Jul 1st, 12:00 AM

Connecting Science and Decision-making: A Conceptual Framework through Organisation Knowledge Management

T. F. Siew

Follow this and additional works at: https://scholarsarchive.byu.edu/iemssconference

https://scholarsarchive.byu.edu/iemssconference/2008/all/236

This Event is brought to you for free and open access by the Civil and Environmental Engineering at BYU ScholarsArchive. It has been accepted for inclusion in International Congress on Environmental Modelling and Software by an authorized administrator of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.
Connecting Science and Decision-making: A Conceptual Framework through Organisation Knowledge Management

T.F. Siew

Abstract: There often exist controversies between scientists and practitioners with regard to the development and implementation of an applicable and transferable decision support systems (DSS) in the field of environmental or natural resources management. The challenge is to support decision-making through the implementation of a DSS across spatial scale as well as under different institutional and political conditions. Apart from the development and implementation of IT-based systems, the problem solutions also require holistic approaches that promote and enhance the cooperation and consensus between science and decision-making spheres. The objective of this paper is to develop a conceptual framework for integrating science and decision-making spheres through organisation knowledge management. Considering the multi-dimensional nature of the problems, the framework has been developed using multiple perspectives approach. It takes into account the elements that underlie the interfacing problems between science and decision-making spheres as well as knowledge construction and use from different perspectives. The understanding of the cognitive and socio-cultural elements are grounded by such concepts and theories as the paradigm lock, epistemic community and bounded rationality. Whilst, knowledge construction and use are elaborated through technical (scientific), organisational (societal) and personal perspectives. At this stage, the framework do not specify what should be done by whom. Instead, it provides an understanding about the issue through the analysis of the state-of-the-art. In addition, it also provides a setting for further study including micro studies on human decision-making and decision makers heuristics. Ultimately, the question of ‘how’ will be answered.

Keywords: Science-decision-making integration; paradigm lock; epistemic community; bounded rationality; organisation knowledge management.

1. INTRODUCTION

The cooperation or collaboration between science and decision-making spheres in environmental or natural resources management involves knowledge management through the implementation of supporting technologies. These spheres together form a socially constructed organisation with respective roles to play in the process of knowledge construction and use. Knowledge management in this organisation is not only about the concurrent management of content, culture, process and infrastructure [Chait, 1999], it also includes the management of social interaction between and within both spheres. Hence, organisation knowledge management could be used as a holistic approach to collaborate a wide spectrum of contributors and retrievers of knowledge resources ranging from people of different disciplines and portfolios to technologies that support the processes.
With regard to technologies, there often exist controversies between scientists and practitioners about the development and implementation of an applicable and transferable decision support systems (DSS) to support decision-making. On one hand, the application of complex environmental models has become an important part in decision- and policy-making processes [Verdenius and Broeze, 1999]. On the other hand, the implementation of DSS to facilitate decision-making remains a difficult issue [Giupponi et al., 2006]. The challenge concerns the generation of credible information and knowledge and the effective uptake of them (through the implementation of DSS under different institutional and political conditions) [Kolkman et al., 2005; Ballantine, 2005; Slob et al., 2007]. In this context, the difficulty from the construction of knowledge through the use of that knowledge is characterised as the interfacing problems between science and decision-making spheres. In recent years, various approaches have been proposed to address the interfacing problems through the development of conceptual modelling. For example, the development of NetSyMoD methodological framework has been developed to facilitate the involvement of stakeholders or experts in policy- or decision-making processes [Giupponi et al., 2008]. The flexible and comprehensive framework uses a suite of ICT tools to tackle problems commonly encountered under integrated water management. Giupponi et al. [2008] concluded that more efforts are needed to strengthen the exchanges between research and policy spheres with regard to knowledge and technology transfer.

In this respect, the problem solutions require not only the implementation of new IT-based systems, but also the practice of knowledge management taking into account the important organisational aspects, particularly human and social issues [Kjærgaard and Kautz, 2008]. In other words, a systems thinking approach that account for multi-perspectives is needed to address the multi-dimensional interfacing problems. Based on this notions, the objective of this paper is to develop a conceptual framework of organisation knowledge management for integrating science and decision-making spheres. The framework has been developed incorporating the concept of multiple perspectives of the Unbounded Systems Thinking (UST) and the Knowing Organisation. The UST promotes the use of divergent thinking and perspectives of experts and non-experts in search of consensus on a solution and also on the pool of solution alternatives [Hall et al., 2005]. Whilst, the Knowing Organization proposed by Choo [1996] provides a unified view of the principal ways how an organisation can make use of information strategically. The ultimate aim of this approach is to strengthen the relationship among science, politics and public administration as well as interdisciplinary cooperation among scientific communities through collaborative construction and use of knowledge.

