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INTEGRATING SCIENTIFIC WITH INDIGENOUS KNOWLEDGE: CONSTRUCTING KNOWLEDGE ALLIANCES FOR LAND MANAGEMENT IN INDIA[1]

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Abstract

Information systems design and development processes by their very nature involve a multiplicity of knowledge systems, including the technology itself, the methodologies for system development, and knowledge relating to the application domain. When an information system is used to advance socio-economic development in less developed countries (LDCs), there are additional sources contributing to this multiplicity. In the case of land management applications, it is important to consider the knowledge that communities have of the land they inhabit. This paper stresses the importance of constructing knowledge alliances between these multiple knowledge systems in order to support more effective IS development and implementation. The term ***knowledge alliance*** *refers not merely to the material characteristics of the knowledge inscribed in technology, but also to the indigenous knowledge of the various communities involved. This includes the social setting that has shaped the practices which are responsible for the communities' production, articulation, and use of knowledge. Two key theoretical concepts, namely boundary objects and participation, are drawn upon both to understand the multiplicity of knowledge systems and to suggest possible approaches to the creation of effective knowledge alliances. The empirical setting for this analysis is a study of the use of geographical information systems for land management in India. This research is not of merely theoretical significance, but also carries important practical implications for scientists and administrators involved in the development of IS, particularly in LDCs.*

Keywords: Information systems, participation, rural development, scientific knowledge, indigenous knowledge, boundary objects, India, less developed countries

Introduction

In this paper, we examine the use of geographic information systems (GIS) to alleviate the problem of land degradation in India. The lens through which this problem is analyzed is that of knowledge, with the focus being on the multiplicities of knowledge systems and the associated communities, the manner in which these systems are contested, their fragmented nature, and the challenges inherent in the attempt to integrate them, thus constructing composite forms of knowledge to better support the effective application of information and communication technology (ICT).

There is increasing recognition in the information systems literature of the potential of less developed countries (LDCs)

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as enablers of socio-economic development, and hence the need for their effective diffusion (Mansell and Wehn 1998; Mejias et al. 1999;Sahay and Avgerou 2002; Sein and Harindranath 2004). International organizations such as the United Nations (UNDP 2001), the G-8, and the World Bank have argued forcefully for a technology push to foster and sustain development[2] in LDCs. This vision of creating information or knowledge societies is reflected in the recent national policies of many LDCs, in Africa (Nhampossa 2006) and elsewhere, as well as in the ongoing implementation of the World Summit on the Information Society (WSIS).

The issue of knowledge has also been raised by several international donor agencies. The World Bank, for example, in its 1999 report *Knowledge for Development,* forcefully advocated much greater penetration and use of ICTs in LDCs to create the knowledge-intensive societies necessary for economic survival in the current era of globalization. At its eighth plenary meeting held in Tunis in November 2005, the WSIS also recognized that the creation and sharing of relevant knowledge contributed significantly to development in LDCs, arguing that facilitating access to information and removing the digital divide was the way forward (WSIS Executive Secretariat 2006).

Donor agencies, typically the proponents of knowledge-based development in LDCs, however, emphasize knowledge about technology (for example, software engineering) and knowledge about attributes (such as the quality of a product) as critical to development (World Development Report 1999). This approach privileges only the kind of knowledge that is founded on scientific rationality. Such a view does not acknowledge the multiplicity of knowledge domains and perspectives that need to be considered in IS applications (Suchman 2002a). In line with Suchman's critique of the "design from nowhere" approach to IS design, based on Western notions of scientific rationality (Suchman 1994, p. 37), this paper explores the multiplicity and contested nature of knowledge systems in the context of the use of GIS to address the problem of land degradation in India.

The paper is organized as follows. In the following section, some of the key issues and debates on the subject of knowledge in the IS literature are discussed. These are drawn upon to propose my theoretical perspective. The empirical approach and the research method adopted are outlined thereafter, followed by the case description. Analysis of the case, focusing on the issue of integration of relevant knowledge domains, is presented next, followed by the contributions of this paper to both the theory and the practice of IS. The concluding remarks highlight the importance of the issue.

[2]The term *development* in this paper refers to socio-economic development of rural areas in LDCs, unless qualified otherwise (e.g., IS development).

Literature Review and Theoretical Perspective

This section is divided into two parts. The first discusses varying ideas of the concept of knowledge articulated in the IS literature, and how this knowledge is internalized by various communities-of-practice (COPs). This discussion focuses on understanding the disparate realms of knowledge involved in the context of this paper, and the associated challenges in bringing them together for more effective IS/GIS design and implementation. The notion of boundary objects, which provides a useful theoretical lens to understand the dynamics of sharing and bringing together various knowledge forms across COPs, is outlined next. In the second part, a theoretical perspective is developed to inform my analysis of the empirical data.

The Treatment of Knowledge in Information Systems Literature: Some Key Issues and Debates

The topic of knowledge, especially knowledge management, has been a subject of extensive discussion in the IS and organization literatures (Schultze and Leidner 2002). The emphasis has been on harnessing the potential of ICT-centered knowledge to improve efficiency and competitiveness in organizations. Organizational knowledge has been defined as either explicit or tacit (Cook and Brown 1999). The former is seen as formal and systematic, and therefore capable of being communicated and shared, for example, in creating scientific models translatable into computer programs (Nonaka 1991). Tacit knowledge, on the other hand, resides in "know-how," for example, the knowledge that workers accumulate over time and with experience; it is, therefore, difficult to formalize and communicate in an explicit manner (Nonaka 1991). Work routines in organizations are inscribed with and reflect tacit knowledge (Gherardi and Nicolini 2000). A central question in knowledge management research has been how tacit knowledge may be captured, made explicit, and shared with others (Nonaka 1994; Nonaka and Takeuchi 1995) so as to improve the knowledge-based competitive edge of the firm.

The above conceptualization of knowledge as some form of commodity (Brown and Duguid 2001; Orlikowski 2002), which can be made explicit and unproblematically dis-embedded from one context and re-embedded in another (Giddens 1990), has been criticized in recent years by various IS researchers. Arguments have been made for the adoption of more human-centered approaches to understand how different forms of knowledge are created and shared (Walsham 2001). For example, Suchman (2002a, 2002b) emphasized the multiplicity of knowledge forms that are context-specific and situated in practice. Blackler et al. (2000), emphasizing the distributed nature of organizational knowledge, suggested that it is indeterminate, contested, emergent, and difficult to control centrally. Lam (1996) underscored the deeply embedded nature of knowledge in his comparative analysis of the role of engineers in British and Japanese firms during a joint technology development project. Lam argued that the inadequacy of British engineers to take up broader management roles in organizational contexts was due to, among other factors, their *education deficiency* (p. 184) arising from narrow and over-specialized education which emphasized a high degree of formal knowledge. The Japanese engineers, on the other hand, did not see their respective roles being constrained by rigid boundaries (p. 186), and based their actions on a more experiential and practice-based form of knowledge.

Nicholson and Sahay (2004) extend this embedded and contextual perspective of knowledge to globally distributed offshore software development. They argue that elements of knowledge situated in organizing principles, routines, and standard operating procedures are relatively nonmigratory because of their contextual embeddedness. However, such knowledge can be understood and shared to a degree between different groups through enhanced processes of communication and negotiation (Boland et al. 1994).

Boland and Tenkasi (1995) highlight the multiplicity of knowledge disciplines, proposing that knowledge is created through processes of *perspective making*. Groups of people in specialized organizations with expertise in particular fields make up *communities of knowing* (COK), each community developing and sharpening its perspective as it refines its methods through joint action and constant interaction of its members. These communicative processes, and the consequent creation of particular perspectives, contribute to reinforcing the unique knowledge of a COK. Boland and Tenkasi argue that the crucial issue for these organizations is to establish communication mechanisms that will achieve integration of knowledge across COKs and thus create new understandings. The inter-COK communicative processes, through which new knowledge is articulated, are referred to as *perspective taking*. Perspective taking thus entails collaboration among diverse COKs, leading to their individual knowledge being "exchanged, evaluated and integrated with that of the others in the organization" (Boland and Tenkasi 1995, p. 358). In a similar vein, Levina and Vaast (2005), referring to COKs as *fields*, argue that the competence of a COK to span distinctive fields in order to produce integrated knowledge requires the creation of a "new joint field" by bringing together disparate COKs to achieve a common organizational objective.

The concepts of COK and fields implicitly and explicitly draw upon the notion of communities-of-practice (COPs), which also reject the objectification and universal applicability of a particular knowledge domain (Luna-Reyes et al. 2005), arguing that knowledge is embedded in context (Lam 2000) and practice (Brown and Duguid 1991; Lave and Wenger 1991). A *community* is made up of people who develop social bonds through shared traditions and identity. Communities thus develop their own distinctive languages, shared norms, values and practices over time (von Krogh 2002). Knowledge is, therefore, socially distributed, since it is constructed and entrenched in the collective actions of different communities. Arising from this conceptualization of knowledge as constructed in social interactions, Wenger (1998) defined community-of-practice as a social construct that positions learning in the "context of our lived experience of participation in the world" (p. 3). Practice, in this sense, can be understood as the interpretive schemes that members of a community draw upon to manage their routine life, as well to develop new ways of coping with contingencies (Walsham 1993).

