# Knowledge sharing technologies to support community participation in natural resource management: a research agenda

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## Abstract

In natural resource management (NRM), people and communities communicate, interact and interrelate though social and institutional networks. In such a complex physical world, knowledge sharing takes place through three types of interactions: people with information, people with people and people with ecosystem models (terrestrial, aquatic, agricultural ecosystems). While Information and Communication Technology (ICT) has devoted much of its effort in supporting the first two interactions (e.g. document management systems, computer supported collaborative work), little has been done for supporting the interaction between people and ecosystems models. Our aim is to design and evaluate a web based knowledge sharing environment to support community participation in NRM. The backbone of such an environment is an open, dynamic and evolving knowledge network composed of documents, knowledge models (ecosystems models, data models) as well as people. This paper describes our research agenda, our research framework and our overall approach in the context of our work in CSIRO Healthy Country Flagship Program.

## 1. Introduction

*" Sustainability is better seen as a measure of the relationship between the community as learners and their environment rather than an externally designed goal to be achieved "* Sriskandarajah [Sriskandarajah et al, 1991].

In Australia the water crisis is worsening, there is a major problem with drought and our use of natural capital is not sustainable. The community is crying out for sustainable solutions. This has lead to one the biggest consultation exercises in NRM undertaken in Australia and involving government, industry, the community, CRCs, universities and CSIRO. All these stakeholders took part in the formulation of the business case of the CSIRO Healthy Country Flagship program [CSIRO 2003].

The Healthy Country Flagship program's aim is to achieve sustainable natural resource management (NRM) through informed participation by engaging community and stakeholders groups. A prerequisite to efficient, constructive participation is that community and stakeholders groups have access to different knowledge sources, are more closely attuned to the different issues and viewpoints, and are sufficiently equipped to understand (and maybe resolve) complex issues (salinity, ecosystem stability, erosion, grazing, nutrients, etc). Our objective is to research and develop methods and technologies for supporting informed decision making in NRM through knowledge sharing, communication and understanding. In NRM, people (farmers, catchment management staff, agents, local council etc.) and communities communicate, interact and interrelate though social and institutional networks. In such situations knowledge sharing takes place in three types of interactions: people with information, people with people, and people with ecosystem models (terrestrial, aquatic, agricultural ecosystems).

While Information and Communication Technology (ICT) has devoted much of its effort in supporting the first two types of interaction (e.g. document management systems, computer supported collaborative work), little has been done for supporting the interaction between people and with ecosystems models. Traditional knowledge sharing approaches in the form of searchable document repository only support people with information interaction. Our research challenge is in addressing the gap. We aim to provide access to a rich, open and evolving knowledge network composed of documents, ecosystems models, knowledge models as well as people. Members of the community will access the knowledge network through a portal to seek information, manipulate and explore individually or collectively the various ecosystem models and finally contribute to the knowledge network regarding sustainability in their local areas and the region.

Our paper is organized as follows: section two presents some knowledge management issues related to natural resource management decision making; section three presents some technological approaches to supporting knowledge sharing; section four presents our research framework and section five describes our research agenda.

## 2. Knowledge management issues in natural resource management decision making

As stated by Allen Kearns [Kearns 2003] a sustainable approach to NRM involves three types of communities: the social community of practice (e.g. the local community: land holder, householder etc.) the community of cognitive enquiry (e.g. the scientists), as well as the community of political interest (e.g. the wider society). The search for sustainable solutions requires these communities to interact, share and create knowledge together.

Another challenge is due to the fact members of the community often are in direct conflict of interest. For example in Queensland, sugar cane growers using pesticides for improving their cane production may have an impact on the tourism industry. The use of pesticides leads to a leakage of nutrients into the rivers, impacting the quality of the water of the rivers which then affects the Great Barrier Reef and its ecosystems. In this

situation, sugar cane growers are in conflict of interest with environment protection agencies and tourist agencies.

From discussions, in particular with a catchment management authority staff in regional Victoria, we observe:

- Little knowledge generated in science is directly impacting on the practices/decision making within the communities. NRM plans and strategies need to be continually adapted to reflect new scientific knowledge. Managers need to access knowledge and tools that both integrate current scientific understanding of the impacts of alternative decisions and provide effective means of collating, interpreting and using that information (Walker et al 99).

- Land managers are central to achieving sound management of land, water and vegetation resources and to addressing critical issues such as salinity, yet they do not always have the required information to make sound decision about the management of natural resources.

- Natural resource management options are not easy to identify due to the limited information on the economic and environment cost and benefit of different management options. Increasingly, a combination of social, economic and environmental (biophysical) information, as well as associated models, is needed for ecologically sustainable development principles to be applied in NRM decisions. Currently, even when this information is made available, it is difficult to judge if the information is appropriate for the intended use (scale, indicator).