The development of the conceptual framework requires the understanding of the elements that underlie the interfacing problems as well as the understanding of how knowledge is constructed and used based on different perspectives. These understandings are elaborated in the following sections based on the review of published literature.

2. CONCEPTS AND THEORIES UNDERLYING INTERFACING PROBLEMS

A number of studies aiming at addressing the interfacing problems can be found in, inter alia, Mills and Clark [2001], Acreman [2005], Kolkman et al. [2005], and Slob et al. [2007]. They presented some insights about the problems based on technology innovations, organisational and/or individual dimension.

The systems approach requires multi-perspectives view about the issue. The following subsections provide an understanding about the cognitive and socio-cultural elements using such concepts and theories as the paradigm lock, epistemic community and bounded rationality. These elements are embedded in each of the dimensions.

2.1 The Paradigm Lock

The interfacing problems have been recognised by the UNESCO-HELP programme as the ‘Paradigm Lock’, in which science and decision-making spheres are locked into separate vicious circles [quoted in Acreman, 2005]. These circles are separated by a dramatic gap in
the knowledge, the aims and the way of thinking between these spheres. In addition, the language between those who analyse and provide disciplinary expertise (i.e. scientists) and those who decide (i.e. decision makers) also presents in the gap [Luiten, 1999]. Furthermore, scientists and water managers are driven by different forces, for instance legislation, transparency, consistency, funding and operation time scale.

According to Willems and de Lange [2007], the often limiting implementation of newly developed tools from the research community is the result of failing to take into account the needs of decision or policy makers at a sufficient level. Scientists seek the best theory to explain the data that is available; they are driven by innovation and understanding; they are concerned more with technical integrity; and their main performance indicator is publications that have been peer-reviewed by other scientists [Mills and Clark, 2001; Acreman, 2005]. As a result, the DSS developed by scientists have been classified somewhere between dilettantism and academic exercises [Biswas, 1975]. Whilst, water managers seek consistent methods and practical decision support tools to support decision-making.

Besides, science is often more comfortable in providing advice on what ought to be done and why, rather than practical advice on how it might be achieved [Boehmer-Christiansen, 1994]. Willems and de Lange [2007] argued that scientists view the end-user in the research project as the client for their research results. There is, however, a significant lack of transfer mechanisms that would allow passing the relevant information on to other stakeholders including policy makers and implementers on the ground. The reasons affecting the uptake of scientific information as well as a lack of universal support for scientific input into policy making also include both contradictory science and uncertainty surrounding the available results. This has resulted in the lack of public confidence in scientific information. In this conjunction, decision makers also have difficulty in obtaining high-quality science at short notice [Slob et al., 2007].

On the other hand, Mills and Clark [2001] maintained that scientific information often is used in emotionally or politically laden natural resource management decisions. While some policy makers are unable to make use of highly technical advice, discrediting science and even the scientist is a strategy sometimes used by antagonists on both sides of the issues. This is because science applications to natural resource issues are usually done in the glare of public conflict and controversy [Mills and Clark, 2001]. In fact, DSS should be used as support systems but not decision makers [Courtney, 2001; Westmacott, 2001].

These debates indicate that there is a lack of coherent relationship between science and decision-making spheres. According to Willems and de Lange [2007], science-policy interrelationship is inefficient at this moment as it should/could be. Slob et al. [2007] also maintained that science and decision-making spheres are not well connected, although there is evidence that they sometimes are.

In the opinion of Acreman [2005], there is actually a continuum of expertise from basic to applied scientists through to water managers. Individual scientists producing research results along the spectrum from fundamental understanding to very applied. The continuum is however bound to complexity, which also introduces risk and uncertainty in the decision environment.

The ‘Paradigm Lock’ is closely related to the paradigm of the expertise community and the rationality of the decision makers. Their relation is illustrated in Figure 1. A deeper understanding about the paradigm of epistemic community and the bounded rationality of decision maker is provided in the following subsections. This understanding could provide a more founding explanation on the cognitive and socio-cultural aspect that exist in the science and decision-making spheres.

