11 regimes are a panacea for the problems of land degradation. There is evidence for success and
12 failure in the management of natural resources using all types of management regime, from
13 common property to private property (Acheson, 2006). Increasing populations, technology
14 change, global markets and insecure land tenure have all contributed to the failure of traditional
15 common property regimes to prevent resource degradation (Attwell and Cotterill, 2000;
16 Campbell *et al.*, 2001). In contrast, re-coupling communities to their environment can create a
17 vested interest in long-term management of resources (Twyman *et al.*, 2001). For example, the
18 BIOTA Southern Africa project⁵ has trained local ‘para-ecologists’ to carry out degradation
19 assessments and monitoring, allowing communities access to up-to-date information that is used
20 to inform local management decisions (Schmiedel, 2006). The security inherent in communities
21 that have autonomy over local resource management can benefit conservation through
22 sustainable resource use. Chhantre and Agrawal (2009) found that communities were more likely
23 to conserve the resources in community-owned forest commons for future use compared to
24 government-owned forest where communities extracted resources of livelihood benefit at a
25 higher rate.

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44 To further harness local knowledge for monitoring and assessment there is an urgent need
45 to identify and share good practice in monitoring and assessment amongst affected communities,
46 both within given locales and between affected communities in similar contexts internationally.
47 This is especially important given the erosion of local knowledge in many affected communities
48 (e.g. through the effects of HIV/AIDS). The long-term retention, implementation and evolution
49 of inter-generational local knowledge are threatened by a range of factors. For example, the
50 sedentarisation of nomads in the semi-arid and arid north-eastern Sudan is leading to a loss of
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58 ⁵ www.biota-africa.org
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3 environmental knowledge as it becomes less relevant to successive generations (Akhtar and
4 Schutzbar, 1994). This is also happening among Bedouin from the Eastern Desert of Egypt, who
5 migrated from the desert to the Nile Valley towns (Briggs *et al.*, 2007). Not only is this
6 knowledge lost by the next generation, but even for the migrants themselves, detailed
7 environmental knowledge is quickly lost or only fuzzily remembered within 5-10 years. Formal
8 education may lead to further losses, given the low value afforded to local knowledge in many
9 education systems. Elsewhere, pressure to continue providing more food for rapidly growing
10 populations has compelled many communities to abandon (both the use and transmission to
11 future generations of) valuable local knowledge and skills in monitoring and responding to land
12 degradation. Although there have been many successful attempts to protect local knowledge
13 through documentation and inventories (e.g. Sallu *et al.*, 2009), knowledge is only shared,
14 preserved and developed if it is used. Thus, developing better understanding of the wider
15 proximate and ultimate drivers and factors that are reducing tendencies and processes for
16 communities to learn and share information about land degradation will be required if existing
17 capacities are to be maintained (Fazey *et al.*, In Press)

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20 Identifying local good practice in land degradation monitoring and assessment is vital.
21 However, despite frequently being seen as a panacea for a new and sustainable development, the
22 use of local knowledge systems is not unproblematic. For example, understanding complex
23 power relations within communities can be a challenge, and because local knowledge is so
24 empirically rooted, there may be a tendency to ignore power relations and so there may be no
25 check on whose view might be the legitimate one (Kapoor, 2002). Nonetheless, this issue cannot
26 be sidestepped, and the power and positionality of actors in these debates must be evaluated
27 critically (Twyman, 2000). There is also the potential danger of romanticising local knowledge
28 systems (Schroeder, 1999; Maddox *et al.*, 1996), or seeing them as static and unchanging
29 (Bebbington, 1993; Kalland, 2000). Some writers are equally concerned about the
30 decontextualisation of local knowledges, and stress that they are fundamentally embedded within
31 the societies within which they were developed and therefore should always be interpreted
32 within their economic and socio-cultural contexts (see, for example, Pottier, 2003).