In the context of this paper, the above discussion resonates with Suchman's (1994) argument for reframing objectivity to develop alternative systems of technology production and use. She suggests that the objective epistemology of scientific knowledge needs to be rearticulated to include "multiple, located and partial perspectives…through ongoing processes of debate" (p. 92) to accommodate the lived experience of organizations. This argument emphasizes the multiple forms of knowledge that need to be drawn upon and made to work together in the process of IS design and implementation. How these aims can be realized, both theoretically and practically, remains the ongoing challenge for IS researchers.

The above discussion emphasizes the idea of knowledge as a social and historical construct, arising from the diverse challenges of a given context. Such a view is in contrast to its conceptualization as a formal, codifiable, and easily transferable commodity based on managerial rationalities. This discussion also underscores the need for IS design to draw upon appropriate composite knowledge articulated by bringing together relevant COPs. Although these learnings

Table 1. Key Characteristics of the Four Knowledge Domains

Knowledge Domain	Key Characteristics
Technology specific: the case of scientific knowledge inscribed in IS/GIS	Explicit, considered universally applicable, rational, analytical objective, codifiable, and hence transferable; extensive use of remotely sensed data and mathematical modeling; implication of computer technology.
Application specific: knowledge implicated in the application domain	Identifying relevant spatial and nonspatial data required to address the application domain; drawing on the accumulated experience of prior scientific work in similar applications.
Community specific: indigenous knowledge	Acquired by local communities through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture.
Implementation specific: the case of resource managers' knowledge	Built upon bureaucratic rules, guidelines, and financial norms prescribed by government and/or international donor agencies.

come from research and writings that have predominantly focused on organizational contexts in Western settings, the lessons are also germane to the topic of this paper: the application of GIS to address the problem of land degradation. Four different forms of knowledge that come into play in such an application are (1) *scientific* knowledge inscribed in GIS (arising from scientists' educational background and their institutional practices); (2) knowledge domains involved in the application of GIS (emphasis on the use of interpreted remotely sensed data; GIS-based modeling); (3) *indigenous* knowledge relating to the application domain (arising through community practice and *in situ* experience); and (4) resource managers' knowledge, drawn upon in field implementations of similar projects (based on norms and parameters prescribed by bureaucracies).

The key characteristics of these four knowledge domains implicated in GIS-based applications in LDCs for addressing issues in government supported initiatives such as for land degradation are summarized in Table 1 and discussed below.

Technology Specific: The Case of Scientific Knowledge Inscribed in IS/GIS

In several IS applications, software development is based on scientific and technical rationalities, for example, those oriented toward defense and scientific applications, and more recently in enterprise resource planning systems. These are modeled along rational engineering techniques, as in Operations Research, with limited inputs from users (Asaro 2000). The analyses of defense requirements and the modeling of security scenarios by the Rand Corporation in the United States typify such computer applications based on a scientific and technical rationality (Hounshell 2000).

GIS technology is described as having its roots in the scientific principles of cartography and mathematics (Harvey 1989; Pickles 1995; Sahay 1998; Veregin 1995), within standard scientific representations of knowledge and cognition (Harley 1992). It has, accordingly, its own particular scientific rationalities inscribed in it, arising from the fact that it is

> an information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for managing spatially referenced data, as well as a set of operations for working with this data (Star and Estes 1990, p. 2).

Goodchild (1987, p. 68) defined spatial analysis as "a set of techniques whose results are dependent on the locations of the objects of analysis." A key feature of these techniques lies in managing spatial relationships over time, and, consequently, the ability to model, analyze, and evaluate the spatial impacts of alternative management decisions (Green 1999). In the literature related to the use of GIS in environmental information systems, there is emphasis on its potential to create spatially explicit mathematical models to represent the structure and processes of ecosystems (Günther 1998). Drawing upon the strengths of mathematical modeling and GIS technology together is seen as an effective strategy to manage natural resources (Brady and Whysong 1999). The modeling contributes to the organization of knowledge around ecosystems, while the GIS provides powerful tools for the analysis of spatial data.

Application Specific: Knowledge Involved in the Application Domain

This deals with the knowledge specific to any particular application, for example, land development. Any given IS is designed for a particular application,thus it requires input of relevant knowledge from potential users (Boland 1978).

In the context of this paper, domain-specific knowledge derives from scientific parameters relating to land, also subsuming knowledge related to GIS and remote-sensing technologies. To address land degradation from a scientific perspective, inputs from at least the following three knowledge domains are relevant:

- *Relevant spatial themes*: Some of these are land cover and current land use, and the properties of the soil: its erodability, infiltration capacity, permeability, drainage patterns, and groundwater potential (NRSA 2002). This type of information is chiefly derived from remotely sensed satellite data[3] (Dasgupta et al. 2000).

- *Interpretation of remotely sensed satellite data*: The interpretation of these data yields information about the status of each of the above themes for the land area under investigation. In order to extract the relevant information, satellite data are digitally processed using image processing techniques and/or by adopting visual interpretation methods (Aronoff 1989).

- *Scientific knowledge base*: This is the accumulation of lessons derived from ongoing research on the application of remote sensing to environmental domains such as land degradation, GIS-based modeling, and the implementation of similar projects in the past, nationally and internationally.

The information derived from these identified spatial themes is then processed on the basis of GIS-based mathematical models to delineate land units with the least possible internal variability with regard to factors related to land degradation. Action plans for land and water resources development are then generated by expert systems based on decision rules formulated by scientists.[4]

Interpretation of remotely sensed data raises particular knowledge issues. It requires specific skills for generating *training sets* and *ground-truthing*, which need to be performed by experienced and trained persons. Since the reliability of the information depends on the extent of ground-truthing, in addition to the skills of the interpreter and the institutional expertise, the use of these data represents the outcome of a socially constructed process (Barrett et al. 2001). For example, Sahay and Walsham (1997a) describe how over-reliance on satellite data for deriving information on vegetation led scientists to underplay the significance of nonspatial socio-economic data (such as income levels and religious make up) in similar GIS projects implemented in India during the early 1990s. Such interpretations, therefore, do not necessarily mirror the ground truth, but represent a social construction (Comber et al. 2005; Hoeschele 2000).

A data model provides formal techniques to represent information and manipulate these representations (Date 1983). IS researchers have argued that data models, an abstraction of reality, cannot capture all facets of real-world problems, particularly when dealing with complex phenomena (Kwan 2002; Peuquet 1984). These modeling approaches seek to construct solutions within a natural science epistemology, and are rooted in the belief that success in the natural sciences can be replicated in the area of applied systems development (Klein and Lyytinen 1992). Researchers further argue that IS design involves making sense of shared meanings, especially in the context of intricate social phenomena, for instance when addressing land degradation. Sahay and Walsham (1996) provide a vivid example of this with respect to the criteria adopted for building the GIS models. They argue that scientists tend to use rationalistic criteria of profit maximization in their models for land use strategies (for example, to plant Eucalyptus trees), while the farmers prefer the strategy of risk minimization to ensure a minimum level of income and survival for their families.

Community Specific: Indigenous Knowledge

The term *indigenous knowledge system* comes from the anthropological literature (Brokensha et al. 1980). Following Schoenhoff (1993), it may be defined as the shared knowl-

[3]Satellite remote sensing functions on the principle that objects on the surface of the earth reflect electromagnetic radiations emitted by sources such as the sun. Information about the nature of the object is carried in the reflected radiations in specific wave length bands, which are detected by satellite-borne sensors, and relayed back to receiving stations on the earth via imaging electronics aboard the satellite (Aronoff 1989, p. 50; Lillesand and Kiefer 2000, pp. 22-23).

[4]The term *scientist* has been used in this paper to denote researchers from remote sensing and GIS-related government institutions in India, engaged in GIS application design for land regeneration in selected rural areas of the country.

edge that a local community has evolved over time, through trial and error (Gadgil et al. 1993), in a particular environment. Such knowledge has been field tested for its suitability to local needs, conditions, and ethos (Mundy and Compton 1995). It may be informally expressed in local customs, experience, technology, and wisdom. The understanding these communities have of their land—its layout, topography, cropping patterns, location of water bodies, the local drainage pattern and much more—is referred to as indigenous knowledge. Such knowledge is often not evenly distributed among community members due to various factors such as "age, gender, experience, profession and personality" (Mundy and Compton 1995, p. 117), and clearly, some of it would be difficult to capture through conventional surveys and remote sensing (Tabor and Hutchinson 1994).