### 2.2 Epistemic Community

Decision-making process requires concerted efforts and combined expertise of a large number of specialists. These specialists include, for instance, economists, sociologists, ecologists, agriculturalists, foresters, wildlife biologists and planners. They all have a part to play in ensuring that the questions being answered are the appropriate ones, the widest possible range of options has been generated, and the likely consequences and necessary
contingencies have been predicted [Jeffers, 1988]. The formation of diverse epistemic communities may result in the emerging interfacing problems.

![Diagram](chart.png)

**Figure 1.** The connection between the ‘Paradigm Lock’, epistemic community and bounded rationality.

Epistemic community indicates a ‘new’ and in some aspects, atypical political actor. It constitutes of networks of experts coming with different experiences, from different backgrounds, a common interest, a shared task and diversity of knowledge [Cinquegrani, 2002]. An epistemic community as defined by Haas [1992] is a network of professionals from a variety of disciplines and backgrounds, who have (1) a shared set of normative and principled beliefs, which provide a value-based rationale for the social action of community members; (2) shared causal beliefs, which are derived from their analysis of practices leading or contributing to a central set of problems in their domain, and which then serve as the basis for elucidating the multiple linkages between possible policy actions and desired outcomes; and (3) shared notions of validity – that is a set of common practices associated with a set of problems to which their professional competence is directed, presumably out of the conviction that human welfare will be enhanced as a consequence.

Kolkman et al. [2005] maintained that the construction of knowledge within different paradigm groups leads to different interpretations of the problem situations. Each scientific discipline constructs its own models using its own paradigm. Consequently, this has also impeded true implementation of interdisciplinary methodologies and the development of generalised models [Norgaard, 1992]. Furthermore, Jakeman et al. [2006] noted that there are not only different paradigms and methods between biophysical scientists and social scientists, but also gaps in shared understanding between some of the major quantitative sciences.

The epistemic communities signify that individual community supports special interests better than collective ones [Norgaard, 1992]. They enable cohesion of a discourse and unite a community of their own followers. On the other hand, the uptake of scientific information provided by the paradigm groups is influenced by the rationality of a decision maker.

### 2.3 Bounded Rationality

Decision-making shares equivalent meaning with problem solving and management, which is the process of converting information into action. Although decision support tools can provide for rational information, the outcome of a decision is very much dependent on the rationality of the individual decision maker with regard to choice of information. According to Biswas [1975], management success depends on not only the quality and extent of the information available but also what information is selected for use and ultimately channelled into the decision-making process.
Hjorth and Bagheri [2006] maintained that any system in which humans are involved is characterized by the following essential system properties: bounded rationality, limited certainty, limited predictability, indeterminate causality, and evolutionary change. Bounded rationality as defined by Herbert Simon [quoted by Choo, 1996] is “the capacity of the human for formulating and solving complex problems is very small compared with the size of the problems whose solution is required for objectively rational behaviour in the real world – or even for a reasonable approximation to such objective rationality”.

Decision-making approaches could be and large be categorised into rational and bounded rational approach. Based on the rationalist approach, procedures for policy and decision-making usually require the collection of information to support the selection of a policy option. It assumes that a rational and therefore legitimate choice can be made (e.g. environmental impact assessment) [Slob et al., 2007]. In this approach, procedural uncertainty is managed through well-defined rules, routines and performances [Joshi, 2001]. On the other hand, the bounded rational approach suggests that the human way of thinking is not normative or rational but conditional. It means that humans use their whole life experiences to reach a decision in the real world. Moreover, individual taking this approach uses his power and influence to deal with conflict resolution, negotiation and compromise [Joshi, 2001].

The rationality of an individual and the resultant of his behaviour is also a crucial factor in affecting his relation with the science sphere. On one hand, individuals and organisations are forced to take standpoints and make choices based on uncertain knowledge and diverse views [Höijer et al., 2006]. On the other hand, each entity with capacity to make decisions and to carry out acts in a dynamic environment will face dilemmas between reconsidering the choice of action at each step based on newly perceived information. This process can be costly. However, unconditional commitment to chosen actions can lead to failure [Hall et al., 2005].

The divergent operational philosophies and socio-cognitive influence are the fundamental reasons for poor communication and interaction between scientists and decision makers. Norgaard [1992] maintained that the differences in the way different organisations transform data into information are the results of different assumptions, cultures, and paradigms within the disciplines. Whilst, the limitations of uptake of scientific information are attributed to bounded rationality of an individual. The embedded cognitive and socio-cultural elements are alike a shadow of an individual. Its visibility and the quantum of its presence (it could be quantifiable) is dependent highly on location and position where an individual is. The more precise understanding of these elements, coupled with the understanding of how knowledge is constructed and used, is imperative for the integration between science and decision-making spheres.