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35 Local knowledge is not always gender or class neutral. For example, Tlhalerwa (2007)
36 revealed the gender-specific nature of local knowledge in Botswana and cautioned that the use of
37 local knowledge may perpetuate or even exacerbate gender gaps. Research in Egypt has reached
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3 similar conclusions, but, in addition, noted that such gender gaps in knowledge can result in
4 women's greater empowerment in the household and sometimes beyond (Sharp *et al.*, 2003;
5 Briggs *et al.*, 2003), and Andresen (2001), working in Nigeria, has drawn attention to the fact
6 that women's environmental knowledge repertoires can be rather different from those of men,
7 something that Engel-Di Mauro (2003) suggests is related to the everyday lived practice of
8 agricultural activity.
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12 Equally, scientific knowledge should not be uncritically accepted without evaluating the
13 uncertainty and associated value judgments in the claims being made (Failing *et al.*, 2007). For
14 example in Australia, Aboriginal knowledge has been repeatedly used to expose the limitations
15 of short-term ecological research (Baker and the Mutitjulu community, 1992). If local and
16 scientific knowledge are both to be used, it is still necessary to subject each to an appropriate
17 level of scrutiny before considering what exactly may be integrated to deliver what may be
18 termed "socially robust" indicators that are both understood and will be applied by stakeholders
19 (Nowotny, 2003). Raymond *et al.* (in press) provide a process for scrutinizing both local and
20 scientific knowledge during both project design and delivery.
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25 After good practices in land degradation monitoring have been identified, integrating
26 local and scientific knowledge where appropriate, it can be helpful to share these lessons as
27 broadly as possible among affected communities. To do this, different mechanisms are relevant
28 at different scales. At local scales, there are a wide range of participatory tools that can achieve
29 this. For example, Reed *et al.* (2008) used village focus groups and multi-criteria evaluation to
30 disseminate indicator knowledge amongst the affected communities they worked with, and then
31 used decision-support manuals to disseminate these indicators and related sustainable
32 management strategies more widely (Reed and Dougill, 2009). At district scales, Raymond and
33 Brown (2006) used participatory mapping to integrate local and scientific knowledge, expressed
34 as values, for conservation areas in Victoria, Australia. They were able to measure the level of
35 spatial agreement and disagreement between national park designations identified based on local
36 values and scientific values, respectively, with the results used to prioritise investment in
37 environmental management. Local communities represent an essential source of information for
38 many of the variables relevant to land degradation monitoring, some of which cannot be
39 collected through conventional research methods or are difficult to obtain within the timeframe
40 of single projects. Whatever the scale, a key aspect of good practice is to find ways of
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3 embedding local or other stakeholders in a process that facilitates learning and interaction (Pahl
4 Wostl, 2009). This potentially changes the way knowledge generation is perceived, with practice,
5 learning and research becoming more intertwined and where distinctions between knowledge
6 generation, dissemination, and implementation become increasingly blurred.
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10 Of course, there are many limitations to participatory approaches (Cooke and Kothari,
11 2001; Campbell and Vainio-Mattila 2003), a principle one being the limited spatial scales at
12 which they can operate effectively. Focus groups and field visits have been used as tools to
13 exchange local knowledge between land users from different countries, but this is generally quite
14 rare (see Box 1). Most knowledge management systems share local knowledge at this sort of
15 scale using Information Technology (IT) (for example, WOCAT). However, IT has its
16 drawbacks: it is not accessible to everyone, and though it makes information widely accessible,
17 knowledge exchange (as opposed to just information exchange) takes place most effectively
18 from person to person through shared dialogue and learning (Pahl-Wostl, 2009). Having said
19 this, there may be opportunities to use IT for knowledge exchange by gathering local knowledge
20 across large and disparate areas, then refining, harmonising and redistributing the collated
21 information between comparable sites at broader spatial scales (e.g. WOCAT).
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25 Finally, for land degradation monitoring and assessment to be adopted and reported by
26 land managers, it must effectively contribute to decision-making, providing real benefits to those
27 who make the measurements. However, conventional decision-support systems are often difficult
28 to implement and information derived is too generic and too late for local land users to make
29 appropriate pro-active decisions (Klintonberg *et al.*, 2008). For this reason there are a growing
30 number of attempts to develop decision-support tools in which land managers can use the results
31 of monitoring and assessment themselves to enhance the sustainability of land management and
32 agricultural production (e.g. Kellner and Moussa, 2009; Reed and Dougill, 2009; Box 2).
33 Organizing and recruiting stakeholders to these activities – and keeping their interest during
34 monitoring and decision-making processes that unfold slowly – is a particular challenge when
35 the object of monitoring and assessment is relatively intangible and in the absence of a perceived
36 ‘crisis’ or ‘threat’. Box 2 suggests that farmers may be motivated to continue collecting data if it
37 feeds into immediate decision-making. Others may want to be assured that results will feed into
38 higher level decision-making processes at national scale (Pahl-Wostl and Hare, 2004). A better
39 understanding of what would enhance the transfer of local results to decision makers may
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3 increase participant motivation. A lack of transparency regarding the processes and pathways
4 linking research, managers and decision makers at different levels may discourage stakeholders
5 from attempting to influence decisions on a larger scale and contribute to a sense that their
6 contributions are not acknowledged or valued.
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10 11 12 13 14 **5 Conclusion** 15

