OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

EMERGING
TECHNOLOGY
SERIES

The use of Geographical Information Systems in Developing Countries: Social and Management Issues

Prepared for UNIDO
by
Sundeep Sahay and Geoff Walsham

INTERNATIONAL CENTRE
FOR SCIENCE AND
HIGH TECHNOLOGY

UNITED NATIONS
INDUSTRIAL DEVELOPMENT
ORGANIZATION

Vienna, 1997

THE INTERNATIONAL CENTRE FOR SCIENCE AND HIGH TECHNOLOGY

The International Centre for Science and High Technology (ICS) is an institution within the legal framework of the United Nations Industrial Development Organization (UNIDO). Its headquarters are located in Trieste, Italy.

The Centre's mandate relates to the transfer of know-how and technology in favour of developing countries, and is justified by the perception that a competitive industrial and technological capability cannot be built-up without adequate scientific knowledge and without participating in the sustainable development and utilization of new and advanced technologies

ICS's target beneficiaries are identified among scientists, researchers and technologists within industrial R&D institutions, science-based industry clusters and/or industries with their own R&D facilities. Close cooperation with the industrial sector is sought, either through direct interaction or through the provision of eco-services by national and regional R&D institutions. To this aim, ICS will carry out the following main functions: long-term and short-term training; research; conduct of workshops and scientific meetings; operation of a scheme of visiting scientists and associates; advisory services; cooperation with industry; cooperation with and affiliation of relevant national institutions; and transfer of technologies.

In the present work programme, the ICS activities focus on specific sectors within the areas of chemistry, environment, new materials and high technology. In selecting the specific sub-programmes and their related actiities, special consideration is given to their relevance in relation to the scientific and technological development of developing countries, with a specific focus on environmental problems.

Further information on training programmes, seminars and other ICS matters should be addressed to the Director, International Centre for Science and High Technology (ICS), Via Grignano 9, 34014 Trieste, Italy. Tel. 040-224572; Fax. 040-224575; www: http://www.ics.trieste.it

ACKNOWLEDGEMENTS

We gratefully acknowledge the contributions of a variety of institutions and individuals in the development of this publication. The research was made possible through a fellowship award by the Isaac Newton Trust and Hinduja Trust at the University of Cambridge for the study of "Information Technology in Developing Countries." The authors acknowledge the support of the Judge Institute of Management Studies, University of Cambridge, where the authors were based during the period of the research. We are extremely grateful to the different scientific and educational institutions in India who provided the researchers with research access, and supported them throughout the period of the study. The joint fellowship award to Sundeep Sahay by UNIDO, Vienna, and the Institute for Science and High Technology, Trieste, Italy, in the area of transfer of GIS technology to developing countries also contributed to clarifying some of the ideas that have been expressed in this study. Financial support provided by UNIDO, Vienna, is also duly acknowledged. Support provided to Sundeep Sahay by the Department of Accounting and MIS at the University of Alberta is gratefully acknowledged. Many different individuals supported this research. Special thanks to Mr. Puri of the Ministry of Environment and Forests, New Delhi, India, without whose encouragement and support, this research would not have been completed. Special thanks to the scientists and other officials in both India and Malaysia who were always extremely willing to spend time to discuss the challenges and opportunities they were experiencing in implementing their GIS projects. The authors would also like to gratefully acknowledge the support of Diana Rhind at UNIDO, Vienna, who encouraged them tremendously in the writing of this book.

CONTENTS

PREFACE

During the last decade, a number of developing countries have been actively engaged in applying geographical information systems (GIS) technology with the aim of improving their environmental and natural resources management practices. Despite the large amounts of recent marketing and academic literature available on the promise of this new and exciting technology to contribute to national socio-economic development processes, we find its impacts to still be rather marginal, and the returns not justifying the large investments of time and money. This less than effective utilization of resources is a critical issue in the context of developing countries, which are faced with the concurrent and inter-connected pressures of managing their economic growth while sustaining their natural resources.

The key questions motivating this study are: has GIS been "successfully" used for real applications in developing countries, especially within the domain of natural resources management; and, if not, why is this the case and what can be done about it in the future. The issues involved in effectively implementing GIS are examined, with a focus on understanding the characteristics of the social and institutional context within which implementation takes place and how these influence project outcomes. The past history of information systems (IS) and GIS implementation in developing, as well as many developed countries, sensitizes us to the importance of social and institutional considerations as bottlenecks to the effective application of technology.

The primary focus of the present research is India, where the authors have been engaged in a long-term and in-depth examination of various national public sector GIS initiatives. India is an interesting example to examine GIS use, because it is currently a focus of many varied globalization pressures; for example, the country is a recipient of large amounts of international aid to implement improved environmental management practices, including the use of GIS technology. India has a well developed infrastructure including a large pool of highly skilled scientific manpower, especially within the domains of computer technology and space science. India has some well-publicized successes with respect to information technology development including its thriving software industry, and it has in place one of the largest national level high-speed telecommunications networks in the Asian region. Despite these relatively high levels of technical and human infrastructure, the researchers have found that the returns from investments being made in GIS are low, and projects seldom reach the stage of full-scale operational use. In this publication, these reasons are examined, and the Indian experience is compared to Malaysia's, where field research was carried out in various governmental agencies.

A key focus of this publication is to examine and describe management implications that aim to be useful for GIS project planners in developing countries to effectively implement GIS projects. The purpose is not to provide a set of prescriptions for project management, but rather to sensitize the planner to some of the key issues he or she must be aware of in planning GIS projects, and what are some of the ways in which projects have been managed in other contexts. Such an approach, which is grounded primarily in a sociological perspective, rests on the fundamental assumption that particular project management solutions are inextricably bound up with the characteristics of the local social and institutional context.

It is hoped that this publication will be useful to a number of different groups and organizations. In addition to the GIS project planners referred to above, environmental and natural resources policy makers may benefit by understanding the nature of GIS outputs, and how they could be meaningfully integrated into policy formulation and implementation processes. The study could help development planners in international agencies, such as UNIDO and the World Bank, to better understand the GIS technology transfer problem, and what can be done to make the transfer process more effective and sustainable. GIS vendors may be sensitized to specific problems inherent in projects in developing countries, which could be useful for market planning efforts. Finally, researchers themselves may find this publication useful in trying to understand GIS project management and implementation issues, and be encouraged to feed back this knowledge to project planners and other relevant agencies.

BIOGRAPHICAL DETAILS

Geoff Walsham

Geoff Walsham is English and his formal education took place in the UK at the Universities of Oxford and Warwick, where he took degrees in Mathematics. His interest in developing countries is a long-standing one, with his first direct experience being one year teaching Mathematics at Mindanao State University in the Philippines in 1966/67. After four years as an operational research analyst for British Petroleum in London, he took up a post in early 1972 as the first operational research lecturer at the University of Nairobi in Kenya. He worked there for three and a half years, and his research during that time included work on macro-economic modelling and income distribution in conjunction with a US professor of economics. He returned to the UK in 1975 as a lecturer in the Management Studies Group of the Engineering Department at Cambridge University, a post he then occupied for 19 years. During this period, he continued to work in developing countries in different roles as a teacher, researcher and consultant. In particular, he was involved in extensive work on "training for trainers" in India, Indonesia, Malaysia and Singapore. His direct interests shifted in the mid-1980s from operational research to the more general topic of the role and value of computerization in developing countries. The GIS work described in this book is one example of this focus. In addition to his work in developing countries, he has worked extensively on computer-based information systems in the industrialized world, and in particular on human processes of interpretation surrounding such systems, described in some detail in his book *Interpreting Information Systems in Organizations* (Wiley 1993). In 1994, Geoff Walsham took up a new post as Professor of Information Management at Lancaster University, where he stayed for two years. He is currently Acting Director of the MBA Programme at the Judge Institute of Management Studies at Cambridge University and an Honorary Professor at Lancaster University. He is continuing to work on the human consequences of computerization in both industrialized and developing countries, with the objective of gaining a better understanding of such processes, and thus endeavouring to contribute towards creating a better world for mankind.

Sundeep Sahay

Sundeep Sahay is Indian and currently living and working in Canada. His formal university education took place at Birla Institute of Technology and Science, Pilani (Rajasthan, Indi), with degrees in Management Studies and Industrial Development. During the course of his studies, he did practical training at development institutions such as the Industrial Development Bank of India, National Institute of Bank Management, and Development Corporation of Konkan Limited. After completing the programme in Industrial Development, he joined the private sector and worked in the inventory control and material management areas for about five years, in and around New Delhi. Sundeep Sahay then left the field of industry and lectured for about two years at a management institute near New Delhi, in the area of operations research and production management, also undertaking some independent software development projects. The teaching experience in New Delhi helped reinforce the desire to make a career in academics, and Sundeep Sahay left India for the USA in 1989 to start PhD studies. There he worked under the supervision of Daniel Robey at the Florida International University, Miami, and wrote his thesis entitled "Social Construction of Geographical Information Systems." In this thesis, he examined how the same technology (GIS) is interpreted quite differently in separate social contexts, and how these differences contribute to quite different implementation outcomes. On completion of his thesis in early 1993, Sundeep Sahay left to work in a post-doctoral capacity at Cambridge University with Geoff Walsham on a project to examine the use of information systems in developing studies. The study focus was subsequently narrowed down to include GIS technology in India and Malaysia, and the extensive field work undertaken during the period from 1993-1995 provides the basis for this publication. On completion of the project, he left Cambridge to take up a lectureship at the University of Salford, Manchester. After one year, Sundeep Sahay joined the Faculty of Business, University of Alberta, Canada in Autumn 1996, teaching in the area of Management Information Systems. His work with GIS applications in developing countries is ongoing, and he was awarded a fellowship by UNIDO, Vienna, and ICS, Trieste, Italy, to examine issues related to the transfer of GIS technology in developing countries.