3. MULTIPLE PERSPECTIVES ON KNOWLEDGE CONSTRUCTION AND USE

Knowledge management has been vastly studied in business and information management fields. Various definitions about knowledge management can be found in Nevo and Chan [2007]. Knowledge management in an organisation is a process through which an organisation construct and use its institutional or collective knowledge. Choo [1996] noted that a solid understanding of how an organisation creates, transforms and uses information in an organisation is necessary. Failing of this understanding, an organisation would lack the coherent vision to manage and integrate its information processes, information resources and information technology.

According to Nemati et al. [2002], knowledge management is the practice of adding actionable value to information by capturing tacit knowledge and converting it to explicit knowledge; by filtering, storing, retrieving and disseminating explicit knowledge; and by creating and testing new knowledge. Sousa and Hendriks [2006] maintained that knowledge management addresses policies, strategies, and techniques aimed at supporting an organisation’s competitiveness by optimising the conditions needed for efficiency improvement, innovation, and collaboration among employees. Knowledge management also involves organisational learning.
Knowledge construction may refer to knowledge creation and knowledge acquisition. Whilst, knowledge may be used or applied through a process of elaboration (the development of different interpretations), infusion (the identification of underlying issues), and thoroughness (the development of multiple understandings by different individuals or groups) [King et al., 2008]. Solving complex problems in a holistic system may require knowledge from any source and those knowledgeable in any discipline or profession with the support of technologies. In this conjunction, it is necessary to comprehend how knowledge is constructed and used based on technical, organisational and personal perspective, respectively.

3.1 Technical Perspective

Technical perspective of the UST relates that scientific technologies function with logic and rationality. In a rational environment, computer-based systems are used by scientists or paradigm groups to produce a series of possible rational (or right) problem solutions for analysing the situations [Hall et al., 2005]. The decision support systems (DSS) field has been recognised as dealing with such technologies for representing and processing knowledge in order to facilitate decision-making. It is believed that these technologies could provide useable knowledge at an appropriate point of decision-making process as well as at an appropriate level of precision [Giupponi et al., 2006]. Besides, DSS has also explicitly included decision evaluation in order to increase user satisfaction and better facilitate group discussion and compromise [Bell et al., 2003]. As a result of this functionality, DSS provide support to decision makers engaged in solving various semi- to ill-structured problems involving multiple attributes, objectives and goals.

In a complex environment, the variability, interdependency and uncertainty of factors affecting decision-making process are complex. DSS integrate data sources with modelling and analytical tools; facilitate development, analysis, and ranking of alternatives; assist in management of uncertainty; and enhance overall problem comprehension [Mowrer, 2000]. Hence, DSS functioning as an expert system can deal with the complexity of the decision problems through the enhancement of the limited capacity of the human mind. They may simulate or even replace human thinking and decision-making by preventing human shortcomings or the improvement of human characteristics [Bender and Manders, 1993]. DSS may support a right decision by providing rational information and knowledge. This includes information on possible outcomes of a decision as well as the values of the outcomes to the individual affected. This functions well in an ideal world, in which rational choice or rational decision-making could be made based on a complete set of available alternatives, reliable information about their consequences, and consistent preferences to evaluate these outcomes [Choo, 1996]. However, the types of information and knowledge used are often dependent on the cognitive level of an individual.

3.2 Personal Perspective

The types of data the actor perceives in the real world, as well as the types of knowledge the actor derives from the data are determined by the frames of perception of individual actor [Courtney, 2001; Kolkman et al., 2005]. These frames are recognised as mental model of an individual. The concept of a mental model is parallel to beliefs, i.e. they are continuously updated as the environment changes, yet the underlying foundations often remain unchanged over time [Hall et al., 2005]. In this respect, knowledge from the personal perspective concerns mainly about tacit knowledge that includes beliefs, perspectives, and mental models. According to Nemati et al. [2002], tacit knowledge consists of subjective expertise, insights and intuitions that a person develops from having been immersed in an activity or a profession for an extended period of time. The challenge of knowledge management is to integrate and implement tacit knowledge into the decision-making process. However, tacit knowledge is often so ingrained in an person’s mind that they are taken for granted.
Acreman [2005] maintained that expert opinion is a form of ‘best knowledge’ possessed by an expert harnessed from their accumulated experience. On one hand, skills and knowledge of individual research scientist are desired to bear on controversial natural resource management policies [Mills and Clark, 2001]. On the other hand, the judgement of decision makers becomes a key element in decision-making with regard to the use of knowledge [Acreman, 2005]. Furthermore, individuals reacting on the UST’s personal perspective may affect not only information seeking/sharing, but also problem reformulation and validation [Hall et al., 2005].