Thus, indigenous knowledge is context-specific and embedded in the everyday practices of the members of a community (Banuri and Marglin 1993). Nevertheless, it has historically been excluded from scientific models that have their origins in Western concepts of rationality, on the assumption that it is inferior (Watson-Verran and Turnbull 1995). Consequently, it has not been seriously considered in domains such as state planning and the design of IS applications (Verran 1998). Today, in the context of socio-economic development, such marginalization of indigenous knowledge is, to a certain extent, gradually being reversed. This change of perspective is due to various factors, for example changes in the politics of development aid; instances of breakdown of technology-driven applications (FAO 1990; Murdoch and Clark 1994); the success of certain community-based initiatives (Krishna et al. 1997); and a high level of political advocacy by non-governmental organizations (NGOs), activist groups, and international conventions. The 1992 Earth Summit[5] formally recognized the importance of indigenous knowledge in achieving sustainable development, and the issue found mention in 17 of the 40 chapters of Agenda 21[6] (Mathias 1994). Such a formal recognition is in itself a step forward. However, this slow and grudging recognition notwithstanding, the integration of indigenous knowledge systems in the scientific domain, and their use to address field problems, remain a challenge.

[5]The UN Conference on Environment and Development, held in Rio de Janeiro, Brazil, June 3-14, 1992.

[6]Information on Agenda 21 is available at the UN Department of Economic and Social Affairs, Division of Sustainable Development web page: http://www.un.org/esa/sustdev/documents/agenda21/.

Implementation Specific: Resource Managers' Knowledge

Resource managers are described as the group of people responsible for the introduction of new technologies. In LDCs, the staff of government-supported projects are typically based in district or subdistrict[7] departments. They are responsible for liaison between the scientists and technologists, on the one hand, and, on the other, the community, which is responsible for the resources such as land and water, the use of which is being addressed through the new technology. In India, these resource managers are district administrators. Their knowledge and understanding are typically derived from the bureaucratic rules, guidelines, and financial norms laid down by the central or state authorities and/or the international donor agencies. These universal rules and norms—relating, for example, to systems of budgeting and project evaluation—have been developed and strengthened by bureaucracies over the years. The domain knowledge of this group thus comes from the accumulated field experience of generations of officials in supervising the implementation of various government-sponsored projects.

Thus we see that various types of knowledge are necessarily involved, and must be integrated, for the successful introduction of GIS to address complex problems in developing countries, especially in rural areas. Similar multiplicities are also evident in unpacking knowledge with respect to IS applications in wider contexts, for example while implementing SAP (systems, applications, and products in data processing) in organizations (Hanseth and Braa 1998).

Multiplicity of Knowledge Systems: The Challenges to Their Co-construction

The analytical challenge is to theoretically understand how the above multiplicity of knowledge systems may be drawn upon to produce relevant "hybridized" knowledge. Specifically, scientists, system developers, and local departmental managers must be brought to acknowledge the importance of indigenous knowledge. Such an expansion of horizons in itself is a critical change, as it challenges existing and deep-rooted assumptions of the superiority of scientific knowledge (Schultze and Boland 2000; Walsham and Sahay 1999). Understanding this challenge requires a socially focused analysis of the different communities that hold and apply such knowledge, of the everyday practices through which their

[7]A district is the basic unit of administration in India, each state of the Indian Union comprising several districts.

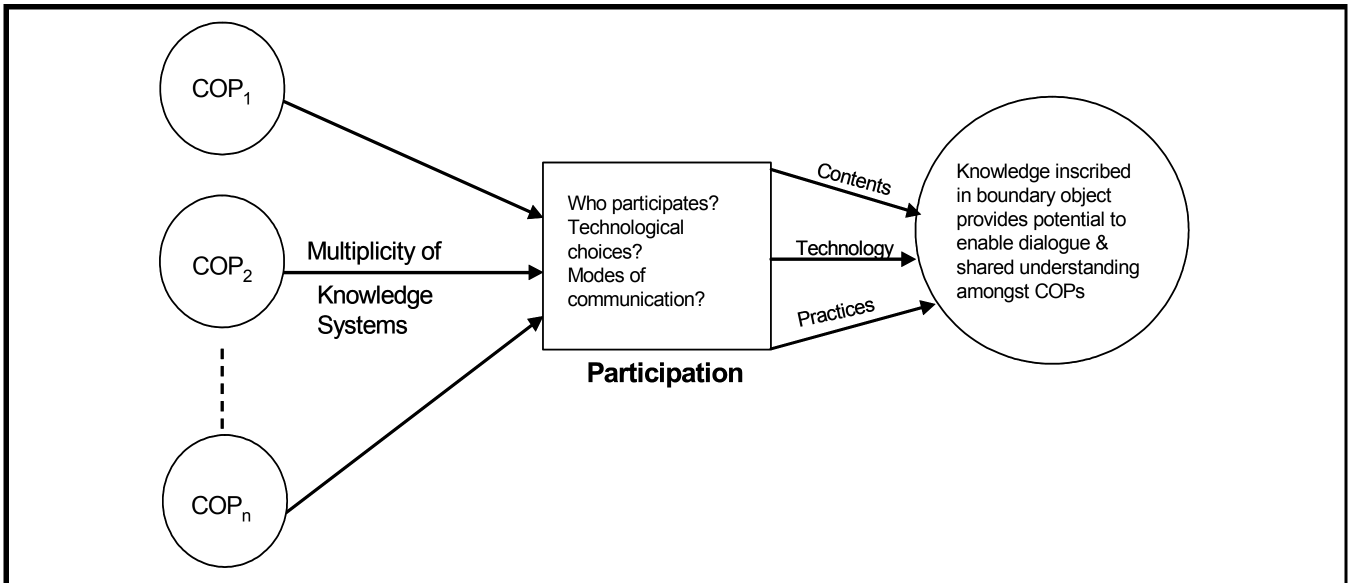

Figure 1. Theoretical Perspective (Construction and Articulation of Boundary Objects)

knowledge is constituted and expressed, and of the socio-political-historical conditions that shape its legitimacy. Three key concepts—communities-of-practice (COPs) (Wenger 2000), boundary objects (Star and Griesemer 1989), and participation (Wenger 1998)—taken together can provide a useful theoretical lens to make the above analysis. It is argued that these three concepts are inextricably interlinked (Figure 1) and together can contribute to develop a theoretical perspective to help understand the knowledge-related issues pertinent to this paper.

Boundary Objects: To Enable Communication Across Different COPs

Boundary objects have been defined as objects that "both inhabit several communities-of-practice and satisfy informational requirements of each of them" (Bowker and Star 1999, p. 297), thus satisfying multiple concerns simultaneously. Boundary objects are used as a means of coordinating and aligning (Fischer and Reeves 1995) differing perspectives across social and geographical boundaries. They have different connotations and are assigned different meanings by communities within their own respective social worlds and areas of responsibilities (Eckert and Boujut 2003). Take, for example, the development of a user interface (Bødker 1998). This is seen by users from the perspective of ease and flexibility of usage, say for data entry. The system designer, on the other hand, may view it from the technical perspective of the underlying programming effort for data validation. Despite these differing perspectives, these artifacts nonetheless provide an effective communication medium through which users are able to convey their requirements to designers. Researchers cite many examples of boundary objects—for example, physical prototypes, standardized reporting forms (Levina and Vaast 2005), spreadsheets, or sketches given by an engineering designer to a toolmaker (Eckert and Boujut 2003). Thus, boundary objects possess dual characteristics: they link the different perceptions of the different COPs using them, while at the same time the latter retain their distinct understanding of them. This potential for sharing comes from the shared knowledge resident in boundary objects (Carlile 2004). Boland and Tensaki (1995) argue that "once a visible representation of an individual's knowledge is made available for analysis and communication, it becomes a boundary object and provides a basis for 'perspective taking'" (p. 362).

In many research studies, the use of boundary objects has been described without their being defined as such. For example, Al-Kodmany (2001) described a case from the University of Illinois where planning and design experts sought the participation of local communities to evaluate existing conditions and to articulate their vision for the future development of their neighborhood. The experts used paper maps and scale models as visualization tools to draw out community expertise and local knowledge. The design experts produced the material component of the boundary objects (paper maps and scale models) to establish dialogue with the local residents and to draw upon the latter's local knowledge. Also crucial in this example were the *contents* (experts' knowledge expressed in their conceptualization of the neighborhood) inscribed in these material objects. Furthermore, these boundary objects and their inscribed knowledge would have been practically useless without support by participatory practices on the part of the designers, whereby they used visual communication tools to make possible an effective dialogue with the users, and thus promoted the community's participation and made its knowledge visible. The case demonstrated how the interaction of technical expertise and community knowledge, complementing and reinforcing each other, produced synergies in design.