CHAPTER 1

INTRODUCTION

Information technology has become an important aspect in the attempt by various developing countries to achieve socio-economic progress. India is an interesting current case since, although it has taken to computerization rather later than some of the other countries in the region, it has already some well-publicized successes, such as the thriving software industry (Heeks, 1996). While recent the growth of this industry reflects India's increasing emphasis on the private sector in recent years, the public sector continues to be a major part of the economy. An interesting question is to what degree has information technology use penetrated.

The focus of this work is on Geographical Information Systems, or "GIS" as it is popularly known, a technology which has of late been gaining increasing visibility in developing countries, including India, especially within the public sector. GIS technology, which was initially developed in university departments in the United States of America and Canada more than two decades ago, has over the years been applied quite extensively in both the public and private sectors of many developed countries.[1] The world wide GIS industry has been growing at the rate of over 30 per cent per annum over the last few years, and is expected to sustain this rate over the coming years. While in the context of developing countries the promise of GIS to support national socio-economic development processes remains largely unfulfilled to-date, governments are making, and are expected to continue to make, large investments to operationalise the use of this technology in future.

In general, the term GIS describes computerized information storage, processing and retrieval systems that are specifically designed to cope with geographically-referenced spatial data and the corresponding attribute information. These systems have the capability to support activities of organizations in managing spatially distributed resources by examining trends, identifying factors that cause them, revealing alternative paths to solve a problem and indicating the implications of decisions. For example, GIS can show how a natural resource such as a forest will be affected by a decision permitting industrial development in a particular region. Based on satellite data, areas that suffer most from deforestation can be analyzed in the GIS by examining parameters such as soil types, rainfall and types of agricultural yield.

GIS finds special applicability within government organizations engaged in the establishment and maintenance of various dispersed resources. For example, in the context of local area management in India (referred to as district administration), many of the issues are highly spatial in nature.The planning and upgrading of roads, the location of

1 For example, Fletcher et al. (1991) have described GIS as the technology which has had the maximum impact on the thinking of country government managers. Similarly, Campbell (1994) has reported the wide-spread usage of GIS technology within local government in the United Kingdom.

local area management in India (referred to as district administration), many of the issues are highly spatial in nature.The planning and upgrading of roads, the location of health facilities, the choice of areas for specific agricultural development, or the management of natural and planted forests, all involve decision-making based on spatial parameters. In addition to their particular value in specific functional areas, GIS offers a basis for the integration of work of different departments by providing a conceptual frame of map-based systems which can be combined in different ways. GIS can thus potentially support multi-disciplinary planning activities, such as the management of an environment that involves forestry, agriculture, wildlife, infrastructure, industries and human resources.

The experience To date, however, the developing country experience with field-level applications of GISoes not match the technology's potential to support development planning and natural resources management. While acknowledging the potential of GIS technology for developing countries, Khalil (1996) writes that this potential has not yet been taken advantage of in practice because of a variety of institutional and political factors. Similarly, writing the editorial comment for a special issue on GIS in developing countries in the **International Journal of GIS**, Taylor (1991) noted that, despite rhetoric to the contrary, the impact GIS has had on the socio-economic growth processes in developing countries could at best be described as marginal. Many GIS projects in their design and implementation had not adequately taken into account the socio-economic realities of the developing country context. Thus, while there were any pilot projects and research exercises, there was little of any substance in terms of actual application. In this study, the authors examine some of these realities that impede the realization of the potential GIS provides, and discuss some social and institutional implications for project planners when attempting to achieve this potential.

A primary focus in many existing GIS texts is on describing the potential of the technology, rather than on examining the problems involved in applying it effectively. Discussion on the problems of applying the technology in the context of developing countries is even more rare in GIS texts. As many developing country governments make continued and large scale investments to introduce GIS in various domains, especially within the context of environment and industrial management, it becomes extremely important for project planners to understand what are some of the problems inherent in implementing GIS effectively, and what can be done about them.

The analysis and discussion presented in this study is primarily based on an intensive empirical research project carried out in India during the period 1993-1995 when the authors were at the Judge Institute of Management Studies, University of Cambridge, UK. This research involved a study of the efforts of the Ministry of Environment and Forests, (New Delhi, India) to use GIS technology to support wastelands management. At a later stage in the field work, some of the other GIS initiatives taking place through government agencies like the Department of Science and Technology, the National Informatics Centre and the Department of Space, were also examined. Less intensively, when compared to the field work carried out in India, some of the GIS-related activities taking place within Malaysian government agencies were examined, which permitted a comparison with some of the implementation related problems experienced in India and Malaysia.

In the remaining part of this chapter, the reader is introduced to the basic nature of GIS technology, and discusses its potential in supporing environmental management applications. A brief overview of the chapters that follow is then provided.

1.1 The nature of GIS technology

In general, the term GIS describes integrated systems of geographically oriented computer technologies having the potential to store, process and manipulate digital data in problems involving spatial analysis (Maguire, Goodchild and Rhind, 1991). Like many emerging technologies, GIS are not easy to define as discrete entities (Kling, 1987), as they refer to many different configurations of computer applications rather than a specific system or technology. Many academic and professional disciplines, such as geography, engineering, forestry, computer science, remote sensing, business and anthropology have participated in the development and use of GIS (Goodchild, 1995). Consequently, definitions of GIS vary across various domains of applications, and the boundaries of the technology are more fuzzy than precise. Adding to this ambiguity are the increasing number and types of GIS applications.The number of system applications is reported to be doubling every two or three years (Frank, Egenhofer and Kuhn, 1991), contributing to a growth rate in the GIS market of about 30-35 per cent annually (Huxhold, 1991). In a recent article, Merchant and Ripple (1996) have reconfirmed these growth trends in the GIS industry.

Despite es ambiguity surrounding the question of what constitutes GIS technology, its central technical characteristics are the digital electronic database and the system of production of electronic spatial representation of these data (Pickles, 1995). In this regard, GIS is a special case of an information system that represents and processes spatial information. While computer hardware, and specialized peripheral equipment, such as digitizers and scanners, are essential for the working of a GIS, the key component of this particular technology is its software. Goodchild (1995) discusses three main principles to examine if a product is a GIS: the ability to store and analyze relationships between objects (often referred to as topology); the ability to store and analyze attributes of a particular object; and the ability to integrate data involving different sources, scales and modes of representation.

A key aspect in a GIS is its ability to enable spatial analysis rather than only allow simple data management and retrieval functions. This capability for spatial analysis is built around the data model underlying the GIS, which concerns the set of rules and procedures for the representation of geography in a digital form in a computer database. Goodchild (1995) discusses two main types of data models used in GIS: layer-based and object-based. In the layer-based model, land is inventoried using descriptive variables, such as its capacity to support agriculture, recreation and other uses. In such a database, each variable is measured uniquely at every geographical coordinate, so that maps can be conceptualized in mathematical terms as a succession of layers. The database captures this information in a "layer cake" that describes each successive field of data over the entire geographic region. By contrast, the object-based data models represent geographic space as populated by various kinds of discrete objects. Any place may be empty or occupied by one or more objects, whereas in a layer-based data model every location has exactly one value on each layer. Such distinctions are relevant to the study of GIS implementation, because the kind of data models used shape the nature of representation, and thus also our understanding of the geography.

The geographical in GIS implies anything that is spatial, which can include remote sensing images, crime files, land-use data, or even medical statistics. A fundamental assumption underlying GIS technology is that the user can reproduce a real world-space as some form of a "true copy" of what normally meets the eye, which can be isolated as unique thematic layers and then recombined to provide different perspectives to the whole picture. This capability to represent and manipulate real world space makes GIS a potentially useful and powerful decision support tool in a variety of application areas that involve a spatial component. For example, a geographer is interested in understanding how population shifts are taking place over space and time. An anthropologist wants to examine the spatial spread of particular cultures. A wild-life expert may be interested in finding out the extent of depletion of a particular animal population across different wild-life reserves in the world. An industrial development policy maker may want to know which new factories should be allowed in different areas to minimize pollution risks. Central to each of these different problem domains is a requirement of a relational system of spatial information handling and representation, technical capabilities that GIS potentially provides.

Recent developments in the technical domain are making the technology more accessible to users from a variety of disciplines. A 1991 directory listed 371 available software products, representing an enormous diversity of capabilities and approaches (**GIS World 1991**). In a recent special issue on GIS, guest editors Merchant and Ripple (1996) report a number of significant technical developments. In computing, major enhancements have taken place in processor speed, parallel processing, data storage and operating systems, all assembled in ever-smaller portable systems. The increased use of Global Positioning Systems for land surveying, and major technological innovations in data conversion and multi-media, are providing increased capabilities to GIS. During the same period, GIS software has become more user-friendly, possessing greater functionality than before, and has better links with CAD, image processing and other software. The internet and the World Wide Web have helped a great deal in enabling the access, retrieval and sharing of data.

Such rapid evolution and deployment of GIS have encouraged many different types of organizations to try and use the technology. However, amid this growing excitement about GIS, concerns have been voiced about the less than effective way in which technology is actually used by organizations (Crosswell, 1991). A number of economic and social factors have been identified as potential impediments to effective GIS use. For example, investments in GIS present economic risks because they are typically large systems that require major financial outlays, especially during the initial stages of implementation where long-term, irrevocable commitments must be made (Sieber, 1991). Thompson (1989) reports that in many US organizations, expenses incurred in developing base maps may reach US$1.25 million annually and recur for as many as five years. Social factors often exacerbate these economic risks, especially in governmental settings. The involvement of multiple stakeholders, each with their individual mission and data needs, may lead to the development of incompatible GIS that duplicate data held by other agencies and encourage redundancies. Conflicts may also appear over the specifications for accuracy and precision of data that multiple agencies may share.