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17 In summary, knowledge management is a process that does not just involve the generation and
18 exchange of data or information: it also requires the development of mechanisms that promote
19 change in understanding of the individuals involved and the cogeneration of new knowledge
20 through the networks and participation of a wide range of individuals. Knowledge management
21 also involves maintaining stocks or reservoirs of knowledge. It may also prevent outdated
22 knowledge from leading to counter-productive responses to land degradation. Knowledge
23 management requires sustainable and efficient means of access and/or brokerage. When carefully
24 designed, such processes have the potential to change basic understandings of key issues. They
25 can also facilitate changes in the higher order thinking that influence the broad strategies that are
26 used to achieve the desired outcomes, such as improved monitoring, assessment and
27 management of land degradation.
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31 The scientific literature offers us many options for monitoring and assessing land
32 degradation. But if we are to capture the dynamic, context-dependant and value-laden nature of
33 land degradation, we cannot overlook the equally valuable but often unrecognised knowledge of
34 local communities and the NGOs, CBOs and Civil Society Organisations that work with them.
35 Some argue that local knowledge is not reliable enough to inform monitoring and assessment.
36 But there are just as many who are disillusioned with scientists who got it wrong and who may
37 have inadvertently contributed to the design of poorly implemented processes that failed to
38 capitalize on local motivations, interests, and needs. Knowledge that is available from different
39 sources needs to be critically assessed, recognising the different epistemological perspectives and
40 ways of knowing of land managers and scientists. This needs to be conducted in ways that ensure
41 that the most relevant knowledge is used and that combines and shares insights from many
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3 different sources. By doing this, we have the potential to monitor and assess land degradation
4 more effectively and more efficiently.
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For Peer Review



Figure 1: Thorny bush encroachment in Boteti, Botswana: a resource for browsers (Photo: R. Chanda, 2009)

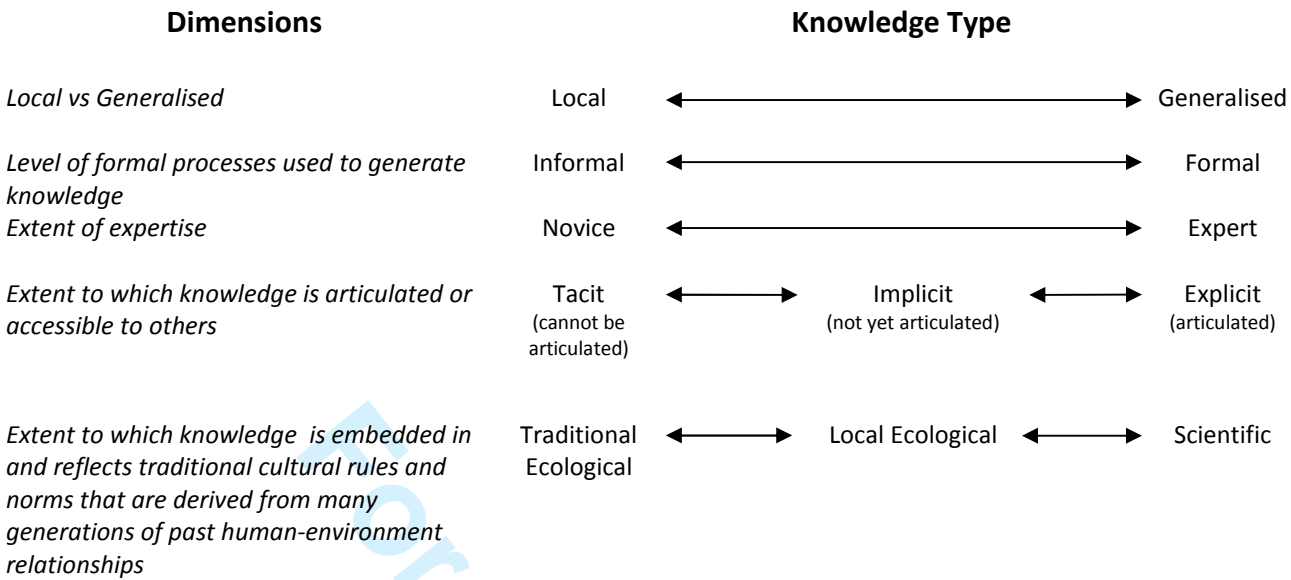


Figure 2: Different types of knowledge, showing a series of overlapping continua that exist in the literature (from Raymond *et al.*, under review)