Another example in which there is no explicit mention of boundary objects comes from Byrne (2004). In her description of the development of a child health community-based information system (CBIS) in South Africa, Byrne describes how the knowledge of the local communities was shared over time with IS researchers and designers. The community health facilitators and health workers for the village presented the data using the *technology* of flip charts (which can be seen as boundary objects) which displayed pie charts and histograms. The *content* of these boundary objects related to existing data on health status, and was communicated through questions on these data and discussions on possible interventions to improve the situation for vulnerable children. The use of these boundary objects was supported by the *practices* which the project facilitators used for the dissemination of health information to the community. These practices were based on song and dance, representing the historically held traditions in the community. These participatory rituals strengthened a learning approach, which encouraged critical reflection and was also linked with action. The process built upon the existing skills and resources of the community, their knowledge and practices, and their talent for song and dance. Based on the knowledge thus acquired by the IS staff, the CBIS was implemented in one municipality in 2003, and later expanded to the rest of the district. The knowledge of the IS researchers and the hospital health staff was based on modern systems of medicine, while for the communities, it was derived from traditional, long-practiced indigenous systems. By engaging with the community through the boundary objects and their inscribed contents, the health staff were able to gain insights into indigenous knowledge systems and practices, and include them into the system design.

Within the GIS community, the notion of maps as boundary objects has been drawn upon by Harvey (1997) and Harvey and Chrisman (1998). Unlike the two examples presented above, the focus in GIS research has been primarily on the material object (the map) and the knowledge inscribed in it. The aspect of participatory processes has been largely ignored. Take, for example, a cadastral map (i.e., a map defining the ownership boundaries of an area). The revenue administrators see it as facilitating tax collection; land departments visualize its potential role in local area development; the judiciary uses it to settle land ownership disputes; while for the farmers it is a legally accepted artifact they can use to obtain loans from banks against their land holdings. However, all these COPs share a common knowledge of these maps as a representation of their "local" worlds, thereby providing the potential for a common point of reference for enabling conversations (Chrisman 1999).

The above examples, where boundary objects have been discussed explicitly or implicitly, help to underscore the three different facets of boundary objects (technology, content, and practices). Thus, the theoretical perspective presented in this paper is based on the visualization of a boundary object as imbued with three attributes: its *content*, or the scope of knowledge embedded in it; the *technology* that goes into the construction of the boundary object; and the *practices* which go into the utilization of the knowledge inscribed in the boundary object. This three-point conceptualization (see Figure 1) helps to provide the notion of the boundary object with more theoretical specificity than when it is merely conceptualized in its material form (as a user interface or a map). Such a view draws upon an ensemble view of technology where it is seen as a socio-technical entity, and emphasizes the "dynamic interactions between people and technology" (Orlikowski and Iacono 2001, p. 126). It is through these interactions that a boundary object comes to be constructed and acquires its three social and technical attributes. This view of boundary objects and the surrounding technology also resonates with the actor-network perspective in which technology is theorized as a part of heterogeneous socio-technical networks which subsume its inscribed aspects, materiality, and organizational practices (Akrich 1992; Akrich and Latour 1992; Callon 1991; Kling 2000; Latour 1987).

A combination of technology, content, and practice helps to inscribe knowledge by COPs, single or multiple, into boundary objects that become a point of reference for other COPs to express and describe their knowledge. This in turn provides the potential for developing some degree of shared understanding across the different communities. Participation and the role it can play in the construction and articulation of boundary objects is discussed next.

Participation: Enabling the Construction and Articulation of Boundary Objects

IS research and practice in the West has been largely confined to organizational settings and shaped by their societal contexts (Asaro 2000; Kanungo 2004; Lyytinen and Klein 1985). A main objective of these systems is to improve organizational efficiency and profitability, or to further some organizational goals based mostly on economic considerations. Spinuzzi's (2003) analysis of user participation in IS design visualizes that knowledge-intensive work requires participants to control the ends, not just the means of work. However, there has been limited discussion in the IS literature on issues such as the differences in why and how workers participate, or the degree and type of participation within the organization. Orr and Crowfoot (1996, p. 205) suggest that the research emphasis should be laid on pertinent questions such as "what counts as knowledge, who is acknowledged as knowing…. and how questions of design deal with these issues of knowledge within the organization…." Both of these critiques of the functional use of participation have also been made within organizational settings. There have been some limited debates in the IS literature outside organizational settings relating, for example, to the involvement of community members who will be served by a health system (Braa 1996; Byrne 2004; Korpela et al. 2002; Korpela et al. 1998). However, analytical focus on the degree and type of participation required to directly involve rural communities, particularly in LDCs, is lacking. There has also been little analysis of how the conditions for them to express their domain knowledge are to be created, and on the use of such knowledge in information systems development.

Development theory, on the other hand, deals with the strategies involved in analyzing change in LDCs, and how such analysis can lead to different policy options (Preston 1996). In relation to the policies and programs aimed at poverty alleviation in LDCs, researchers started investigating issues and options to improve the participation of communities some 40 years ago. The failure of top-down modernization and dependency models of development (Escobar 1995; Montgomery 1974), which entailed very little participation of local communities, led to the rise of more intensive participatory approaches during the 1980s. Several theoretical and empirical models aimed at seeking and enhancing community participation, and drawing upon indigenous knowledge to improve the design and implementation of field programs, have since been developed and used (Chambers 1994).

Bass and Shackleton (1979) distinguish between the structural and cognitive aspects of participation. They argue that while industrial democracy movements (in Scandinavia) constituted formal, structured and often legally supported mechanisms, described as *structural* in nature, the *behavioral* participative management approaches tended to be more informal, varying with individual managerial styles and corporate ethos. The behavioral perspective emphasizes the way in which informal practices, such as the use of paper maps or song and dance rituals, can bring about participation, which makes it possible to share and transfer knowledge between, for example, designers, planners, and IS researchers. However, the behavioral approach alone is inadequate while seeking the structural changes required for fostering and institutionalizing community participation.

The participatory design literature in IS addresses several issues relevant to the development debate. For example, the involvement of ICTs has not generally been discussed and analyzed in development theory. Another lesson is the distinction between structural and cognitive participation. Development theory, on the other hand, provides insights into how community participation may be enabled, nurtured, and sustained. It also highlights the importance of using structural changes to facilitate participation, leading to the more positive outcome of development projects.

Participation plays a key role in defining and interlinking the three attributes of boundary objects described above, namely content, technology, and practice. Although described separately for analytical purposes, these attributes are inextricably intertwined. Participation influences content, according to who participates and who is excluded. For example, through the use of song and dance as mechanisms for participation (Byrne 2004), community members could participate in the system development process; they would be excluded if formal systems development methodologies are used. Participatory processes thus involve negotiations leading to technological choices being made. However, these choices and negotiations not only are a function of behavioral processes, but are shaped by historical conditions. For example, as the research of Sahay and Walsham (1996, 1997a, 1997b; Walsham and Sahay 1999) has emphasized, decisions to use GIS and formal development methodologies for land management in India had their origin, on the one hand, in the politics of donor funding and, on the other, in the existing bureaucracies of scientific institutions where gaining expertise in technology was seen as an end in itself rather than as a means to address a given problem (for example, land degradation).

The theoretical perspective adopted in this paper seeks to conceptually link participation and boundary objects as a framework to understand the nature of the challenges related to the multiplicity of knowledge systems and how these can be addressed. This perspective is examined in the context of the empirical case of GIS for land management in India, which is now described.

Empirical Approach and Method

Qualitative methods within the interpretivist tradition (Klein and Myers 1999; Walsham 1993, 1995a, 1995b) were adopted for this study. The approach to field data collection and its analysis is discussed after a brief description of the research site.

Research Site and Historical Roots of the Initiative under Study

Anantapur, a poorly developed district of Andhra Pradesh, is situated in the rain-shadow zone of peninsular India, suffering from low annual precipitation and extensive land degradation. Historically, the district has been drought-prone, a problem exacerbated in recent times due mainly to massive deforestation in catchment areas, excessive use of ground water, and increasing soil salinity (Rao et al. 1993). However, the socio-political factors leading to land degradation have not been considered in scientific analyses of these problems.

Initiating the Use of GIS to Alleviate Land Degradation and Water Shortage

The use of GIS to address the problem of land degradation was first taken up at the central level in India in 1991 with 10 pilot projects. These projects were extensively researched and analyzed by Sahay and Walsham (1997a, 1997b), whose findings underscored the lack of user participation in system design and implementation, and the strong technical focus in the implementation efforts. The key motive for the participating scientists was to engage in research involving the "latest" technologies, while the subsequent social acceptance and use of these systems in the field was accorded secondary importance (Hutchinson and Toledano 1993; Walsham and Sahay 1999). All in all, the studies concluded that the full potential of the GIS technology had not been realized, mainly as a result of socio-cultural rather than technical factors.