- Local and indigenous knowledge is not always taken into account. This leads to reduced community ownership of local problems, and little adoption of new methods and policies ( see Productivity commission Report Feb 2003).

- There is little understanding of other stakeholder's views and issues.

Natural resource decision making environments can be characterized by:

- Complex decision making and competing interests and goals: Natural resource management in the age of sustainability is not characterized so much by problems for which an answer must be found, but rather issues that need to be resolved and will often require one or more of the parties to change their views. This requires the creation of new knowledge that can deal with ill-defined tasks, in which objectives are hard to define, decision making is uncertain, measures of performance do not exist yet and human behavior is not always rational.

- Various experts and practitioners from various institutions. They may include experts in hydrology, biodiversity, economy, land management and irrigation experts. These experts use various data types (textual, spatial, geographical and economic data); have diverse mental representations of the various issues/problems at stake may use various modalities of communication

(unstructured text, graphical representation, model etc.) and come from a wide range of organization.

We have established that support for knowledge sharing is key to searching for sustainable NRM solutions. Knowledge sharing need to take place among various communities (social, cognitive and political) using various information types (databases, documents, decision support systems, ecosystem models, etc.) and engaged in ill defined, complex tasks with conflicting goals.

In the next section we review some existing approaches to knowledge sharing.

# 3. Some technological approaches for supporting Knowledge sharing

As global competition based on knowledge intensive products/services rapidly increases, many organizations are seeking ways to harness knowledge through business strategies and Information Communication Technology (ICT). Computer networks, Internet and Intranet, e-mail, bulletin boards, groupware, workflow, news groups, data warehousing, decision support systems, Lotus Notes etc. have already become an important medium for knowledge creation, sharing, and transmission (which are core to knowledge management) [Liebowitz 99, Macintosh 94, O'Leary 97].

Research in technologies for supporting knowledge sharing often uses a combination of the following approaches:

- The data/document approach in which data bases and documents based repositories with associated data mining and search engines facilities.

- The knowledge based approach in which knowledge models in the form of ontologies [Gandon 2001], [Decker et al 99], in the form of Cases representing past experiences [Simon et al 95], in the form of best practices/lessons learned [Alem 98A] are codified and represented, and in which distributed knowledge servers are being designed [Gandon et al. 2002].

- The people finder approach with associated Yellow Pages, Expert Finder [Mclean et al 2003], [Craswell et al 2001], peer helper technologies [McCalla et al]. Framework presented by Alem and Mclean [Alem & Mclean 2003] where the lessons learned corporate memory is coupled with people finder capability.

- The collaborative approach CSCW, Video conferencing, mind mapping technologies [Waern 1996]. Work by (Kethers et al 98) uses knowledge models (a conceptual model of the domain and a meta model describing the terminology structure) for supporting collaborative work

- The community centered approach call on people interaction with associated, online communities (online Communities of Practices COPs and communities of

interest COIs) chat rooms, or bulletin boards technologies [Preece 2002], [Brown et al 99], [Walker 2003].

Limitations of current approaches are:

- The database, document and knowledge based approach often operate in a very constrained environment where the tasks people are engaged in are well defined, the people are collaboratively working towards a common goal, people are within a similar practice (automotive engineers, aerospace engineers, offshore oil operators) and/or within one organization whose leaders are supportive of knowledge sharing.
- The knowledge based approach is often very labor intensive: building the ontology, maintaining it, manual annotation of documents, etc. There is a need for a more cost effective approach (light weight approach). Also, as far as we know, the knowledge based approach has dealt mostly with representing and exploiting ontologies and lessons learned models. We do not know of any work using this approach that represents and exploits more physical models (of ecosystems for example).
- The community based approach is often restricted to supporting one specific practice; e.g. farmers [Walker 2003]; health practitioners [Preece 2002].
- As far as we know little has been done in linking the community centered approach with the document and knowledge approach.
- Impact of knowledge sharing is not evaluated. Important questions, such as whether knowledge sharing let to learning, better community understanding, and better environment management, need to be addressed.

In NRM we deal with situations where members of the community are from different practices and, in some cases, in direct conflict of interest. Also, as stated in the introduction, decision making in the context of NRM decision making is a complex process, ill defined and therefore hard to formalize.

These needs suggest that supporting knowledge sharing in NRM requires an integrated approach, combining a community centered approach, with data, document and knowledge-based approaches, supporting not only document sharing, but also idea and view sharing and collective exploration of ecosystem models in an open, evolving and networked information environment.