Along with the technical scope and complexity of GIS, these social and economic risks of implementation take on a much more magnified and serious dimension in the context of developing countries, especially within government organizations, because of limited financial resources and a weak understanding of the nature of computer support. Considerable effort must be exerted by many parties over time to produce a system with the potential to yield significant benefits. The realization of these benefits depends upon the acceptance, understanding and use of the system by its users, and the changes that are made in the existing institutional arrangements to accommodate the new ways of GIS-supported work. These changes are often difficult to initiate for a variety of reasons. For example, government priorities may be on implementing poverty alleviation schemes rather than on applying new computer technology.

In this study, the authors have sought to understand some of these social and institutional challenges in using GIS more effectively within developing country government organizations, especially for environment and natural resources management applications. To place this issue in a wider context, the potential of GIS as a decision support tool for environment management is discussed more generally in the next section.

1.2 The potential of GIS for environment management

GIS technology, which supports the computerized capture, management and display of spatial data, is a powerful tool for resource managers and planners. GIS has helped to open up new dimensions in our ability to monitor and manage natural resources – from the micro level of soils, to the analysis of such regional phenomena as population shifts. Simonett (1993) also emphasizes the communicative aspects of GIS, and how its visualization and networking capabilities support environmental decision making. GIS serves as a communication interface in the political and educational domain by providing information about natural resources to politicians, planners and the public. The networking element reflects the capability of GIS to help bridge interfaces between the technical, user and application domains.

In recent years, resource and environmental management has become a vital subject of concern throughout the world. The importance of resource and environmental management has become underscored by the increasingly pressing problems of natural resources depletion and environmental degradation. An important impetus for the use of GIS comes from an increasing awareness of environment management in the world today, and the need to integrate basic and applied research to better address the issues of management, policy and societal implications (Stafford, Brunt and Michener, 1994). The foci of such research include natural resources management and sustainable stage, involving the creation of a map culture and building awareness of spatial databases and GIS technology through pilot projects and other scientific exercises. In developing countries, the challenge today lies in creating sustainable mechanisms at the policy and operational levels to make effective use of the technology in solving locally relevant natural resources and environment management problems.

1.3 Study focus

The focus of this study is on understanding more deeply the social and institutional challenges planners in developing country governments face when trying to use this technology, especially within the context of environment management, and discussing some of the ways and means by which these can be addressed. The intention is not to try and provide a set of prescriptions in the form of "do's and don'ts" for GIS project management, but rather an attempt to sensitize planners to the obstacles they are likely to encounter, while drawing attention to how GIS projects are managed in some other contexts. For example, it may be pointed out that national policies on data sharing have helped GIS projects in other developing countries. While this may alert the planner to look at the feasibility of introducing such a policy in his or her particular context, it does not prescribe how it should be done, since the specifics of such solutions are inextricably bound up with local characteristics.

Making clear distinctions between the technical and social aspects of GIS is difficult, because each has elements of the other embedded within it. For example, problems of data quality are tied up with social issues relating to which institution is responsible for collecting the data. While satisfying technical pre-conditions are necessary for GIS implementation, they are not sufficient by themselves, because technology is always to be designed and used within a particular social setting. As a result, our focus is on understanding and addressing challenges that are inherent in institutional and social settings within developing countries, rather than on discussing strongly technical issues such as the merits of different brands of software, or the mathematical appropriateness of data models for specific applications. The history of computerization projects in developing countries, including India, also indicates that in the past, institutional and social challenges have been more difficult to overcome than purely technical ones (Madon, 1993).

The GIS literature from the developed world also tends to emphasize the significance of social and institutional factors as impediments in GIS projects (Campbell, 1996; Crosswell, 1991). Campari (1993) has highlighted the importance of considering cultural aspects in the design and use of GIS. She writes: "For long it (cultural aspects) has been hidden in many statements, critiques, claims and aims that appear in the GIS folklore of reports of experiences with a particular system....sentences like 'GIS are widely used tools but still difficult to learn'...often hide some cultural issues, but rarely have they been openly declared" (pages 10-11). Some cultural differences that Campari feels should be taken into account in the design and use of GIS systems include language, and the dependency of spatial data management on the national context, specifically the kind of rules and procedures that exist for the storage and access of data.

development, environmental monitoring, environmental risk analysis and restoration ecology. Improved management of our natural resources requires that we develop improved environmental monitoring programmes to identify and track the condition of specific resources at appropriate spatial and temporal scales. The success of such new resource management strategies, and their impacts upon ecosystems and industrial development, cannot be assessed without improved methods of analyzing environmental risk. The relatively new field of environmental risk analysis seeks to develop capabilities for predicting risk that can be used for management, policy development and the validation of eco-system models.

Another impetus for the use of GIS comes from the increasing availability of data on natural resources. According to one estimate, the amount of data in the world doubles every 20 months (Frawley, Piatetsky-Shapiro and Mathews, 1992). Earth observing satellites launched in this decade are expected to generate one terabyte of data every day, which amounts to creating the entire 17-year Landsat archive every two weeks (Marshall 1989). In India, too, the National Remote Sensing Agency has been providing satellite images to the remote sensing community since 1979. With the launching of the IRS-1C satellites in December 1995, a whole new range of products have become available to the users, with better resolution, wider area coverage, stereo imaging and revisit capabilities. These technological developments have resulted in an increasing gap between data generation and our understanding of data, with our ability to gather and store data being much more advanced than our ability to manage, analyze and interpret them. These knowledge gaps result in the increased use of such spatial analysis tools as GIS technology for data management and, within the last decade policy makers in developed countries have acknowledged the potential of GIS to address complex environmental concerns, respond to growing regulatory pressures, manage scarce resources, and allow public involvement in environmental decisions.

In the USA, a National Center for Geographic Information Analysis (NCGIA), funded by the National Science Foundation, has been established with the aim of examining how GIS could better support ecosystem, landscape and global change research (Jelinski, Goodchild and Steyeart, 1994). The NCGIA initiative seeks to support the increased integration of GIS and environmental modelling using techniques for managing, manipulating, analyzing and displaying spatial data. Other areas of emphasis include the assessment of the quality of global data, development of methodologies for the creation of GIS supported spatial databases, and understanding the linkages between various human and biophysical systems. These initiatives are multi-disciplinary in nature and span a range of topics, such as improved user interfaces for GIS products, better understanding of the errors in GIS spatial databases, enhanced languages for GIS to support environmental modelling activities, and the more complete integration of spatial statistics and GIS.

In countries such as the USA and Canada, the use of GIS in environment management is fast shifting from one of just map generation to a more sophisticated level involving spatial analysis and modelling through such efforts as the NCGIA initiative described above. However, in developing countries like India, the efforts are still at a very initial

At a more individual level, Medyckyj-Scott and Hearnshaw (1993) have emphasized the role of cognitive and perceptual factors in the design and development of GIS because of critical issues related to the usability of systems.

Theorizing on a large-scale comparative study of the adoption and diffusion of GIS technology in local government in Europe, Campbell (1996) argues for the adoption of theoretical perspectives to study GIS diffusion, which explicitly take into account institutional considerations. She emphasizes that the widespread diffusion of GIS is dependent upon the acceptance and the merits of the technology within each institutional arena. It is therefore within specific institutional contexts that GIS innovations become socially constructed and decisions are made about their adoption, implementation and utilization. A variety of institutional factors have been identified in the literature, and these include: the need for organizational change to accompany the introduction of new technology; the importance of establishing data exchange standards; creating mechanisms to enable inter-departmental and inter-organizational data sharing; the complexity of project management issues given the large size, scope, and costs of GIS efforts; other human resources problems concerning communication; and the development of awareness and acceptance among users. While most of these impediments are also visible in developed country contexts, the manner and intensity in which they manifest themselves are significantly different. Besides, there are a number of other unique socio-economic realities to be addressed in developing countries which the authors highlight using the cases of India and, to a limited extent, Malaysia.

1.4 Organization of the study

This study is organized in six further chapters. In Chapter 2, the problem of the use of GIS technologis placed in a wider context by examining what has been the past experience with GIS in developing countries, including some from the Asian region. The authors emphasize that the use of GIS in developing countries cannot be adequately understood without examining some of the global pressures involved; for example, growing environmental concerns, increasing linkages of international aid to the use of technologies like GIS, and the associated problem of technology transfer. With respect to GIS use in developing countries, the problems of technology transfer, institutional constraints, manpower development, data management concerns, and project management practices are specifically examined.

Chapter 3 describes some of the ongoing GIS initiatives ongoing within the Indian government sector. The authors begin by providing a detailed description of their research approach and the field work, which is the basis of their analysis.The government GIS initiatives discussed include a set of projects undertaken by the Ministry of Environment and Forests (MoEF), and other programmes within the Department of Science and Technology, the National Informatics Centre, and the Department of Space. An initiative of the World Wide Fund for Nature – India, who on the behest of the MoEF are in the process of establishing a national level data centre to support activities related to bio-diversity management, is also discussed. The discussion and analysis around the MoEF projects is more detailed compared to the other initiatives, because of it was the primary focus of the research. Also, by examining a specific project in detail and over time, some of the more micro project-level problems inherent in such initiatives may be better understood.

In Chapter 4, the authors move from the project focus of the previous chapter to discuss more broadly some key social and institutional challenges in implementing GIS in India. In this, they first take a look at the history of computerization efforts in India, and how one may learn from the past and try to avoid similar pitfalls. Key research areas pointed out by the GIS literature in the developed world are also examined in order to broaden the scope of understanding. Also examined is the need for creating stable networks of people willing to promote the use of GIS technology over time, and the associated difficulties in undertaking this in developing countries for a variety of complex social-cultural reasons.