Subsequently, an integrated mission for sustainable development (IMSD) was visualized in the mid-1990s by the Department of Space, with the National Remote Sensing Agency (NRSA) as the nodal technical institution for implementation (NRSA 1995). IMSD was positioned as a modern and scientific approach to development planning, involving the use of both satellite remote sensing data and GIS technology. The IMSD is currently being implemented in 175 districts in India (covering an area of 84 million hectares), including Anantapur. Its two main objectives are (1) to arrest land degradation by promoting appropriate land use, thereby enhancing the productivity of existing degraded lands, and (2) to improve water availability in the arid and semiarid regions of the country (NRSA 2002). These objectives are to be realized by (1) preparing natural resource databases for the districts concerned, and (2) using these databases to generate location-specific action plans, including optimal land use practices. The plans, generated on the basis of recognized scientific principles, draw upon spatial inputs derived mainly from the interpretation of remotely sensed satellite data, while the nonspatial data are derived chiefly from secondary sources. The IMSD methodology emphasizes a normative approach based on scientific methods and computer-based modeling, with little involvement of the end users in the design and implementation processes, or even in the action plans. Once generated, these plans are transferred, along with the GIS software and database, to district authorities for adoption and implementation.

The IMSD approach mirrors the post-independence Indian policy of state control over land resources and development programs, without much (or any) involvement of the local communities, following the colonial model of "subserving the interests of urban and rural elite" (Gadgil and Guha 1995, p. 15). However, over the years some shifts in the policy of state control can be discerned (Haeuber 1993). These are reflected in moves by government and international donor agencies toward decentralization, although initially more on paper than in practice (Mitra 1992). A critically important development was the promulgation of the 73rd amendment to the Indian Constitution in 1992, which accorded legal status to *panchayats*,[8] with provision to establish local self-government in rural areas. In spite of weak implementation in the initial stages, the recognition of the *panchayats* as the primary institution of local self-government represented a step away from the earlier system of domination by the center, and toward one in which local communities could take responsibility for the management of their own affairs.

Another critical element in promoting decentralization was a shift in implementation practice toward watershed-based[9] rural development. Traditionally, land-based development programs were sector-oriented, that is, they were implemented by various government departments (forestry or agriculture, for example) in isolation. This led to duplication of effort, wasteful expenditure, redundancies, and, often, conflicting objectives, with limited involvement of the local people. The

[8]The *panchayat* is a village body, constitutionally recognized as an elected unit of local governance. However, in many states of the country, effective functioning and true empowerment of this institution have been impeded by the domination of local élites, as well as political and bureaucratic apathy (Chhotray 2004).

[9]Watershed is a geo-hydrological resource unit which drains to a common point. It comprises all bio-physical resources such as soil, water, and vegetation such as trees, grasses, and crops (Farrington et al. 1999), as well as human resources (Subramaniyan 2000).

watershed-oriented development approach, initiated in the 1990s, was based on a holistic view of land, water, and other related resources (Farrington et al. 1999). This model used the micro-watershed (an area of about 500 hectares) as the unit of development, and laid down that development programs and projects should be designed, implemented, and monitored by a watershed development team (WDT) in each micro-watershed. It was recommended that WDTs should include both officials from the relevant line departments and community representatives from the villages concerned. The WDT was to be chaired by a nonofficial (MoRD 1995, 2001). In theory, at least, and in contrast to earlier development policies, the new guidelines endowed the community with wide-ranging administrative and financial powers in micro-watershed development activities.

To sum up, the implementation of the IMSD program needs to be seen within the context of the move toward decentralization of development activities, which potentially created a structure to enable community participation, even in technology-related endeavors like the one under study.

Data Collection

Most of the field work was completed in two phases during the period November 2002 through April 2003. In addition, in late 2005, I met with the former head of NRSA, who had played a key role in the formulation and implementation of the IMSD across the country. Primary data were collected mainly through semi-structured interviews with concerned stakeholders—villagers, the district administration, the local university, NGOs, scientists involved in the project, and officials of the state and central governments dealing with rural development and IT-related policy issues. These interviews provided access to the stakeholders' interpretations of actions and events, thus constituting a primary source of data (Walsham 1995a). In all, 88 interviews were conducted, either singly or in groups. Meetings with villagers were held mostly in groups or during *gram sabha*[10] meetings, and focused on scrutinizing the progress of development projects under implementation, or those planned by the watershed development teams. Prioritization of future activities was debated by community members and government officials in these *gram sabhas*, keeping in view the availability of funds. At least one GIS professional was also present during these group discussions. Participation in these meetings helped me to understand the nature of the working relationships among the various groups (communities, officials, WDTs, and GIS personnel). During group meetings with the local people, an attempt was made to interpret their perception of their role in development through participation (e.g., whether passive or active; whether or not they felt they were taking ownership), their communication with officials and scientists, and whether they felt something positive had been achieved by their participation. Participant observations (Whyte 1997) made during the *gram sabha* meetings also strengthened my contextual understanding of specific issues, such as the value of traditional water harvesting structures in improving the local availability of water. I also witnessed several demonstrations of the locally developed GIS system conducted by the local GIS team based in the district administration.

Table 2 gives a summary of the interviews conducted, excluding the *gram sabha* meetings.

The interviews were conducted in English. They were not tape-recorded, as this is not a customary practice in India, particularly when dealing with government officials. Detailed notes were taken, however, and immediately transcribed using the informants' own words as far as possible. Most of the informal conversations with villagers were carried out in the local language, Telugu, with the help of local interpreters.

Wide-ranging secondary data were also obtained from government departments, NGOs and a local university. These included official reports, guidelines, presentation material, maps, project reports, and evaluation and assessment reports made by independent agencies. Reports in the local media relating to the participation of people in rural development initiatives provided further contextual information. For example, an analysis of the recently concluded elections for village watershed development team members underscored how democratic procedures were taking root in these processes.

Data Analysis

Data collection and its analysis go hand in hand in interpretive research with no clear demarcation between the two processes (Myers and Avison 2002). This mutual interaction represents the interplay of theoretical concepts and empirical data, both consciously and in the subconscious mind of the researcher. With increased exposure, the researcher's understanding of the phenomenon under investigation deepens, and specific themes begin to emerge. To give an example, at the start I was skeptical as to the outcome of participatory development; but during the course of my research, I began to appreciate how new government policies aimed at the devolution of

[10]The *gram sabha* is the village council, the body made up of all adult members of the village. It is the electoral college for holding elections for the *panchayat*.

Table 2. Summary of Field Work (2002-05)

Number of villages visited	Number of Persons Interviewed					
	Scientists	Government officials	Villagers and Farmers	NGOs	Academia	Total Interviews
11	15	19	45	5	4	88

power to local communities had contributed positively to the success of participation. The theoretical concepts that shaped the earlier thinking were deeply entrenched in the nature of the Indian bureaucracy (Jain and Dwivedi 1990; Montgomery 1974). As a result, legislation aimed at devolution of power to grass-root institutions was not, in the past, effectively implemented. However, as I witnessed the *gram sabha* meetings, I began to be convinced that effective participatory processes were possible, even at the grassroots level, although the mechanisms of participation were different from those described in the IS literature dealing with Western organizations. This led me to the notion of boundary objects, and the kinds of facilitative roles they play in making such participation possible.

In order to discern pertinent themes, I prepared a summary of each interview and my thoughts on it from the transcripts of the field notes. Broadly, these themes reflected the users' assumptions, expectations, and knowledge relating to the use of GIS and the application domain. I made a point of meeting some of the respondents a second time to gain additional insights by discussing my interpreted themes such as the community's knowledge of the local topography. The themes that emerged from the first cut of my data analysis grouped themselves around participation, technology, and knowledge.

A central concern was providing coherence to the various themes, for example how could participatory processes foster the integration of scientific, indigenous, and local knowledge? In the next stage of my analysis, I tried to provide coherence by linking them as the challenges to be faced in the task of integrating disparate and multiple knowledge systems, and how these challenges might be addressed.

The Case Study

This section is organized in three parts. The first part reflects on the shift from the top-down approach to development and GIS design toward decentralization of these processes. The second part ("Designing the GIS Database Locally") examines how a bottom-up approach was used for data collection and construction of a new GIS database in Anantapur. The third part ("Generation and Implementation of Action Plans") shows how the new database was used to generate locally relevant action plans, and the outcomes of implementing those plans.

The Shifting Emphasis of Development and GIS Application

Anantapur is one of the 175 districts in which IMSD is being implemented. The Andhra Pradesh Remote Sensing Application Centre (APRSAC) is the scientific institution responsible for the implementation of IMSD in Anantapur. Located in Hyderabad, about 200 miles from Anantapur, the APRSAC was assigned the task of developing the land and water GIS database for the district and preparing "action plans" according to the IMSD methodology (NRSA 1995). The project director, who is responsible for land and water development in the district and the related IT work, disclosed that APSRAC had not consulted either the district or subdistrict departments concerned or the local people while finalizing the IMSD-generated action plans. She further mentioned that, since the data being used by APSRAC were of 1991 vintage, changes occurring in land degradation status and water availability since 1991, due to continuing and severe drought conditions in Anantapur, were not taken into consideration in the GIS models. Also, the action plans depicted on 1:50,000 scale maps were too coarse to be useful in field applications (1 centimeter on this map scale represents 500 meters on the ground). Therefore, it was not possible to locate the interventions suggested to individual landholdings. The usefulness of these maps, accordingly, was limited to prioritizing areas for development at the broad level of a watershed. Use of an appropriate larger map-scale for micro-watershed level of 1:8000 was indicated.