## 4. Our proposed approach

Our aim is to support individual participation as well as group participation, in an knowledge sharing environment where relationships between participants are being developed (collaboration models, social network), resources are being used (models, documents, web resources), new information/knowledge is created and shared

(collaborative design of NRM plans and strategies, collaborative design of biophysical models) and learning is supported (e-learning).

We propose to integrate a community centered approach with the data, documents and knowledge approach in an open and rich information environment composed of:

- Moderated discussion forums to support online community (the discussions will tap into local knowledge, individual views etc.)
- Documents (local as well as scientific knowledge) and data
- Knowledge models (scientific knowledge, domain models, user models)

This environment will provide participants with a set of knowledge sharing services, which includes tailored information delivery, support for participation and e-learning as will be described in the section 5.

We therefore propose a portal (Figure 1) that incorporates the three dimensions: information (documents), discussion (forum) and knowledge models (domain knowledge, user models, biophysical models, simulation models), all dynamically evolving through users' participation (as suggested by the big arrow).

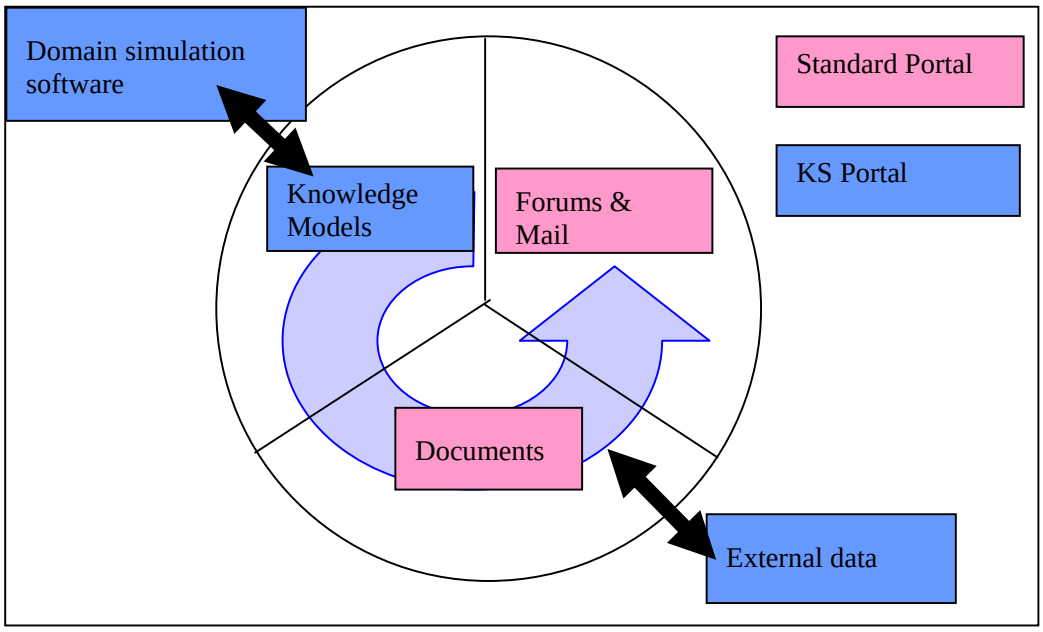


**Figure 1: The knowledge sharing portal**

Central to our approach is the notion of designing lightweight/shallow models (see example below) and leveraging on these models for the design of the knowledge sharing services. This approach we believe is more cost effective then the knowledge intensive approaches such as [Gandon et al 2002]. As well as providing simple navigation and concept search, such shallow knowledge models will be used to improve the delivery of information to participants (see section 5).

Figure 2. gives a simple example of a knowledge structure for the physical and ecological character of landscape systems in a given catchment. We envisage that this knowledge would contain links between elements (in this case, topics and issues), perhaps of varying strength or importance, that can be used to improve the quality and relevance of information delivered to a participant in response to an information need. For example, consider a user who has just registered with the Corangamite portal and is interested in shallow marshes in this area. Knowing that "nutrients, salinity and land clearance" are the major issues for this topic will enable the system to automatically gather and present the relevant information so that he can quickly see the current state of affairs.