Chapter 5 examines the social and institutional challenges outlined in the previous chapter in a broader context, by comparing it with what we see to be happening in Malaysia. In the field work in Malaysia, the authors did not focus on a specific project over time, but have tried to obtain a broad overview of the issues involved in the use of GIS in a number of government agencies. Interviews with key people involved with these projects provided an understanding of some of the challenges being experienced in Malaysia.

In Chapter 6, the question of "what can be done to help planners in developing countries to implement GIS projects more effectively?" is addressed. The discussion on challenges in Chapters 4 and 5 provides a basis on which to develop recommendations for project management, discussed under the categories of "social" and "institutional" implications. The "institutional" category includes a discussion around issues related to technology transfer, inter-agency coordination, and implications at the level of the individual institution involved in the adoption of GIS technology. Social implications include a discussion of issues around aspects of communication, human resources development and project management.

A look into the future is provided in the concluding Chapter 7. Issues are examined that relate to the feasibility and appropriateness of GIS technology for developing countries in the future. This discussion is founded on the issue of "indigenization," which refers to the process by which GIS technology can be adapted and made compatible to local needs. More specifically, two sets of related questions: "what does indigenization involve?"; and "is indigenization possible?" are also examined.

CHAPTER 2

GIS IN DEVELOPING COUNTRIES: PROSPECTS AND PROBLEMS

Taylor (1991a) describes GIS technology as a product of the developed world, which has unique complexities and problems when applied to developing countries because of their very different socio-economic realities and priorities. Taylor adds that for GIS to be of use to current challenges facing developing countries, planners would need to actively respond to these realities and priorities, including such problems as: inadequate financial and human resources; infrastructure bottlenecks; difficulties in initiating change in government organizations; the existing work-culture; and issues related to the transfer of appropriate technology. The quite different operating conditions in developing countries emphasize the need for distinctive implementation approaches and technical configurations from systems that exist in the developed world. Within the specifics of these social and institutional conditions, it is important to understand clearly the problem areas where GIS has the potential to contribute to knowledge, and the conditions required for it to be applied to its full potential (Simonett,1993).

This chapter is organized as follows: in section 2.1, we first examine how global forces influence the creation of socio-economic reality in developing countries, which provides the context for GIS use. In section 2.2, discussion moves from a more global to a regional discussion, and examine some of the GIS initiatives taking place in Asian countries. This helps to put in sharper focus the later discussions on GIS projects in India and Malaysia. Then, in section 2.3, we take a detailed look at the literature on GIS utilization in developing countries and identify major impediments to project success, including: technology transfer issues; institutional constraints; data management issues; manpower constraints; and project management practices.

2.1 GIS in developing countries: a broader global context

The issue of GIS use in developing countries cannot be examined without placing it within a broader global context. Many computerization projects in developing countries have been launched with enthusiasm, but computer solutions, successfully implemented in developed countries, have often failed to perform because of significant differences in the socio-economic situation. For example, in developing countries, the attitudes of people related to authority, rationality and time are quite different from those existing in the developed world (Lind, 1991). These differences cause significant problems in technology transfer because, for example, transfer projects specify strict deadlines and deliverables, which are often not adhered to in the recipient country. Such differences create critical problems in the design and use of systems, and need to be better understood to obtain a deeper sense of why these problems occur.

There is a growing realization that even as national efforts continue to implement GIS, there is a need to support and foster them through international efforts. Like most other information technologies, Taylor (1991) describes GIS as primarily a "first world technology," an artifact of industrial and post-industrial societies in the developed world, and whose introduction into a developing country context takes place through a process of technology transfer. While this process is useful in providing know-how, technology, and aid-dollars, it is often a major source of conflict between the officials from the providing and receiving countries.

The process of technology transfer is never neutral and value free, but on the contrary is fraught with the transmission of values, histories and assumptions of how work should be done, along with the transfer of more objective commodities including software, hardware, aid-dollars and consultants. The relation of these more global values to the ground reality of the developing country context is often problematic, and significantly influences the process of GIS use. The reasons documented for the failures of such GIS technology transfer projects include the inability to define clearly the areas of work GIS technology should support (Taylor, 1991; Yeh, 1991); the lack of cooperation among different agencies and groups (Sahay and Walsham, 1996; Hastings and Clark, 1991) and problems related to the management of data (Fox, 1991; Yeh, 1991). In general, in developing countries we find that the systematic use of information in computerized systems is uncommon, and the use of coherent spatial planning systems is even more so (Nijkamp and De Jong, 1987).

Despite these multiple difficulties in effectively applying GIS, its value in developing countries is becoming increasingly significant, given the current worldwide concern about the state of our environment and the pressure to sustainably manage natural resources. GIS technology, with its inherent capabilities to support users working on spatial problems, has tremendous potential as a decision support aid for natural resources management. The Institute for Aerospace Survey and Earth Sciences (ITC) in the Netherlands has been extremely active for many years in building remote sensing and GIS capacities in developing countries. The United Nations system has also been particularly active in the introduction and use of GIS in developing countries. The United Nations Environmental Programme (UNEP) in 1985 set up the Global Resource Information Database (GRID) within the framework of the Global Environment Monitoring Systems (GEMS) to support global efforts to collect and manage environmental data for planning and decision making (Taylor 1991a). GRID was designed to be a dispersed system so that its data and technology could be brought closer to users throughout the world, and during the pilot-phase (1985-87), centres were established in Nairobi and Geneva, and another was set up later (1988) in the Asian Institute of Technology, Bangkok.

The United Nations Institute for Training and Research (UNITAR) is another UN body that is quite central to GIS growth in developing countries. Under the umbrella of "Economic and Social Development Training Programmes," the UNITAR office in Geneva has been cooperating since 1986 with UNEP/GRID to develop and implement training programmes in GIS for natural resources management. The trainees on these programmes are from developing countries who, in addition to being trained on GIS, are also encouraged to try and establish GIS information exchange networks in their own countries that would be capable of benefiting from GRID's technology and datasets.

After some initial courses in Geneva, the training has now been diversified and decentralized with regional sub-programmes in Nairobi, Bangkok and Kathmandu (Simonett, 1993).

The Rio Earth Summit of 1992 helped attract global attention to ongoing environmental problems and the need to integrate development and environment concerns in more meaningful ways. The Agenda 21 Declaration of 1992 noted that, to meet challenges of environment and development, States need to create global partnerships to facilitate the sharing of technology and know-how, and establish measures for sustainable development within an international context. As a fallout of this 1992 Declaration, international agencies such as the World Bank and UNIDO, have undertaken a series of policy initiatives to encourage projects that include environmental dimensions, utilizing GIS as a decision support tool for management.

An example of such an international effort is the recently initiated long-term UNIDO programme to transfer GIS technology to developing countries. The impetus for this programme comes from UNIDO's recognition of the necessity to change its traditional views on industrial development, and to focus instead on the protection and conservation of environmental resources in more cost-effective ways. A consequence of UNIDO's broader strategies for environmentally sustainable industrial development (ESID) is the programme that aims to promote the effective transfer of GIS as a decision support tool for environmental impact and industrial development in developing countries. The programme, which is being implemented by the International Centre for Science and High Technology (ICS) in Trieste, Italy, seeks to strengthen the capabilities of developing country organizations to effectively use GIS for managing environmental problems (SPCM 1996). The specific activities involved in the programme include training courses, fellowships, study tours and action-oriented research in the context of specific environmental projects being undertaken in developing countries.

Similarly, UNESCO has initiated a series of programmes to facilitate international cooperative efforts to promote sustainable use of natural resources and to prevent further deterioration of the environment, taking into account the world's diversity in socio-economic situations and cultural contexts (Aureli et al., 1993). Some specific UNESCO initiatives include the International Hydrological Programme, International Geological Correlation Programme, and the Man and the Biosphere Programme. Each of these programmes have specific mandates to make the best possible use of new advances in technology, and in particular of GIS and remote sensing, specifically as an aid to decision making and planning.

A consequence of such international programmes has been the initiation of a variety of GIS-based application projects for environmental management and sustainable development in countries like India. For example, the World Bank, realizing that India is one of the twelve "mega-diversity" countries in the world, accounting for nearly 60-70 per cent of the world's biodiversity, is funding a large-scale ($US 67 million) five-year project under the Global Environment Facility (GEF) for eco-development in the country. Under this programme, the Government has identified "protected areas" in the country, and is attempting to develop socio-economic profiles of these regions using

GIS, which can be used by planners to conceptualize and implement development plans. Planning based on relevant local-level data is expected to help reduce the pressure on the existing biodiversity resources of the area.

The structure and agenda of these various international initiatives are important to understand, because they significantly influence project implementation in developing countries, including the choices of software, consultants and the adoption of specific management practices. The global nature of environmental data, and the increased connectivity between the providers and users of data through the use of technologies like the internet, also emphasize the need to look at the issue of GIS use within a global context rather than in isolation as a local problem.

2.2 GIS technology: a regional perspective

We now examine some GIS activities in the Asian region in order to put a sharper focus on the Indian and Malaysian case studies. We first place the issue of GIS use within a broader context of the development problems being experienced in the region. We then take a closer look at some specific GIS initiatives in China, Indonesia and Thailand. The cases of India and Malaysia will not be taken up in this section as they will be examined in detail in later chapters.

2.2.1 GIS and development

While problems of poverty and environmental degradation are very severe in many developing countries of the world, there have also been some successes in the poverty alleviation efforts of a few Asian countries, including Hong Kong, the Republic of Korea and Singapore. Malaysia and Thailand are also examples of Asian countries that since the late 1980s have been moving on the fast tracks of national development. Taylor (1991a) writes that while China and India, the two most populous countries of the world, have also made impressive progress, macro-economic statistics tend to mask the severe inequities between rich and poor, the rapid depletion of natural resources, and the ongoing pressures on the social and political fabric of the country. Over the years, planning aimed at reducing some of these social inequities by implementing poverty alleviation programmes, have become important components of the political agenda of many Asian nations.