A middle-level officer in the district soil conservation department explained that the interventions suggested in the action plans were at variance in several respects with departmental thinking. Also, farmers were not able to relate to the recommendations, howsoever "scientific" they might be, as they felt that these prescriptions were incompatible with local needs. For example the inter-cropping patterns suggested in the plans did not take into account the practical reality of the existing pattern of small land holdings, or of the need of individual households to produce what they required to survive through a year of drought. The lack of consultation between scientific and line departments was emphasized by another official as follows:

> The scientists and the institutions concerned are not controlled by us, and do not speak our "language." They ask us to accept what they provide and use it. I cannot study action plans, consult subject matter experts in other departments, take these plans to villages, seek people's opinion, and provide feedback to scientists within a few weeks. By the time I was ready to do so, the concerned scientists were engaged in some other "priority" work. They came to us at their convenience, when half the concerned people might not be available at the local site. The structure was all wrong. The whole thing had to end in a disaster.

Ignoring these infirmities, a senior official in the central ministry of rural development emphasized his ministry's commitment to GIS in the following way:

> See, harnessing the inputs of science and technology in our field programs is a key component of this organization's mandate. Therefore, we have to do something positive and demonstrable in this behalf. We have sought advice of scientific institutions at the national level, and taken action accordingly. Tomorrow, no one can blame us for not abiding by the mandate.

The project director explained how the decentralized model of development, by making watershed development teams responsible to the *gram sabhas* for the design of village-level development activities, was a step toward the empowerment of communities. The implementation of the development works envisaged in the design agreed to by the *gram sabha* was also taken up by the people themselves, through user teams elected in the *gram sabha*. The district administration also realized that if ICTs including GIS were to be effective tools in local development, then software teams needed to be locally established within its administrative control. As a result, the IT/GIS infrastructure was set up in the district headquarters by the creation of an IT center manned by personnel trained in GIS and software, who reported to the project director.

During a group meeting with villagers, I asked their opinion about the changes that had occurred as a result of the administration devolving powers to WDTs. An elderly woman responded,

> I have observed the government sponsored programs for many years. No one consulted us earlier. They did what they wanted. Now, things are different. We know what we want by way of development, and design the activities accordingly, and also implement and monitor them. It is all very transparent.

The woman's approving comments were supported by the evidence of many wall paintings in the villages which provided details of the projects under implementation by *gram sabhas*. This visibility, and thus potential accountability of government, had been absent before.

In summary, the watershed-based decentralized model of development appeared to be functioning effectively, with communities providing design inputs as well as taking charge of the implementation of programs and projects. The local administration, by deciding to locate and populate the GIS center within its control, showed its keenness to use ICTs like GIS to improve the effectiveness of these programs. These changes represented a major shift from the earlier top-down approach in which the local communities had little say.

This shift in perspective encouraged the scientists to become more engaged in implementation. This in turn, together with setting up a local GIS unit, contributed to the deepening involvement of the local communities in development, creating further opportunities to draw upon their knowledge in the design of a new database for the district.

Designing the GIS Database Locally

In the meetings of *gram sabhas* (in two of which I participated), development plans for the area were discussed and finalized. The deep understanding of the communities about the land, water, and vegetative resources of their localities, and their perceptions as to how these should be developed and used, were discussed with administrators and the GIS scientists. Communities explained their perspectives by means of *participatory mapping*. They drew resource maps on the ground (not to scale) to depict the location of various existing resources, and the appropriate locations of the proposed interventions. The scientists acknowledged that some of the elders had a keen sense of the local topography and drainage patterns, and were aware of how traditional water-harvesting structures had been beneficially used in the past. The markings

Figure 2. Participatory Mapping in Progress

made by the community members on the ground maps were subsequently incorporated into the GIS database by the GIS scientist who participated in the resource mapping exercises, although primarily as a bystander. To give an example of the villagers' input, they convinced the scientists to realign the routing of a feeder canal. Their reasoning was that the course suggested by the latter would adversely impinge on the long-standing division of land practiced among the communities. Figures 2 and 3 depict participatory mapping and the villagers' preparation of a resource map to explain to the scientists their conceptualization of local development.

During my field work, I met local GIS scientists several times to get an idea of how the bottom-up GIS database design was progressing. They explained that the data collection had been carried out by field teams comprising a civil engineer, one person from the village concerned, one NGO representative, and a scientist from the local GIS unit.

During 2001–2002, these teams undertook village-wide surveys using global positioning system (GPS) handsets to note the latitude and longitude values of spatial entities such as wells, check-dams, and agriculture holdings on paper-based cadastral maps (1:8000 scale). The GIS team leader explained that these paper maps, with the manually recorded data, were sent to the National Remote Sensing Agency (NRSA) for digitization, quality check, and eventually the construction of a GIS database. This database was then transferred by NRSA to the district office to be used for multifarious applications. Its use in the water audit carried out in the district in 2003 in partnership with the British Department for International Development (Rao et al. 2003) is only one example. This audit led to the formulation of long-term policies and interventions to develop and manage water resources, and to promote more equitable access to water for productive uses. The Department for International Development representative with whom I exchanged several e-mails in 2003, and the project economist whom I met in New Delhi in May 1993, vouched for the accuracy and topicality of the database. With the adoption of the bottom-up approach to GIS design, the role of remote sensing institutions was also redefined, especially with regard to the generation and implementation of the action plans.

Generation and Implementation of Action Plans

I attended several demonstrations of GIS-related work in Anantapur, and observed the use of the locally generated data-

Figure 3. The Final Shape of the Resource Map Showing Existing Land Use and Location of Water Bodies (Not Captured through Remote Sensing)

base. One striking example was the survey and recording of all water harvesting structures; the subsequent analysis of these data led to the identification of 29 redundant structures out of a total of 176 built under various government programs in the past years. Besides the wasteful expenditure incurred, such redundant constructions potentially had a negative impact on the availability of water downstream and the recharge of ground water. GIS thus helped to make visible the shortcomings of past projects, which added to the impetus for change. As a result, the district administration issued orders to revive the traditional water harvesting structures, and also decided that, in future, proposals for new water-harvesting structures would need to be more closely scrutinized.

During a meeting with villagers, I sought their opinion about the changes brought about by the administration in development procedures. An elder said, "Our voice is now listened to and we ourselves implement the activities approved in the *gram sabha*." When asked whether they were overawed by the presence of officials and scientists during meetings of *gram sabhas*, the response was emphatically in the negative, although in the beginning there had been some skepticism about the new "openness." The villagers attributed this openness mainly to the political initiatives taken by the chief minister, and the interest shown by the district collector[11] in providing adequate powers to *gram sabhas*, such the as financial powers now vested in WDTs.

In a village where a canal was under construction to irrigate 260 acres of land, the villagers confirmed that the work was being implemented by several user groups comprising about 80 local farmers. Reflecting that the execution of such tasks requires engineering knowledge, I probed further with a few questions about the local drainage pattern. A villager responded,

> We are better than engineers. The officials are welcome to check all the accounts, see the quality of work and progress. We assure you that we have much better knowledge of the area because of long

[11]The district collector is the head of district administration hierarchy.

> local experience than any outsider can develop in a few days or weeks or even years. I know where each and every drop of rain falls here, and where it goes.

During a meeting in April 2003, the APRSAC scientists acknowledged that the development plans then emerging from discussions with people, and implemented through the mechanisms of the *gram sabha* and WDT, were in tune with local needs. Such discussions were an effective way to bridge the gap between the communities' and the scientists' thinking. Explaining this, a senior scientist said that APRSAC had been formally assigned the Anantapur district in 1999, and three scientists had been made responsible to ensure that the IMSD action plans were reviewed and revised in consultation with the communities and local departments concerned. That was the new official mandate "from the top." Another scientist said,

> Although this new approach was initially resisted by us, after several meetings with communities and the district administration, we decided to give it a fair try. Over the last 4 years, my interaction with villagers and local resource managers has been somewhat of an eye-opener. They indeed had valid reasons not to use earlier action plans, which I appreciate now. We need to learn many lessons on land and water development from them. I now believe that knowledge coming to us scientists from the so-called nonscientific sources deserves to be at least examined with an open mind.

NGOs also emphasized the recent participatory approach to decentralizing ownership of development to communities, and explained that this had elicited the latter's cooperation. The NGOs had participated in GPS data collection; they believed that while the ancient water-harvesting structures were not hidden, modern reliance on technology alone had ensured that they fell into disuse over time. As government agencies assumed near-total control of development, communities could not but watch helplessly as the previous approaches to land and water conservation were discarded. The knowledge of these ancient techniques had survived, however, as elders in the community often recounted tales of how water shortages during past droughts had been dealt with using local resources.