## Topics

### Landscape Systems

| Terrestrial | Flowing waters | Still waters |
|---|---|---|
| Plains<br>Alpine regions<br>Non-alpine ranges and their foothills<br>Coastal | Highland streams<br>Foothill waterways<br>Lowland waterways | Saline lakes<br>Ephemeral saline wetlands<br>Shallow marshes<br>Deep Marshes<br>Water-meadows<br>Billabongs |

## Issues

| Physical – Chemical | Ecological -- Biological | Overt Physical Disturbance |
|---|---|---|
| Salinity<br>Water Regimes<br>Erosion<br>Nutrients<br>Pesticides, Herbicides<br>Toxic Pollutants (not pesticides/herbicides)<br>Climate & Weather | Ecosystem stability, population genetics & dynamics<br>Pest Plants<br>Pest Animals<br>Diseases<br>Grazing | Land clearance<br>Drainage<br>Hunting, & collecting |

**Figure 2: Part of a simple knowledge structure could be a hierarchy of topics and issues for a particular catchment authority**

We also promote the notion that the portal should be open and able, where appropriate, to take advantage of external information. One example is simply using external web resources that are well known sources of domain specific knowledge such as Department of Sustainable Environment (DSE), CMA, Department of Primary Industry (DPI), etc. Information delivered to a particular user in response to a query may not just come from information captured within the portal, but also from external web sites and databases.

## 5. Our research agenda

A basic knowledge sharing system can be seen as an advanced knowledge portal that allows community members to:

- Access all the information they need through browsing or querying the portal
- Add documents and new information
- Interact online with other members through various discussion forums. Past discussions are made accessible to the participants.

Such portals do not directly facilitate or support the elicitation of existing knowledge or the creating of new knowledge as the result of the interaction between the participants. They are also limited to information that has been explicitly added to the portal by a participant or a facilitator. We propose a portal that extends the classical portal architecture in three ways: 1) we add an explicit knowledge model level to support better access to and understanding of information, 2) we open the portal to external web sources that are dynamically added to the portal and 3) we offer a participation component that elicits people expertise, roles, networking and involvement in discussion. We further detail those features below.

**Knowledge Models**

As shown in figure 1, we first propose a knowledge portal that incorporates the three dimensions: information (documents), discussion (forum) and knowledge models (user models, biophysical models, simulation models).

Our approach is to leverage on explicit representations of the models to provide better information to the participants in several innovative ways

- model-driven navigation and enhanced search in the portal. This allows access to the information at a more conceptual level and enforces conceptual learning. For example, in response to a query about “salinity”, the responses could be organized by topics such as “terrestrial” “lentic”, “lotic” and their subtopics. The technical challenges here are 1) to extract (or capture) metadata that map with possibly

evolving knowledge models, 2) to select the part of the model that is relevant to the query and/or the answers.

- personalized information delivery: since participants register to the portal we can capture directly and indirectly their profiles. Individual or stereotype profiles are used to select and organization information according to user's interest, background and preferred conceptual model. Profiles will evolve through the active participation of the user, for example when posting a document or engaging in a topic discussion. The approach here could be to build different predefined "views" of the models of interest. Views may be display/browsing views associated with a model, or different conceptual views associated to the same ecosystem model.

- group delivery to support discussion. To enhance mutual understanding, each participant in a discussion will have access to the different views of the models that better represent how the others may understand a given model.

- finding the right person to engage with. The portal will offer a People Finder tool that helps to locate people with the required expertise together with some evidence of the expertise. A facilitator can use this tool to solicit an expert to engage in a current discussion.

- developing new models as a result of the discussion. The system will offer a tool to express new models designed by the participants. New models will be dynamically integrated in the system and immediately activable.

We are particularly interested in evaluating which knowledge models are appropriate and what is the required level of simplicity/complexity to be effective.

**Open Environment**

Second, we propose an architecture where relevant web resources can be automatically incorporated to the portal, either permanently or as an expanded answer to participant's need (posting in a discussion forum, search query). We call it an "augmented portal". Web resources include pages from other portals, or documents related to the participants (e.g. their home page). The challenge here is to develop algorithms for scoping what to include on the portal, for example algorithms for identifying the type of information or the quality of information.