During the 1970s and 1980s, some South and South-East Asian countries started making serious efforts towards decentralizing their development planning and management functions. A key element of these efforts was the diffusion of information technology to local areas. From a management perspective, decentralization is considered vital for providing information about local conditions, which is often difficult to obtain at the national level. Decentralization is also introduced by governments in order to increase participation in the local political and economic processes, ensuring greater accountability towards people's needs, and to encourage coordination among various local-level planning and implementing agencies (Rondinelli and Cheema, 1983; Shams et al., 1987; Wunsch, 1991;).

The literature relating to the computerization of such development planning efforts suggests that a variety of factors have prevented the fulfillment of initial intentions in many cases, such as the lack of funds, ambiguous organizational commitment, and the lack of technical support for maintaining the computer resource (Deboeck and Kinsey, 1985; Gecloea, 1988; Wunsch, 1991;). Also, such local-level planning requires the transfer of power and responsibility from central ministries to the local level, to devolve decision making and enable horizontal coordination between departments. Bringing about such institutional changes is very difficult for a variety of reasons, including the complexities inherent in government bureaucracies; the time involved in taking decisions to do so; and often because of the lack of will to do so. The problems experienced in many situations also stem from the fact that system developers assume that development planning is a rational process, and ignore the other informal aspects of the organizational context in the design of their systems.

Despite these problems in using GIS to effectively aid development planning processes, an infrastructure to support computerization efforts has been established in many Asian countries. This provides the basis and confidence to introduce GIS, and a need for a strong GIS for the Asian region has been articulated in different forums. For example, the Asian Development Bank (1992) has stated that the use of GIS and remote sensing in the region should be further developed to improve project design and monitoring. GIS technology is currently being introduced by many Asian country governments to support development planning and natural resources management. This introduction raises a number of issues which have also existed with respect to past computerization projects. For example, should a bottom-up or top-down approach be adopted to facilitate the introduction of GIS technology? The failure of many previous top-down computerization initiatives help to sensitize us to the problems involved, and emphasize the need to draw lessons from history.

However, a number of issues associated with GIS implementation are novel, requiring fresh approaches and strategies. GIS is a relatively new technology, and awareness of its potential problems and capabilities is still not very well developed. The introduction of GIS comes at a time when the rapid depletion of environmental resources is putting pressure on government departments to shift their focus from development schemes to area-oriented planning. Such planning systems are novel, since they require a wider perspective; for example, they need to incorporate human needs and social pressures into planning systems, because environment degradation is caused often not by people's greed, but out of desperation and a need for survival. The focus of many GIS efforts in this region are thus aimed at providing alternative income generation schemes for the poor, and reducing the pressures on the natural habitat. We now take a closer look at some specific GIS initiatives in three Asian countries.

2.2.2. Some Asian country initiatives

Struggling through the traffic jams in Bangkok, Jakarta, Kuala Lumpur and New Delhi, breathing in air that is thick with vehicle exhaust, provides one with a small sense of the extreme pressures the environment is under today in some Asian countries. Additional pressures on natural resources in the Asian region are being created as forest lands are increasingly being utilized for agricultural production. In recent years, the clearing of forests for cultivation and to provide land for agricultural resettlement and the raising of livestock, has become a matter of international concern (Hastings, 1996). In many areas of Asia, the destruction of rainforests is taking place at an alarming rate. Hastings reports that recent estimates of the Food and Agricultural Organization of the United Nations (FAO), place the annual rate of deforestation in Asia to be 3.9 million hectares, up from 2 million hectares in 1980, and more than 50 per cent more than the loss rate for Latin America.

Resource managers in Asia are facing a number of formidable land-use problems that have been created by rapid urbanization, deforestation, and non-sustainable development of energy, land and water resources (Fox, 1991). In many Asian countries, where governments are faced with the dual pressure for economic survival versus the long-term concern for sustainable development (Aureli et al., 1993), resource managers are looking towards GIS and remote sensing technologies to radically change how they collect, store, analyze and think about spatial data. Many Asian countries, in particular China, India, Indonesia, Malaysia and Thailand, have committed and continue to commit , sizeable amounts of economic resources on GIS technology. Planners in Viet Nam, a country which has only recently embarked on the path of rapid industrial development, are looking at GIS technology as a tool to help them incorporate environmental concerns into industrial policy formulation processes (Sahay, 1997; Son, 1997). Large-scale investments around GIS technology in Viet Nam are coming about through a variety of international aid agencies operating in the country. Despite these significant investments, however, the history of GIS implementation in this region indicates that the technology is still rather limited in supporting broader national socio-economic development processes. We now examine some specific efforts from Thailand, Indonesia and China.

Thailand: Through the efforts of the Asian Institute of Technology (AIT), Bangkok, GIS-related activities started relatively earlier in Thailand compared to some other countries of the region. The AIT GIS concept was developed around the UNESCO seminar in Vishakapatnam, India, in 1985, which emphasized the introduction of multi-level, decentralized planning that would be supported by computerized information systems (Taylor, 1991a). An initial initiative at the AIT was through the Human Settlements Development Group, which tried to create a "bottom up" methodology for implementing GIS that would utilize local resources. Yapa (1989), working initially out of AIT, developed CARP (Computer Assisted Regional Planning), a low cost system to support such local-level rural development activities.

These initial activities helped to provide visibility for GIS and over the last five years there has been a major growth in the use of GIS in Thailand. From virtually no users in the late 1980s, the technology has spread into almost every spatial information using agency in the Royal Thai Government (RTG) (Hastings, 1994). Hastings noted more than 30 public sector agencies to be using GIS in the country. An example of this growth is the initiative of the Department of Mineral Resources (DMR) of the Royal Thai Government, which recently compiled a long-term master plan for the operationalization of GIS to support departmental activities in various application areas including environment, geological survey, groundwater, mineral resources and legislation. An interesting aspect of this master plan is its focus on institutional aspects, and on the need to seriously incorporate organizational change issues to help adapt the technology more effectively. Hastings notes that in the past, institutional factors had not been given due care, which is seen to have contributed to the ineffective use of GIS in a variety of projects in Thailand. Another large future application concerns the use of GIS to implement a strategic plan for industrial pollution control in southern Thailand. Hastings (1993) reports on another joint project between the Thailand Development Research Institute (TDRI) and the Thai-Australia Highland and Social Development Project. The main thrust of this project is to improve the environment as well as the social and economic welfare of the hill tribes of northern Thailand.

This rapid growth in GIS activities also highlights the need for improved coordination of the various projects. For example, organizations such as the National Environment Board and various universities have acquired different software systems, which makes central coordination rather difficult. A private sector organization, the Thailand Development and Research Institute (TDRI), now called the Thailand Environment Institute (TEI), has taken a lead role in coordinating GIS activities, and also tries to examine issues in making the technology more applicable in Thailand (Phantumavanit and Hastings, 1988). The TEI also conducts research with university departments and government agencies; for example, they are collaborating with the Education Department to develop an "Adopt a School" programme with the aim of spreading spatial literacy to school children (Hastings, 1994).

The Thailand Remote Sensing Center is also playing an active role in national GIS development efforts, and a major part of these efforts is on using remotely-sensed LANDSAT data and the maps obtained through aerial photography. In recent years, this centre is shifting its focus to carrying out more application-oriented work; for example, the LANDSAT Thailand project for the Chiang Mai Basin involves the use of GIS for land-use applications utilizing criteria of soil capability, drainage and forest cover. However, the impact of these case studies on a larger scale in Thailand is yet to be seen, and it is not clear how government departments will adopt the technology to support their day-to-day work processes.

Hastings (1994) writes that there have been a variety of obstacles to GIS development in Thailand, but the most significant of these relates to the lack of a coherent institutional plan to describe what the organization wants to do with GIS, and how they plan to develop and nurture the system so that it goes beyond short-term individual departmental goals to a stage of supporting long-term, overall institutional goals. Hastings adds that even though there are not many published stories of failure in the country, this is often misleading, because the "path to a fully functioning GIS within a large complex organization is epitomized by institutional and personal frustration and slow, painful progress."

Indonesia: Indonesia is a country that is significantly dependent on its natural resources to sustain its current economy and to ensure long-term growth. Seventy-five per cent of Indonesia's total land area is covered by forest. Approximately 110 million hectares are under primary forest designated as either "protected" or for timber "production" under a scheme of selective cutting. Timber is second only to oil and gas as a major source of national revenue (Hastings, 1996). Given the importance of forestry to the national economy, in 1981 the Government of Indonesia prepared a policy to organize forest planning within each province by developing consensus amongst the parties involved. GIS is being used as a key tool in the development of these forest plans.

Given the above importance of resources, the Indonesian government set up the National Coordination Agency for Surveys and Mapping (BAKOSURTANAL) in October 1969, to maintain data on natural resources and to assess significant trends in their utilization. Interestingly, the agency's mandate emphasized that it was in the information rather than mapping business (Rais and Suharto, 1990). Attempts to forge a national-level natural resources development policy were initiated as early as 1972 through a workshop jointly organized by the Indonesian Institute of Sciences (LIPI) and the National Academy of Sciences (NAS), USA. With support from UNESCO, in 1973 a natural resources information systems was proposed based on a decentralized data network.