The faculty members of a local university who had provided training to the NGOs on how to conduct GPS surveys had also, together with the NGOs, held informal workshops in clusters of villages to impress upon the communities the benefits of technology. They explained to the local people how their knowledge of agricultural practices, water conservation and organic manures, for example, could provide useful inputs into technology-related development initiatives. The faculty also conducted independent assessments at randomly selected sample locations to evaluate the impacts of ongoing programs, including the use of GIS, on land and water productivity. They were good enough to share several of these reports and findings, reflecting positive outcomes, with me.

During the second visit to Anantapur after a gap of about six months, I learned that a new district collector had been appointed. I was keen to find out if the initiatives taken by the previous incumbent were still in place. During visits to several villages, participation in a *gram sabha* meeting, and also in discussions with the project director and the GIS team, there was no evidence of any discernible change. The new district collector told me,

> In several districts, the use of remote sensing and GIS has been largely symbolic, with colorful maps adorning various offices. I intend to strengthen the decentralized style of technology diffusion adopted in Anantapur, and the immediate plan is to ensure the present database is kept updated and further strengthened. NGOs and the local communities will continue to play a key role in this activity along with the scientific staff.

These remarks would seem to indicate that the decentralized model of development and the bottom-up approach to GIS design and its use are gradually being institutionalized in Anantapur.

I met the former head of NRSA in November 2005 in order to learn from him how the rather sudden change in the attitude of scientists vis-à-vis local administrators and village communities had come about. The scientists now appeared to be receptive to the inputs provided by the rural "users" of GIS. He said,

> Participation of users was originally envisioned as a main feature of IMSD. However, two key factors that forced scientists to change their earlier thinking and resistance to considering other knowledge inputs were: (1) assigning specific districts to a group of scientists; besides the research component, the revised emphasis was on "producing" results in the field—that would be a significant parameter in the assessment of their work, (2) institutionalization of the watershed model and devolution of power and authority to local communities by the government.

Table 3. Key Features and Characteristics of the Case Study

Context and Phases of the Implementation Process	Key Features	Illustrations	Implications Around Knowledge
Shifting context	Communities given ownership of development; GIS infrastructure and expertise instituted locally; scientists attached to districts.	*Previously*: Development work scattered across departments, little involvement of communities; IMSD action plans scantily used. *Now*: Land/water development designed and implemented by WDTs; communities participate organically; database constructed locally more useful, relevant and in everyday use.	Community knowledge rendered visible and included in development scenarios.
Design of the GIS database	Key data elements included as per local needs; role of scientific institutions redefined; indigenous knowledge shared and made visible to scientists.	Data collected by local teams; technical infrastructure of scientific institution used to construct spatially valid database; indigenous knowledge expressed through resource mapping.	Indigenous knowledge used for data collection and ground-truthing; scientific knowledge drawn upon in construction of database; indigenous knowledge included in the database.
Generation and implementation of action plans	Database used to support land/water development; past inefficiencies revealed.	Water audit; identification of unprofitable water harvesting structures, choice of species to be planted.	Co-constructions of scientific and indigenous knowledge in evidence.

Table 4. Key Themes

Themes	Key Characteristics	Illustration
Participation	From near-absence of participation of communities in development, their deep involvement in these activities now discernible. Move toward empowerment of communities.	Communities organically participating in *gram sabhas*; powers devolved to watershed development teams.
Technology	Now seen as not an end in itself, but the means to provide support and improve development initiatives in the field.	Scientists being given the mandate to produce results in the field.
Knowledge	Dependence on the domain knowledge of scientists alone contested; communities expressing their knowledge with confidence, some recognition of indigenous knowledge.	Rejection of action plans produced by remote sensing institutions; scientists attending *gram sabha* meetings inclined to take indigenous knowledge into consideration.

A summary of the case reflecting the key characteristics identified in its three parts, described above, is provided in Table 3.

Adoption of a decentralized model of development governance brought about active participation of communities in local area planning and the implementation of their identified needs. At the same time, top-down structures, within which GIS technology was applied by scientific institutions and local inputs were ignored, were also being incrementally redefined to facilitate the adoption of a bottom-up approach. Gradually, these changes modified the exclusive predominance of scientific rationalities earlier evident in GIS designs, and made indigenous knowledge visible, leading to a more effective alliance of these two forms of knowledge. Setting up the GIS unit helped to increase technological awareness in the staff of the district and subdistrict departments. When this was combined with their existing field level understanding gathered over a number of years, the implementation and monitoring of projects improved. The database constructed on the basis of this composite knowledge proved to be more relevant than earlier ones for addressing the application domain (i.e., the problem of improving the land and water regime in the district).

Key themes emerging from the case are summarized in Table 4.

Discussion and Analysis

The theoretical perspective developed earlier identified three interwoven concepts—communities-of-practice, boundary objects, and participation—to help analyze the empirical data. The case is now discussed around these three themes, with focus on understanding knowledge-related issues. The theoretical and practical implications of this research are presented thereafter.

Identifying Knowledge Systems and Their Characteristics

With respect to the application of GIS for land management, three different knowledge systems held by different COPs can be identified. These are (1) the knowledge of GIS and remotely sensing technologies held by scientists, (2) the domain knowledge of departmental functionaries, and (3) the indigenous knowledge held by communities. Historically, these disparate knowledge systems have existed largely in isolation and have operated in a fragmented manner. I use the three aspects of boundary objects described earlier to analyze how in past GIS initiatives they contributed to the fragmentation of knowledge systems and how, in this case, the changing nature and application of the boundary object has helped to bring about better integration and more effective implementation outcomes. The increased participation of the local communities is also discussed in both cases, along with their contribution to the articulation of very different kinds of boundary objects and their use.

Historical Situation with Respect to GIS Implementation

The IMSD outputs were made available to the district departments by way of suggested action plans and their depiction on 1:50000 scale maps. These maps (boundary objects) were expected to be put into use by the departments of the local administration, which were to translate the scientific knowledge inscribed in them into field level action through the mechanisms of projects approved by the departments themselves.

The *technology* employed was GIS modeling, and the use of expert systems, based on the underlying assumption that the action plans (applied in 175 districts in India under the IMSD) generated through modeling and the rules inscribed into the systems were universally applicable. This approach, based on the correlation of different map layers in the search for causal relationships to explain degradation, restricted the *content* of the IMSD plans to the domain of scientific knowledge, largely ignoring the social factors that contributed to degradation, such as asymmetrical and marginal landholding patterns among the poor communities. These science-based approaches also ignored previous government efforts to develop water structures that had not yielded positive results. The *practices* of IMSD were derived from the remote-sensing institution's preference for interpreted satellite data.

Participation in the early IMSD projects was almost exclusively restricted to the COP of scientists, with few inputs into the formulation of action plans, or their application in the field, from the line departments and local communities, the other two COPs necessarily involved in their implementation. Behavioral aspects were de-emphasized; for example, there was little interaction with departmental managers and communities, nor was there consideration of the latter's perception of efficient land use that would also be consistent with the local needs and ethos. Neither the departments nor the farmers could relate to these boundary objects, which were at odds with the latter's knowledge domains and social practices developed over generations of land use. For example, the locale for digging a well suggested in the action plans was unacceptable socially because it fell within a cremation ground. Again, the suggested adoption of a particular cropping pattern to maximize theoretical economic rationality failed to take into account the extremely small individual land holdings (often less than half an acre), which made it infeasible for the marginal landholders to undertake. In sum, the implementation of the IMSD demonstrated a fatal weakness, namely the fragmentation of the three knowledge domains implicated in addressing land degradation.

All this does not imply that ICTs like GIS are irrelevant to social development processes. What it demonstrates is the importance of a more participatory approach in order to synthesize the relevant knowledge domains in information systems development, coupled with more appropriate choices of technology, something not attempted in the past. The IMSD approach ignored the social implications of degradation and the best practices that would be locally efficacious. Blaikie and Brookfield (1987) had such a scenario in mind when they argued that there are competing social definitions of land degradation, raising the need to move away from a single scientific definition and measurement to incorporate multiple perspectives: "This means we must put the land manager [farmer communities in this case] 'centre stage' in the explanation, and learn from the land managers' perceptions of their problem" (p. 16). It follows that scientific ventures like the IMSD must focus on empowering people to take their own decisions about land use in order to take advantage of the wealth of indigenous knowledge held by the local communities. This knowledge needs to form alliances with relevant technologies, for example, GIS in the case discussed.

GIS Implementation in Anantapur

In the case under study, the boundary objects that served to make indigenous knowledge visible to and sharable by scientists were the resource maps made by communities. The technology used to prepare these maps was home-grown. Their content reflected the community's knowledge of the local landscape and ecology and, thus, articulated their understanding of the drainage patterns, water bodies, and other features of their land which in turn explained their choice and preference for species to be planted. It also expressed their vision for the kind of development they desired in line with local culture and practices. The practices entailed in the construction of these boundary objects were based on the local ethos, and the everyday methods used by local communities for communication between themselves. This local knowledge, meaningfully merged with the power of scientific and GIS technology, led to the design of an effective IS that contributed to the success of rural development programs and justified the utility of the GIS system.