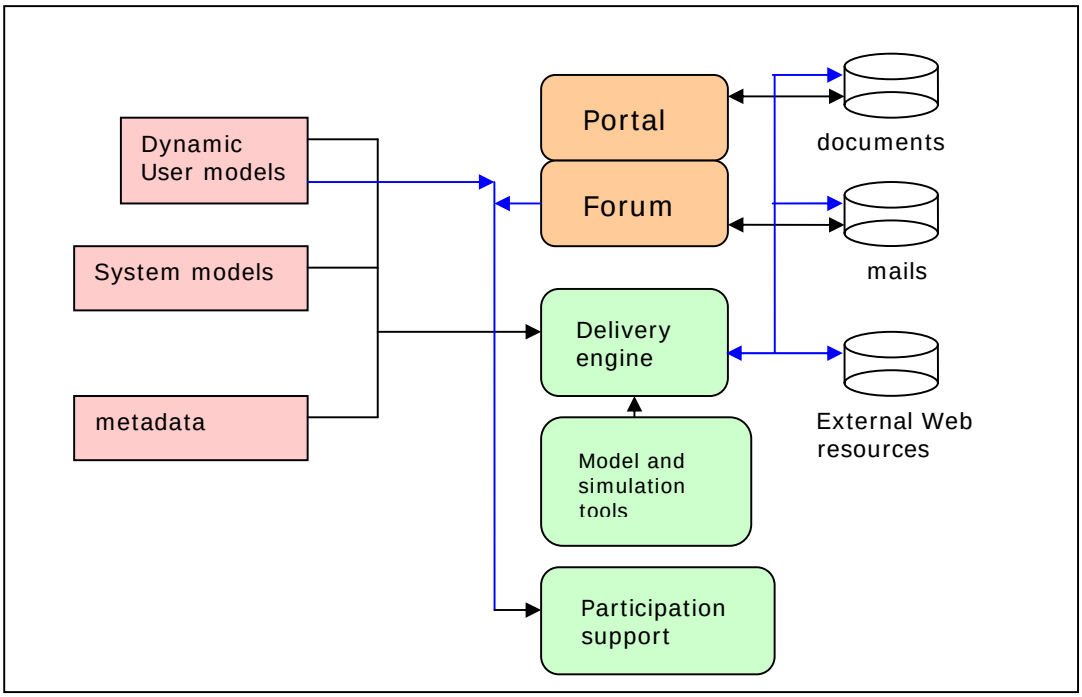


**Figure 3. The KS Portal components**

## Participation and Awareness

Finally we will design and implement support for participation and awareness. Our approach will be to model individual users and their level of participation in a given discussion, as well as the group connectivity over time. It involves the possible following tools:

- group awareness tool: measuring the level of participation, analysing the participation process (social proxy, trust etc..), evaluating individual credibility (expertise, reputation, contribution, social network)
- connected presentation of the information : links between discussion, models and documents
- support for facilitator role, such as authoring tool for the mediator to capture where the discussion is at.

We are particularly interested in evaluating these tools in the broad context of the HC project. In particular we want to evaluate:

- the adoption of the tools by various projects in HC, to what extend this approach supports participation, and more generally how there are suited for supporting groups of people in achieving their goals.
- the level of participation, the actual outcome of the participation process (e.g. new models, new documents, new processes, trust, awareness).

CSIRO HC is a live project and there are both immediate and longer term needs for knowledge sharing. Our pragmatic approach has been to engage with different stakeholders to determine the core needs and to start from a simple, off-the-shelf web tool that allows people to start sharing knowledge as soon as possible. Our initial implementation provides a basic web presence and includes tools for document management and discussion forums as there was an immediate need to distribute project information within the CSIRO HC teams. Our next iteration will upgrade this "cobbled-together system" to a more sophisticated on-line content management system, while developing the next generation tools to support community participation.

Figure 3. Gives an overview of the KS system components we intend to develop. It shows the standard portal and forum we will start with, then the more advance tools we will develop and how they interact with the data and the models.

## 5. Conclusion

In this paper we have presented an agenda for researching knowledge sharing technologies for supporting community participation for natural resource management. We have examined the domain, looked at the particular needs of various stakeholders and potential case studies and have distilled out a number of requirements for a knowledge sharing solution. We have proposed a solution architecture and a number of potentially valuable technologies. We have identified that a knowledge sharing solution in this domain needs to be more sophisticated than a standard portal and must include the ability to collectively design and use knowledge models. It should also be open and able, where appropriate, to take advantage of external information. .

We also note that, as Huysman & DeWit (Huysman et al 2002) stated in their recommendations for managing knowledge sharing, "one should not fall into the known trap of assuming that it is the use of these technologies that stimulates people to communicate and share knowledge. The first thing to be addressed is the question of how to stimulate a need to share knowledge among a group of people. It is only when this need is satisfied that physical and electronic spaces are used for knowledge sharing purposes."

Therefore, for our knowledge sharing project in Healthy Country, we have identified two specific case studies which are in fact real live projects where there is particular support for knowledge sharing and recognition that a human facilitator will be necessary to make any system successful. Once we have established a presence, have uptake and data being entered, we can iteratively "upgrade" the system through a series of feedback, user needs analysis and development of our own technologies. Due to immediate needs and practical considerations, an initial implementation offering basic functionality will be developed quickly that allows people to start sharing knowledge.

Finally, it is important to evaluate the impact of any technological solution in order to verify the validity of the research outcomes and the usefulness of the developed tools, a process all too often neglected.

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