In 1980, the computerized COMARC system from California, with its COMPIS software, was purchased for the encoding and storing of natural resources data. National base maps were prepared in the early 1980s, and under a new national-level programme for Land Resource Evaluation and Planning (LREP), PC-based GIS systems were established in the eight provinces (called BAPEDAS) with the aim of increasing the capability of provincial planning agencies in Sumatra to manage resource information and support local-level planning activities. The system was linked with those of other geo-information producing and information using agencies. Under the LREP system, new hardware and software were purchased to enable spatial analysis and terrain modelling, in addition to the earlier data management tasks. A variety of systems were purchased and installed in the training centre, and also networked with systems in other agencies dealing with soils and metrology. This provided the basis for the establishment of a long-term programme (1985-1990) to create a national topographic database on resource potential and environmental conditions, including coastlines, hydrography, roads, administrative systems and land use.

At present, the national-level GIS is being coordinated by three government agencies including BAKOSURTANAL, which acts as the coordinating agency, the Directorate General of Regional Development and the Center for Soil Research (Rais and Suhorto, 1990). Fox (1991) writes that while the idea of linking the various provinces in a distributed network is appropriate, the highly structured nature of the organizations, the extensive co-operation expected between them, and the lack of awareness about GIS, makes the project difficult to implement effectively.

People's Republic of China: The Chinese authorities have from very early on recognized the vast and varied scope of GIS, and have made considerable progress in mastering this technology. The importance of natural resources was recognized very early on, and an Integrated Survey of Natural Resources was established as early as 1956. In fact, its importance is reflected by the fact that GIS is also called Resources and Environment Information Systems (REIS) in China (Jianbang, 1990). The development of GIS in China has been described by Jianbang to have taken place in three stages: the stage of preparation for GIS study (1978-1980); a stage of establishing the detailed parameters for the GIS study (1981-1985) including preliminary studies for data capture and the development of application models; and the stage of preliminary development of GIS since 1985, which involves the integration of GIS with the country's economic construction.

The Chinese government has recognized the importance of strengthening institutional frameworks, especially for the coordination of national level GIS activities, and in 1984, the National Remote Sensing Centre was given the task of standardizing the national and regional systems. More than 220 institutions and 15 ministries were part of these coordination efforts, and now GIS-derived information from integrated sources is an important element of the country's seven-year development programmes (Asian Development Bank, 1992).

China established a laboratory of resource and environment information systems in 1985, as a cooperative effort between the Institute of Geography at the Chinese Academy of Sciences, and the State Planning Commission. This laboratory, which serves as a focal point for the Chinese efforts, was based primarily on an application-driven concept, where user needs were given primary importance in the design of systems (Chen, 1987). A key analytical unit for these experiments was the county, of which there are over 2,300 in the country, and is the administrative centre for micro-level planning efforts. A micro-based GIS was to be established in every county to provide comprehensive information for local-level planning.

Such comprehensive and integrated planning has helped to create the institutional infrastructure for supporting GIS activities, aimed at solving a variety of locally relevant environmental problems, such as soil and water conservation in regions where soil erosion is taking place on a large scale. For example, the Yellow River was receiving a lot of silt deposits; this in turn was affecting agriculture and animal husbandry. Evaluation of soil erosion was done in a GIS using satellite-derived data, which provided information for carrying out soil-conservation efforts. Computer models with real time flood forecasting facilities have also been developed to aid planners with respect to flood control activities. Other important GIS application areas are forest resource management and the evaluation of the ecological impact of various development programmes.

In general, the Chinese experiments reflect deep thought on the need to balance local, regional and urban approaches to planning (Taylor, 1991a). The Chinese planners have looked at the experience of other countries, and have established the need to create mechanisms for data sharing to permit national and micro-level decisions. They have demonstrated that while local needs cannot be met with unconnected systems, a solely national system tends to use data that is over generalized and does not reflect local needs. They have thus sought to create a dual system, combining both national and regional components in a multi-level structure, with an emphasis on national control, and also on developing regional initiatives (Chen, 1987). During the last few years, a number of scientific advances have also been achieved, including the development of a variety of GIS software and different analytical geo-models and expert systems.

Summary

From the above description, it is quite evident that many Asian countries have shown great willingness to invest large sums to acquire spatial information technology and to establish different initiatives to use GIS as a DSS for environment management. In addition to the three countries whose GIS activities have been discussed in some detail above, GIS projects are also known to be ongoing in other Asian countries, including Bangladesh, Nepal, Pakistan, Philippines and Viet Nam. As mentioned earlier, the cases of India and Malaysia are discussed in detail in later chapters.

Impressive strides have been made by many Asian countries in the technical domain. For example, India was the third country in the world after France and the USA to launch a satellite (IRS-1) for resource management applications. Many of the LANDSAT receiving stations are located in Asian countries, for example in China, India, Indonesia, Japan and Thailand. However, with respect to GIS, it appears that despite its tremendous potential, the stage of its full-blown operational use to support ground-level work processes has not been reached. It does seem that while many of these countries are heading towards the stage of greater operational usage, the rate of progress is rather slow and quite different for each country, and does not match the significant investments currently being made on GIS projects.

Resources management is a key focus of GIS efforts, and countries like China have made tremendous progress in applying this technology to support a variety of environment-support applications, for example related to flood control, soil erosion and natural resources management. However, in China, as also in many other Asian countries, GIS usage appears more limited to the scientific domain, rather than it being part of a larger-scale use within a broader set of application areas.

While a number of factors impede GIS implementation efforts, a key constraining factor in many Asian countries relates to the existing institutional arrangements, including the absence of policies that coordinate the GIS efforts of different agencies, and enable cooperation, for example, in implementing integrated data management strategies. However, over time, governments are learning from these past experiences and taking appropriate steps. For example, the Thailand Environmental Institute (TEI) has achieved a fair amount of success in coordinating national projects (Hastings, 1994). However, a question that is relevant in relation to this process of learning is to ask whether Asian countries have the buffer with respect to time and financial resources to continue to learn from these mistakes. Given the extreme pressure the environment is under, and the desperate natural resources situation, the answer to this question is definitely "no." The challenge for all of us therefore, is how can we reduce this cycle with respect to time and cost utilization, from the time of the actual introduction of GIS to the stage when it has a significant impact upon management processes.

2.3 Experience of previous GIS initiatives in developing countries

In this section, we move away from the regional discussion of the previous section, to analyze more broadly what has been the experience of developing countries more generally, when they have tried to apply GIS technology. In general, the literature suggests that GIS projects tend to have limited impacts upon management processes, and there is often an ineffective use of a large amount of scarce resources which such projects typically involve. Many different factors have been described to contribute to project failure, which we have synthesized under five broad categories: technology transfer; institutional factors; data management; manpower; and project management. These are discussed below in some detail.

2.3.1 The problem of technology transfer

As discussed earlier, GIS technology is a product of the developed world, and is generally introduced into the context of developing countries through the process of "technology-transfer." In a majority of cases, the transfer of GIS technology to developing country governments is facilitated by international aid agencies such as the World Bank, the United Nations, the UK Overseas Development Administration or the United States Agency for International Development. The process of technology transfer is influenced significantly by the agenda and management styles of the specific agency involved.

GRID and UNITAR within the UN System have played significant roles in GIS technology transfer by setting up a number of operating centres, and training professionals throughout the world. However, Simonett (1993) criticizes these UN organizations for their over-emphasis on technology, and for often uncritically promoting GIS to developing countries. He believes that instead of trying to promote similar kinds of technology-driven solutions worldwide, it would be worthwhile to dedicate more efforts to "indigenize" (Taylor, 1991a) the technology, whereby it is adapted to the needs and capabilities of the particular situation in which it is used.

The World Bank efforts at enabling GIS technology transfer have been described by Simonett (1993) as a top-down, policy-level approach, aimed at the level of the national government and their environmental policy development processes. For example, the World Bank, in collaboration with the Government of India, has initiated a large project on biodiversity information, which is expected to have high level policy implications on the conservation and monitoring of ecosystems in the country. While space is explicitly left for decentralized efforts, its impact in practice has yet to be seen. Simonett criticizes World Bank initiatives as rather vague on central issues such as communication, and also in assuming that the technical implementation of systems will automatically lead to growth in applications. The top-down implementation approach has also been criticized for not taking adequate account of the characteristics of the local situation.

GIS technology normally comes as part of an aid package that also includes project implementation guidelines, training, consultancy and financial support. The literature on information technology transfer to developing countries is replete with stories of failures, and many of the issues that cause such failures are also relevant in the case of GIS technology. Aid agency sponsored transfer of technology efforts are normally project-based and structured within a limited time period, and with specific funds. Simonett (1993) describes these structures to be *ad hoc*, because the period and money allotted is inadequate for longer-term, sustainable implementation. Even in the context of developed countries, the task of building an integrated GIS database is recognized as extremely complex, requiring at least three to five years, and contributing to about 75-80 per cent of the total project cost. In the context of developing countries, where digital data and a culture of computerized mapping is almost non-existent, the requirements of time and money for GIS projects are magnified. Under aid agency projects, which typically run for a period of two or three years, it becomes impossible to carry GIS projects to a stage where they represent full-blown and operational applications.

Many aid agency sponsored projects are primarily geared towards transferring the "black-box" containing GIS technology from the developed to the developing country, without giving adequate consideration to the question of how these applications will be sustained after the expatriates leave the scene, a common problem in many such GIS projects (Yeh, 1991). Often this problem occurs because no one from the local context has been identified as the custodian of the system, and the expatriates do not know whom to train. In the development of the JAMGIS system in Jamaica, Eyre (1989) described the project-based nature of aid to be the most significant constraint, and once the aid money dried up there were no means to sustain the application. Also, since the original project was located within the Ministry of Agriculture, other departments at a later stage were unwilling to add more data to the existing system, and instead negotiated with other donor agencies to build their own GIS systems. In a similar vein, Angus-Leppan (1989) describes a GIS land-titling effort in Thailand to have been successful, because even though the project was developed with the help of Australian advisors, care was taken to impart technical training to the local staff to run the system after the expatriates left the scene.