Active cooperation among the three COPs (scientists, communities and departments) in *gram sabha* meetings was evident. This cooperation had both structural and behavioral characteristics. For example, watershed development teams functioned within the new structures that encouraged participation, and the GIS scientists operated within the ambit of the district administration rather than in the isolation of their institutions. The behavioral aspect was evident in how the communities articulated their perceptions of development and in the creation of resource maps. The freedom to express themselves and communicate with other COPs on a relatively equal footing with the scientists helped them to draw upon their practices and knowledge to produce an effective boundary object. The resource maps helped to demystify the GIS technology itself, by putting it in perspective as only one of several inputs, not in any way privileged over the local knowledge expressed by the villagers.

A notable feature of the case was the changing nature of the boundary object and its implications. Both the IMSD maps and the Anantapur resource maps can be conceptualized as boundary objects; but when viewed from the content–technology–practices perspective, they differ substantially. While in the IMSD case, the boundary objects were not very useful in mediating different knowledge domains, the resource maps were remarkably effective. The absence of participation in the one case and its active presence in the other made all the difference to the outcomes. The dialogue established between the three COPs by the adoption of behavioral modes of participation led to the synthesis of their respective knowledge domains in the resource maps.

The Anantapur study demonstrates the way in which, by changing the institutional structures within which rural development projects are implemented (i.e., by devolving powers to local *panchayats* and *gram sabhas* and thus empowering the communities), the role of the scientific institutions was redefined. They formally assumed greater ownership of GIS activities in specific districts, thus to some extent changing the earlier focus, which was only on research and technology development. As a result, it was noticed that scientific institutions provided more active technical support, which complemented the ongoing efforts of the district computing staff in the GIS unit. Also, as the local GIS infrastructure became capable of generating the required outputs and maintaining the local database, the comprehensive infrastructure of the scientific institutions was drawn upon for more advanced work, for example to construct a spatially valid and consistent database for the district, which would have been beyond the capacity of the local GIS team.

Based on the theoretical framework developed and the analysis of the case discussed above, the theoretical and practical contributions of this paper are outlined next.

Theoretical Contributions

Key theoretical contributions lie in visualizing and articulating the concept of building knowledge alliances across COPs, in proposing a "triad" perspective to strengthen the conceptualization and potential use of boundary objects, and in broadening the concept of participation in ISD by drawing upon development and organizational theories.

Proposing the Notion of Knowledge Alliances

While the social, political, and historical nature of knowledge has been emphasized by several IS scholars, there is a relative lack of discussion as to how the different domains of knowledge involved in a particular IS design setting may be synthesized. Particularly in the context of LDCs, IS designs based on these insights are almost completely absent. The theoretical discussion and case analysis presented in this paper are an initial attempt to fill this gap. The concept of building up knowledge alliances between different stakeholder COPs to address a particular problem domain through the judicious use of ICTs contributes to the existing literature related to knowledge engineering.

The concept of knowledge alliance acknowledges the importance of both the functional and the constitutive aspects of indigenous knowledge. In its functional role, indigenous knowledge contributes to the improvement of ISD, while the recognition of its constitutive aspect is vital to empowering local communities and taking them a step closer to participating in decisions relating to technological choices, which potentially should be used to further their developmental aspirations. Indigenous knowledge has not been traditionally considered in IS design in LDCs. Understanding the informal knowledge articulated by communities, and inscribing it into IS application designs, which in the past have been primarily based on scientific knowledge reflecting formal decision-making methods, involves boundary crossing (Suchman 2002a), and is a complex process (Arce and Long 1992). This paper has demonstrated that the use of improvised resource maps can be an effective communication tool to facilitate the scientists' appreciation of the value of indigenous knowledge, and a concrete mechanism by which it can be incorporated in IS models. Thus, indigenous knowledge can be expressed, provided that the suspicion and skepticism that communities harbor with regard to "outsiders" are mitigated by the creation of appropriate conditions for dialogue.

Theoretical Reconceptualization of Boundary Objects: Triad Perspective

This paper seeks to broaden the concept of boundary objects by defining the key attributes that determine the use and effectiveness of these objects in practice. Considering knowledge, boundary objects, and participation as inextricably linked arguably provides deeper theoretical insights into the dynamics of COP interactions that permit (or fail to permit) the sharing of knowledge across boundaries. The content–technology–practice triad concept has the potential to contribute to the literature on boundary objects, particularly the literature treating IT as boundary objects. The notion of the boundary object, although frequently drawn upon in IS studies, has often not been given much theoretical specificity but rather is described as *anything* that performs a boundary spanning function. The *triad* conceptualization articulated in this paper has the potential to advance a deeper understanding of boundary objects.

Broadening the Theoretical Conceptualization of Participation

While IS studies often treat participation in a binary fashion (i.e., absent/present), development theory admits its various shades and levels. Participation is a process that changes over time, being shaped by and also shaping varying institutional conditions and human agency. Such a nuanced understanding shows that participatory processes are not only possible in a Western context, but can also be fostered in the more hierarchical and bureaucratized societies of LDCs. However, methods of encouraging participation will inevitably be different in the West and in the LDCs, according to their different assumptions and conditions of democracy, infrastructure, education, and awareness. This paper demonstrates how participation comes about from the knowledge and the capable agency of people attempting to support development processes and, in doing so, creating the potential to reconstruct institutional structures which define, facilitate, and foster development. Collective human agency, expressed as participation, has the potential to redefine existing structures and practices embedded in the institutions of bureaucracy that typically implement development projects.

Emphasizing Bass and Shackleton's (1979) distinction between structural and behavioral forms of participation is another contribution of this paper to the participatory IS literature. The need to achieve a judicious balance between these two forms of participation has been pointed to through the case analysis. The importance of structural change to facilitate and sustain participation, and how this can affect the outcome of both socio-economic and IS development projects, has been underscored. The behavioral focus, on the other hand, shows how user needs can be effectively incorporated into the IS design processes by basing their design on collective thinking and shared perspectives among the stakeholders, thus creating more effective systems.

Practical Contributions

Through the analysis presented in this paper, it is argued that the case of Anantapur demonstrates ways of combining different kinds of knowledge that can help develop a more effective strategy to combat the larger problem of land degradation. While it is important to draw upon indigenous knowledge in the design of development projects locally, we must at the same time consider the macro-problem: how can the lessons of experience be drawn into efforts to address the complex problem of land degradation? At one level, land is a *resource-in-use*, inextricably related to the people and society that use it, implying that degradation may have complex local causes. At another level, there are patterns that repeat themselves in human–environment relations (Blaikie and Brookfield 1987), implying some context-free elements that can be modeled using technologies like GIS. For example, loss of vegetative cover can be predicted through modeling the land use pattern and intensity of resource use. The challenge then is to develop approaches that, on one hand, take into account the capability of new technologies like GIS and, on the other, draw upon the relevant indigenous knowledge and the power of local agency. The discrepancy lies in the fact that GIS and other technologies, while potentially enabling the larger spread of projects, tend to come with government institutional structures that are not conducive to active local participation and, on the contrary, may even stifle it. This dilemma represents a dialectical relationship where each process simultaneously both supports and undermines the other. Castells (2000) refers to this predicament as a key challenge in creating new structures of governance in contemporary civil society. While resolving this predicament is beyond the scope of this paper, its identification helps to raise at least two key questions for future theoretical and empirical work. The first concerns the challenge of developing *composite knowledge* that blends indigenous and scientific knowledge. The second relates to the development of institutional frameworks within which participatory processes can be nurtured to facilitate application of this knowledge for the larger good of land conservation. Initiatives like the Anantapur case provide inspiration and may suggest a way forward.

Conclusion

Walsham (2001) raises the important question of whether ICTs are contributing to the creation of a better world. This question is largely ignored by IS researchers whose dominant concern is whether or not the potential material benefits of technology are being realized by its application. It becomes all the more relevant, however, in social applications such as land management in impoverished areas where land provides the fundamental source of livelihood to the majority of the people. It is not enough merely to consider the efficacy of an ICT on the technological level; the issue needs to be raised as to whether, through its use, the given problem domain has been addressed, and whether the ICT has helped to improve the livelihood of the poor farmers. In the Anantapur case, it was found that the use of GIS had made possible effective action leading to a significant rise in the water levels, which in turn allowed beneficial changes in the cropping patterns. However, these changes came about not just from the use of the technology, but also as a result of the associated redefinition of the relationships between scientists and community members, and the restructuring of the institutional framework. It follows that social considerations are of the essence in the application of new technologies, and these need to be foregrounded in IS research—all the more so when these systems are applied for the betterment of poor and marginalized communities.

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