In order to ensure purposeful use, the knowledge resources need to be managed systematically and effectively in an organisation taking into account the elaborated perspectives as well as the cognitive and socio-cultural elements. The following subsection elaborates on how an organisation manages its knowledge resources.

3.3 Organisational Perspective

Knowledge has long been considered an important organisational resource [Nevo and Chan, 2007]. An organisation can be viewed as a distinct entity or an open system that manages knowledge resources. Knowledge of all types (i.e. technical and individual knowledge) must be supported in this environment. Courtney [2001] noted that all types of knowledge include tacit and explicit, deep and shallow, declarative and procedural, and exoteric and esoteric knowledge. In addition, the relationships and reciprocal influence between the organisation and the external environment also need to be considered during knowledge management process in an open system.

An organisation creates knowledge by developing new knowledge or replacing existing knowledge with new content through the implementation of technologies. It also acquires knowledge from individuals or through the search for, recognition of, and assimilation of potentially valuable knowledge from outside the organisation [King et al., 2008]. Choo [1996] maintained that knowledge creation is achieved through a recognition of the synergistic relationship between tacit and explicit knowledge in the organisation, and through the design of social process that create new knowledge by converting tacit knowledge into explicit knowledge.

In a decision-making environment, an organisational action is taken through the process of information interpretation, information conversion and information processing. This information is used by (an individual or) organisation to make sense of change in its environment, to create knowledge for innovation, and to make decisions about courses of action [Choo, 1996].

On the other hand, culture is also recognised as a knowledge resource of an organisation. According to Holsapple and Joshi [2001], cultural knowledge resource comprises basic assumptions and beliefs as well as an organisation’s values, principles, norms, unwritten rules and procedure. The behaviours of the members of an organisation with regard to knowledge acquisition, sharing and internalisation are influenced by cultural knowledge. Therefore, it is important for researchers and practitioners to appreciate cultural knowledge resource.

The effective management of knowledge construction and use processes is important for creating and delivering relevant and useful information and knowledge by and to the right person at the right time. On the other hand, the extent to which an individual makes his knowledge available as an organisational resource depends heavily on managerial influences (e.g. leadership, reward systems, evaluation systems) [Holsapple and Joshi, 2001].

4. CONCEPTUAL FRAMEWORK OF ORGANISATION KNOWLEDGE MANAGEMENT

The understanding of the cognitive and socio-cultural elements that underlie the interfacing problems and the knowledge construction and use by different perspectives provide a setting for the development of the conceptual framework of organisation knowledge
The necessary understanding is important for an organisation to holistically manage its sense-making, knowledge building and decision-making processes [Choo, 1996]. The framework shown in Figure 2 has been developed by incorporating the concept of multiple perspectives, i.e. technical, organisational, and personal perspective as proposed by the Unbounded Systems Thinking (UST) model and the Knowing Organisation. It illustrates the organisational structure of knowledge management in a decision-making system.

Figure 2. Conceptual framework of organisation knowledge management.

An organisation is framed as an knowledge management entity that manages the process of constructing and using the technical knowledge as well as its personal and institutional or collective knowledge. This organisation may be represented by an epistemic community,
which is a network of professionals and experts, who come from a variety of disciplines and backgrounds and who have a shared set of normative and principled beliefs [Haas, 1992]. In the ideal situation, the multi-person actor, who works within the framework of complexity and uncertainty, tries to re-define problems in broader context and attempts to comprehend ‘change’, and able to ‘anticipate’ using knowledge, various backgrounds and expertise [Cinquegrani, 2002].

The framework of organisation knowledge management emphasises on the relation and interaction between different perspectives and processes. According to Lovering [1999] and Lagendijk and Cornford [2000], it may be necessary to represent and clarify the relation between knowledge management, ICT usage and experts as mediators between the complexity of political decision and the tendency of institutions to become advanced learning organisation.

In this socially constructed organisation, the respective institutional functions and capacity of scientists and decision makers in a decision-making system are fundamentally determined by their respective roles in the decision-making system. The roles and capacity need to be clearly and effectively defined and communicated between science and decision-making spheres. In this respect, basic or applied scientists and social scientists provide expertise support to decision makers. Whilst, the decision makers have to make decision to come to an action and ultimately to solve environmental and societal problems.