Differences of opinion between the aid-agencies sponsoring GIS projects and officials of the recipient country are often responsible for the breakdown of the transfer process. Aid projects normally come with stipulations about the kind of software and methodologies that should be used, and consultants from developed countries are called in to oversee project management. A large proportion of the aid money is therefore spent on supporting the consultants' travel and hotel costs, in addition to the steep consultancy expenses, which is often resented by the recipient nation. The aid agencies themselves represent complex bureaucracies, and the bureaucrats involved in the interactions with the recipient country often do not themselves have a clear vision of the nature of the problems encountered in implementing programmes for improved information management in the local context.

While in theory aid agencies profess to adopt a participatory approach to transfer GIS technology, wherein "those who are intended to adopt the technology must be involved in the design, execution and evaluation of the project in which it is demonstrated" (Hutchinson and Toledano, 1993), in practice this is not often the case. Sahay and Walsham (1996), in reference to the USAID-sponsored project in India that Hutchinson and Toledano write about, describe how officials in India disagreed with the USAID approach. While Hutchinson and Toledano describe the "participatory approach" adopted by USAID to be very effective, some Indian officials felt this approach was not relevant to India because it had been developed from experience in Africa, and that they were also at a more advanced stage of understanding the technology than the methodology assumed.

In summary, common problems associated with technology transfer relate to the contents of what is transferred, the structure of the transfer process, and the absence of mechanisms to sustain the system once the aid project is completed. For a truly sustainable transference of GIS technology, it is important to ensure that within the domain of the receivers of technology, which are often state institutions, conditions are established wherein the project can be continued and reinforced (Harris et al., 1995). In aid projects the GIS is often transferred to scientific institutions, which in turn are placed with the responsibility of moving the technology from the "lab to the land." This process of technology transfer is again fraught with a number of significant problems related to institutions, manpower, data and project management. Some of these issues are now discussed.

2.3.2 Institutional constraints

Various authors have highlighted a number of institutional factors, especially within government organizations, that significantly influence the effective use of GIS in developing countries. Fox (1991), for example, points to the problems that arise because of the existing culture within government agencies. Decision making is often confined to a central official who holds all the strings, and he neither delegates responsibility nor tolerates dissent, thus discouraging participation of users in the implementation process. When the individual is inaccessible, decision making often grinds to a halt. An example of such a decision making scenario can often be found in the Indian district administration, where nothing moves without the assent of the Collector, who is the head of the district. The GIS technical experts frequently find it problematic to start fully-fledged GIS projects in a district, because they did not have the opportunity to take the Collector into their confidence, and because he may have been too busy coping with day-to-day administrative and political problems. Such "people-based" rather than "institution-based" ways of working also prove problematic because of the rapid turnover of government staff from their posts. New incumbents, rather than trying to build upon past efforts, often start from scratch, resulting in unfinished projects and a significant waste of resources. An associated problem, which Mathieson (1992) describes in the context of Thailand, is that over-zealous GIS experts often oversell the benefits of the technology to the decision makers, who then expect the system to solve all their administrative problems. The realities, however, do not match up to the expectations, and the decision maker is left feeling disenchanted and skeptical about such governmental initiatives.

Another major problem in implementing GIS technology in developing countries arises from the sectoral form of functioning of government institutions, resulting in the improper coordination of project activities. To make decisions using GIS, there has to be good cooperation between the computer specialist who is developing the systems, and the subject-expert who has to interpret the output. However, the developer and user are typically responsible to different ministries and departments, and the functional manner in which these organizations operate makes the sharing of data and other technical and organizational resources extremely problematic (Al-Ankary, 1991; Fox, 1991). Absence of national level policies to coordinate such departmental efforts can often lead to duplication of efforts and encouraging of redundancies. In the context of Thailand, however, Hastings (1994) describes how the National GIS Centre (NGIS) helped coordinate the activities of various government agencies by playing a supporting rather than a watchdog role. Similarly, the Malaysian government is exploring the feasibility of developing a national level land information system (NALIS) to enable coordination of land-related records at the central level. However, such national level efforts are presently rather sparse in developing countries. For example, in a country like India, where there is a multitude of national GIS initiatives taking place through various agencies, there are as yet negligible efforts being made to coordinate and regulate projects at the central level.

The bureaucratic and hierarchical functioning of government organizations further magnifies the problems created by the sectoral structure of work arrangements. For example, in Jamaica, Eyre (1989) noted a major constraint to the JAMGIS system due to the system being located in a division or sub-department of the Ministry of Agriculture, which was very low in the bureaucratic hierarchy, and did not have the authority to enroll the active participation of other agencies. Such structures and management styles impose a rigidity to project efforts, stifling the processes of organizational change required to facilitate effective implementation. In government organizations, even within the context of developed countries, there is a bias against existing tools and methods involving geographic analysis, resulting in resistance to experiments with new technologies such as GIS (Obermeyer, 1993).

Another institutional impediment to GIS projects in developing countries is the nature of the relationships between scientific institutions responsible for implementing the technology, and the planning bodies that are the potential users of the systems. There is often an over-dominance of the technical institutions, and the technocrats do not feel it necessary to take into account users and their application needs during the processes of system development and use. Since GIS is primarily used in departments such as survey, forestry, and remote sensing, which already have a computer and mapping background, the new GIS technology stays confined within the scientific and technical domains, not diffusing adequately to the planners, and thus also neglecting their needs (Yeh, 1991). In many developing countries, for example India and Thailand, where there is a strong tradition of remote sensing, the responsibility for introducing GIS technology into governments has been entrusted to the remote sensing experts, who may see GIS as primarily being a tool with which to use remotely sensed data, rather than to solve socio-economic field-level problems (Sahay and Walsham, 1996).

2.3.3 The data management problem

The effectiveness of GIS depends on the degree of relevant data as inputs. In developing countries, the collection as well as processing systems are relatively inadequate, notwithstanding the increasing use of satellite data. These problems are both technical and institutional in nature. The technical concerns relate to data availability on appropriate scales, usability problems because of the over-dependence on remotely sensed data, quality problems because of maps being outdated, and non-standardized formats of data that are not supported by standard software. Maps are hand drawn, causing decision making based on such data to be unreliable. Data are often non-existent; for example, high resolution data on tropical forests are generally unavailable as they have to be captured using synthetic aperture radar systems (Lauer et al., 1990). Institutional arrangements cause problems relating to the absence of coherent data management strategies to guide and coordinate national GIS projects, and in enabling data sharing between various concerned agencies. Data are also often hard to find due of lack of programmes, institutions and institutional commitment to provide data.

Other cultural and technical limitations also significantly influence the availability of data (Yeh, 1991; Barthel, 1991). In many developing countries, a variety of reasons, e.g. military related security restrictions, contribute to a rather weak culture in the use of maps for planning purposes, and therefore the availability, and even the use of paper maps, is rather limited. The use of digital maps to support government planning is even more rare. Socio-economic data are not generally available in digital form, and data sharing between institutions is not easy to come by, because incentives for sharing are non-existent. Often land ownership data, which are crucial for developing spatial databases, are not available, and in many cases vested interests benefit in keeping it unavailable (Fox, 1991). Equipment availability and cost are further impediments, since data integration involves additional hardware and software, which is not easy to come by as a result of limited budgets and inadequate support staff.

An issue that also contributes to the non-availability of appropriate data arises from the dependence of many GIS applications in developing countries on data generated using remote-sensing technology. Remote sensing techniques are appropriate solutions in many, but not all situations, and these differences are often not well understood by decision makers. Narayan (1993) writes that remote sensing in theory allows the gathering of spatial data over large areas at a reasonable cost. Experience, however, often conflicts with theory: data supply queues are long; clouds often obscure the Earth's surface at critical times; image interpretation is more of an art than a science; precision geo-coding is difficult and time-consuming; and the attributes of many spatial objects are undetectable using remote sensing techniques. Remote sensing data are frequently limited, in the sense that they may mostly relate to land cover, from which extraction is tedious and expensive.

Another technical problem with data concerns quality. Data are generally outdated, and organizational procedures rarely exist to continuously verify the quality of the data collected (Yeh, 1991; Al-Ankary, 1991). Taking the example of Jamaica, Eyre (1989) described how the data quality in JAMGIS suffered considerably because some of the toposheets used were more than 40 years old and updating them was a gigantic task, both in terms of time and money requirements. The data collection centres, for example the meteorological division in Jamaica, were working with outdated technology and under poor operating conditions, which made the data collected by them to be suspect. As a result, while some layers of data were good, other unreliable layers made it frustrating for the user trying to conduct an analysis.

Technical data problems also arise because of data being collected in non-standardized formats, whose conversion is not supported by standard GIS software (Yeh, 1991). Conversion, when possible, requires additional editing work, and thus also involves significant investments of time and money. Standardization problems arise because of the data not being in similar scales, resolutions and accuracy levels (Yeh, 1991). For example, Eyre (1989) reports that in JAMGIS, the geological layer was on 1:250,000, while most other layers were at 1:25,000 scale, thus making the entire data set inadequate for conducting a detailed and integrated analysis. Using the example of India, Nag (1987) notes that since data from the 31 states are collected in different formats and scales and that there is considerable variation in both the cartographic and statistical contents of the database, integration is a complex and time-consuming task. Absence of policies to define data standards for access and exchange magnifies the problem of developing national and regional level GIS systems, and many GIS projects are initiated without any coherent data management strategies.