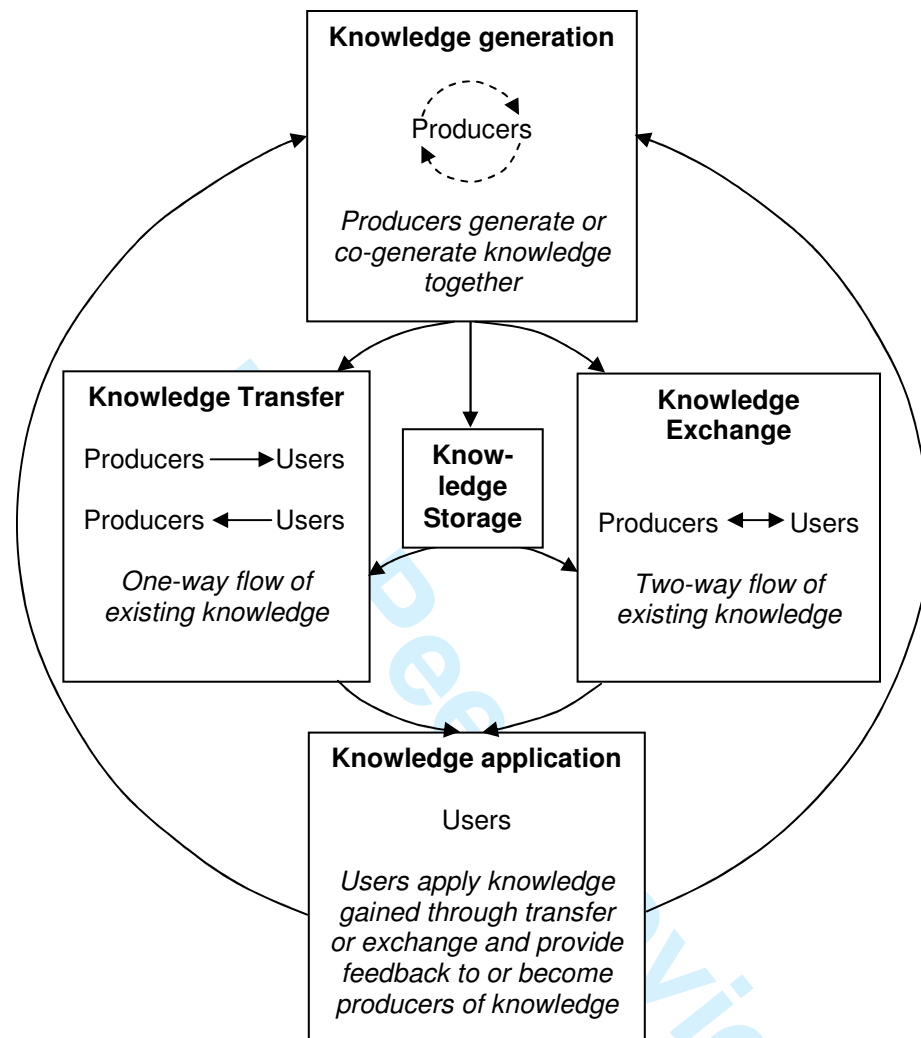


Figure 3: Modes of knowledge management, showing how knowledge is generated, with the potential to store, transfer or exchange knowledge between producers and users of knowledge before it is applied. People and organisations (e.g. scientists and members of policy and wider stakeholder community) may take on different roles in different parts of the knowledge management cycle. Hence knowledge producers can become users of knowledge, and users can become producers of knowledge, providing the potential for different actors to co-generate knowledge together. A key challenge is therefore to find mechanisms that break down traditional linear modes of knowledge production, dissemination, and implementation, and see all stages as processes for mutual learning, dialogue and providing motivation for real and sustained action.

Box 1: Horizontal knowledge management success stories from Drynet

Rather than dissect our failures, by looking for and learning from success stories, it may be possible to spread knowledge more widely. However, the context-specific nature of case studies means that we cannot just identify success stories with the assumption that knowledge will indeed spread to those who need it. Several other factors play a role in whether a particular local technique or approach spreads or not, for example: i) the extent to which the knowledge is context specific or more widely generalisable; ii) the extent to which the knowledge provides a good return on investment within a reasonable time frame for others to adopt it; iii) a technique or innovation should not demand a large amount of labour or capital; iv) the presence of institutional collaboration, existing networks or non-state agencies that can provide extension services and facilitate exchange of knowledge. Therefore, before success stories can become a vehicle for knowledge exchange, a close look is needed on why something is a success, and what elements are transferrable to other contexts. The way in which these stories are conveyed is also important. For example, a field visit may be far more effective than written documentation.