The expertise support provided by scientists contribute to the decision-making process through facilitation of sense-making and knowledge creation stages. As explained by Cinquegrani [2002], the demand for the expert advice is a common phenomenon in policy-making processes at local, national and international level. Consequently, science has in fact undergone a major paradigm shift and moves from the traditional methods of production of scientific knowledge in the post-normal science era by taking into account its social and political context [Gibbons et al., 1994]. In this conjunction, science has been redefined as a social process, set in a social context, and involving actors and institutions and it is often called upon to provide solutions to societal problems [van den Hove, 2007]. In this context, social scientists should play an active role as mediators in the knowledge management process. They could strengthen the integration between science and decision-making spheres by facilitating the understanding of the interfacing problems as well as by implementing holistic approaches to address the problems. Social scientists contributes to the knowledge mediation process by developing conceptual models or problem structuring techniques to deal with the complex management problems.

Each personal in this organisation may seem to be driven by different forces in achieving respective aims and targets. However, they are interconnected by certain implicit forces as well as physical components in a multi-disciplinary environment as they attempt to solve common problems. In this framework, knowledge portal that stores explicit knowledge serves as a common platform of intellectual interaction. Models and decision support tools generate technical and rational knowledge that is reposited in the knowledge portal. In this regard, the needs of the decision makers should be considered sufficiently in developing models or DSS, as argued by Willems and de Lange [2007]. In order to improve the credibility of the rational knowledge, the technical tools that operationalise method into practice have also taken into account the issues of scales, uncertainty and risk.

The decision-making process incorporated in this framework is presented under the personal perspective of a decision maker. A decision maker makes use of the information and knowledge stored in the knowledge portal for sense-making and knowledge creation in order to make a decision or take an action [Choo, 1996]. During the decision-making process, tacit knowledge acquired by a decision maker should also be converted into explicit knowledge, which will continually enrich the content of the knowledge portal. Mental model is also used for this purpose, which could deal with the bounded rationality of an individual.

On the other hand, feedbacks or responses through communication among actors are represented by ‘dotted-line arrow’ in this conceptual framework. As maintained by Schwartz [2001], the need for suitable feedback is important in cognitive learning that deals with insights, reasoning and imagination. The process of feedback emphasises retrieval and extraction, association, repetition, recognition and the solution of problems. In addition,
Schwartz [2001] also noted that networks learn by changing the strengths of their interconnections in response to feedback and adaptive production systems. The framework provides an overview and understanding about the organisational structure of knowledge construction and use process as well as the interrelation and interaction between different components and processes under technical and personal perspectives in a decision-making system. For addressing complex management problems using systems thinking, external implicit or explicit forces that have influences and impacts on each of the component and process in this organisation must also be considered. However, they are not illustrated in this figure.

5. CONCLUSIONS

The difficulties in the development and implementation of a transferable decision support systems could be addressed using systems thinking through the concept of multiple perspectives (i.e. technical, organisational and personal perspective). The conceptual framework of organisation knowledge management proposed in this paper illustrating the interaction between scientists and decision makers through collaborative knowledge construction and use processes. At this stage, the framework do not specify what should be done by whom. Instead, it provides an understanding about the issue through the analysis of the-state-of-the-art. Hence, the framework has been developed to provide a setting for further study on the cognitive and social-cultural aspects including micro studies on human decision-making and decision makers heuristics. Ultimately, the question of ‘how’ will be answered.

On the other hand, the successful implementation of the framework also requires further investigation and elaboration on the relevant tangible and intangible components and processes. The key components and processes may be changed, added, validated or improved.

Most importantly, it is necessary to instigate the awareness of the importance of forging and strengthening the relationship between science and decision-making spheres using holistic approach.

ACKNOWLEDGEMENTS

The author would like to thank DAAD for offering financial support for the purpose of pursuing a doctoral degree. The support provided by Prof Dr Gerhard Oesten and the constructive comments, inspiration and motivation given by Dr Frank Ebinger are also gratefully appreciated.

REFERENCES


Joshi, K.D., A framework to study knowledge management behaviors during decision making, the 34th Hawaii International Conference on system sciences, 2001.


Kolkman, M.J., M. Kok, and A. van der Veen, Mental model mapping as a new tool to analyse the use of information in decision-making in integrated water management, *Physics and Chemistry of the Earth*, 30(4-5), 317-332, 2005.