Drynet (www.dry-net.org) is a networking and capacity building effort of 14 CSO partners from around the world. Within the Drynet project, success stories (called “inspiring initiatives”) are documented and made public. The stories describe initiatives of various actors such as local soil and water conservation techniques, innovative ways to share information at local or national level, or successes in influencing national policy. They serve to inspire policy-makers as well as fellow practitioners. To ensure successes are spread effectively, additional activities are planned, such as selected exchange visits between practitioners within a country (horizontal knowledge exchange) and for national decision-makers to visit local projects (vertical knowledge exchange).

Another important lesson is to distinguish between the spontaneous spread of successful strategies and practices at grass roots level, and the role of external agents such as donors and development agencies in actively promoting this diffusion. The experience of the Drynet partners is that such external organisations can and should play an active but background role in the process. They should help to identify success, and facilitate their spread, including the provision of the necessary enabling conditions. But the lead role in the process should be taken by resource users and their local organisations. This means that there should be enough incentives for local land users to share their knowledge, for example by ensuring they learn something from others in return that they can use, by compensating them, or by ensuring somehow that they contribute to a process of change relevant for them in the future.



A participatory mapping exercise carried out as part of the Birjand Carbon Sequestration Project which is part of Drynet, finding cost-effective ways to rehabilitate degraded rangeland

Box 2: Forum for Integrated Resource Management (FIRM), Namibia

In Namibia a local monitoring system involving local community members was first developed for monitoring of wildlife in the Grootberg conservancy in north-western Namibia (Stuart-Hill *et al.*, 2005). This approach was adopted and further developed into a tool that can provide local farmers with relevant information (Klintonberg *et al.* 2003, 2008). The methods developed are specifically designed for communal farmers and their unique requirements in mind based on indicators identified by the farmers themselves. The LLM system provides detailed, relatively immediate and useful information needed for improved management of rangelands (Klintonberg *et al.*, 2008).

Recording of observations made by the farmers is an important part of the system. Most farmers, as part of their normal procedures, make decisions based on one or several environmental (or social) indicators. However, observations are seldom systematic or recorded. Information is often lost, as the memories fade and get mixed up between years. By recording his/her observations the farmer obtains a better understanding of how variable environmental conditions, e.g. amount and seasonality of rainfall, influence the state of the environment and his/her agricultural production. Secondly, by recording each observation in the prepared field guide, a historical record is created, which allows the farmer to compare conditions over the years and also to compare with fellow farmers in community Forums for Integrated Resource Management (FIRM) or comparable CBO (Kambatuku, 2003b; Klintonberg *et al.*, 2008; Kroll and Kruger, 1998).

FIRM is an approach designed to put rural communities in the driver's seat in terms of their own development. It involves a Community Based Organisation (CBO) of rural farmers taking the lead in organising, planning and monitoring their own development while coordinating the interventions of their service providers (Kruger *et al.*, 2003; Kruger *et al.*, 2008; Stringer *et al.*, 2007).

The joint discussion of results amongst farmers in a community FIRM is one of the key features of the LLM system, providing an information base for joint planning and decision making. Information generated through this farmer driven monitoring is ideally forming a central part in planning and decision making done by FIRM groups (Kruger *et al.*, 2008). At the same time, having a record supports the farmers in their communication with service providers, other natural resource managers and policy makers.

Research combining scientific observations and traditional knowledge held by local farmers has been carried out in central northern Namibia by various 'boundary organisations' (Klintonberg *et al.*, 2008; Klintonberg and Verlinden, 2008; Verlinden and Dayot, 2005; Verlinden and Kruger, 2007). By comparing results from a national land degradation monitoring system (Klintonberg and Seely, 2004) with local perceptions of environmental change, Klintonberg *et al.* (2008) could show that local perceptions corresponded with environmental changes identified by national monitoring. However, it was also shown that information given by local farmers revealed a more complex picture of causes and effects of environmental changes compared to the variables used for national level monitoring. It was therefore concluded that traditional knowledge held by local farmers could contribute meaningfully to improving national indicators when communicated through inter-level linkages.

This example illustrates the value of integrating traditional knowledge into scientific investigations of environmental change and land degradation based on an inter-level exchange of information. Integration of traditional knowledge improved the understanding, by scientists and the local community, of the complex systems being investigated. By involving the local equivalent of a FIRM and ensuring information flow between community members and scientists, results can be used by all participants, e.g. (Seely, 1998; Seely *et al.*, 2006, 2008). Moreover, as the research results are conveyed to different levels, communication pathways remain open by involving the FIRM and its members and service providers as possible.