2.3.4 Manpower constraints

An acute shortage of trained manpower in both absolute and relative terms provides critical constraints in the implementation of GIS projects (Fox, 1991; Yeh, 1991; Specter, 1989). In general, when compared to the rapidly increasing demand of GIS personnel in developing countries, the supply remains grossly inadequate. For example, Hastings (1994) reports that the educational infrastructure in Thailand is not adjusted towards catering to even 50 per cent of the industry demand for GIS staff. There is an extreme shortage of funds and as a result universities in developing countries lag considerably behind the technology. Students interested in taking up GIS as a career often have no alternative but to go abroad for studies, and on their completion, frequently prefer to stay and work in organizations outside their home countries. GIS does not provide an established and visible career structure in developing countries, thus discouraging students to take up GIS jobs on a long-term basis. For example, in India, despite the large number of ongoing and future planned GIS projects within the public sector, there is no cadre recognizing GIS or even informatics skills within the Government. The inadequate prevailing government salary structures also make it very difficult to attract and retain qualified personnel and prevent them from joining the more lucrative private sector.

While pockets of GIS research are taking place within university departments in developing countries, degree programmes that are able to provide a steady flow of GIS professionals into industry still do not exist. In India, for instance, centres of research within the Indian Institute of Technology, Bombay, and Annamalai University, Madras, have over the years been carrying out high quality research in GIS, but these efforts are not primarily oriented towards producing GIS professionals for industry. Also, since GIS training is generally confined to the departments of computer science, remote sensing and surveying, students in user departments such as planning or resources management, do not receive adequate exposure to the technology (Yeh, 1991). Universities represent large and complex bureaucratic structures, wherein policies on the existing curriculum are "written in stone." Convincing such organizations to make radical changes, such as introducing new degree courses, is an extremely complex and time-consuming task – a project by itself.

2.3.5. Project management practices

With respect to GIS project management practices, a general comment concerns the primary focus given to the technical aspects of implementation – for example, acquiring the state of art in hardware and software at the expense of the social and institutional aspects required to ensure effective technology adoption and use. Since GIS represents a rather new phenomenon in developing countries, with limited awareness in user departments as to its potential, the responsibility of introducing it to organizations is normally entrusted to the technocrats from scientific institutions. As a result, a strong technical bias seems inevitable at the early stages of a project. However, as projects move from the technical implementation stage to organizational implementation where the technology is expected to support users' work processes, it becomes critical to understand social aspects; for example, user expectations and fears with respect to the new technology. Since GIS-supported work represents a radically different way of doing work (for example, it entails working with maps compared to the traditional methods of using lists and tables), it becomes important to focus on the social aspects of work. This obliges organizations to make significant changes to their structures and the ways in which they operate in order to effectively adopt a technology (Sommers, 1989).

Another important aspect of project management is the manner in which the processes of technological transition are planned, which represents the process of change as users move from one method of work to another. Users can develop negative feelings towards a technology if this process is abrupt and discontinuous (Madon and Sahay, 1996). In many developing countries, the introduction of GIS represents a radically discontinuous transition, because it involves an attempted changeover from a non-map and non-computer based way of working to one supported by GIS. Madon and Sahay suggest that such discontinuities can be minimized by careful planning. Instead of confronting the user directly with GIS, it would be more effective to gradually introduce users first to the basic principles of database management, the basic ideas of a map and spatial concepts, and then to a computer generated map. Clarifying such foundation spatial concepts would later help in understanding more advanced GIS functions of overlaying and other forms of spatial analysis and modelling.

A further important element related to GIS project management concerns the time involved in the conceptualization and implementation of projects. Typically, a GIS project may involve three to five years, over which time it becomes difficult to sustain the interest of the concerned parties. Also, problems in implementation typically cause large time and cost overruns in such projects. Under such circumstances, the financial sponsors of the project tend to become impatient, wanting to see some tangible outputs, otherwise they lose conviction that the project is worth the investment. Educating sponsors on the time and money involved in such projects, and providing them with some examples and prototypes at periodic intervals, can be useful in managing the problem of extended time involvement inherent in such projects.

The effective management of GIS projects in developing countries is also significantly impeded by the absence of sustenance mechanisms which can allow for the system to operate over the long-term. As noted earlier, a majority of GIS projects are initiated through consultants sponsored by aid money, and there is the problem of sustaining these projects after the consultants leave the scene, and when the aid money is no longer available (Angus-Leppan, 1989). The primary focus of many aid projects is on technical implementation, including the acquisition of the hardware and software, while a secondary focus is given to the creation of local expertise to sustain projects over time. This problem is also compounded by the frequent transfers of local project staff, which does not allow for the development and growth of a core group of GIS staff to oversee the long-term continuance of such projects. For example, Hastings (1994) writes that in Thailand, the GIS staff at the provincial level are transferred with an alarming frequency – "one week they might find themselves in the northern part of the country, the following week they might be transferred to the deep south." The absence of coherent human resources policies that would allow the creation and continuance of such core GIS groups, magnifies this problem with respect to the long-term management of projects.

2.3.6 Summary

In the discussion above, we have highlighted and discussed five key sets of issues that impede the effective utilization of GIS. While an understanding of these factors helps to sensitize the planner to project related problems, by themselves they are not adequate to provide an understanding of why these problems arise. To develop this deeper level of understanding, these factors need to be examined within the wider socio-political-cultural context of project implementation. For example, the problem related to lack of sustenance mechanisms in GIS projects in India has to be understood within a wider context, including how the government bureaucracy works; how science and technology development is viewed in the country; and what are the institutional roles and responsibilities of the various actors involved in such projects, including the scientists, users, government departments, vendors and international aid agencies. It is also important to understand the past experience of users with computerization projects; do users see the current project as yet another attempt by the government to introduce the latest available fad from developed countries, or does it involve a more serious intent of changing how they perform their day-to-day work? If it is seen as a fad, then there will probably be no serious efforts by the project staff to develop longer-term sustenance mechanisms.

CHAPTER 3

SOME SPECIFIC GIS INITIATIVES IN INDIA

In this chapter, various Indian large-scale national GIS initiatives are discussed and analysed so as to gain an understanding of some of the factors specific to the Indian situation. This will contribute towards an understanding of the factors discussed in the previous chapter, and enable a broader discussion in Chapter 4 of the social and institutional challenges to establishing and sustaining GIS initiatives in India. The chapter is organized as follows: section 3.1 provides a background to the research, including details of the various GIS initiatives studied and the reasons for their selection. Details of the field work are also provided, including data sources and data-gathering strategies. In section 3.2, the genesis of GIS use in India is taken up, including an historical analysis of some earlier government efforts to introduce computers to support district administration, and how these have contributed to creating the basis for the current GIS efforts.

Some specific GIS initiatives currently taking place in India are discussed next, especially with respect to their conceptualization and design, as well as an examination of some of the problems and opportunities that planners face when trying to make these initiatives effective. Firstly, in section 3.3, the Ministry of Environment and Forests GIS initiative, which was the main focus of the research, is described and analysed. Then, in section 3.4, the authors critically analyse other large ongoing initiatives in the public sector through the National Informatics Centre, Department of Space and the Department of Science and Technology. Finally, in section 3.5, an interesting GIS initiative taking place in the non-governmental organization (NGO) sector in the World Wide Fund for Nature (WWF), India, is discussed.

3.1 Background of research approach

The analysis in this chapter is based primarily on research over a period of three years from early 1993 to late 1995. The authors began by investigating a particular set of GIS projects that were taking place under the umbrella of the Ministry of Environment and Forests (MoEF) of the Government of India. At a later stage, the study was widened to include other central government agencies, and in the end the research took into account almost all district-level GIS initiatives in India. Since 1995, the GIS activities of the WWF have been followed in their attempts to develop a national data centre to support biodiversity management in India.

Since the authors wished to study how GIS were being used to support natural resources management, and whether their use was successful or not, they needed to gain an in-depth knowledge of the GIS technology that had been developed in certain locations, the action and perceptions of various stakeholders concerning the use of technology, and the changing contexts within which the attempted technological introduction was taking place. They attempted to gain this understanding by carrying out a longitudinal study of GIS development, introduction and use in their field sites, in which they observed and collected data on changing circumstances, perceptions and actions over time, and as they occurred. To understand the GIS activities which had taken place prior to the start of the research study in 1993, the authors used historical reconstruction from archival documents and recollections of the past, focused largely on 1991-93 when the GIS projects were commissioned and operationalised.

Ten GIS projects were examined in the MoEF, which were concerned with different districts in India, and detailed investigation of the five most advanced was carried out. A further range of district-level GIS projects was also carried out, initiated by agencies other than MoEF, specifically projects of the National Informatics Centre, and the Department of Science and Technology, with detailed examination of six additional districts. The authors carried out 127 formal interviews with 105 personnel at different hierarchical levels during five separate field trips.Table 1 gives details of those who were interviewed; some key personnel in scientific institutions and central government agencies were interviewed on more than one occasion. Interview lengths varied, but a typical interview lasted from one-and-a-half to two hours. Extensive interview notes were taken during each interview by both field researchers where both were present. Tape recording was used infrequently, and not at all during the later stages of the research, as it was felt that most participants were more inhibited in their opinions when being recorded.

Table 1: Summary of interviews conducted

Nature of Group	Number of Interviews: Field Trips and Other						*Totals	
	No.1	No.2	No.3	No.4	No.5	Other	Interviews	Responents
Scientific Institutions	11	6	4	5	Workshop		26	15
District Admin.	3	10	5	7	21		46	46
Central Govt. (MoEF.NIC/DST)	6	9	8	5	6		34	23
Vendors	2	1				8 (6 in USA, 2 in UK	11	11
Others (NGOs/Aid Agencies/Academics	2	2	2	2	2		10	10
Totals	24	28	19	19	29	8	127	105

*The totals for the number of interviews in some cases are more thanthat of respondents because some of the respondents were interviewed more than once.

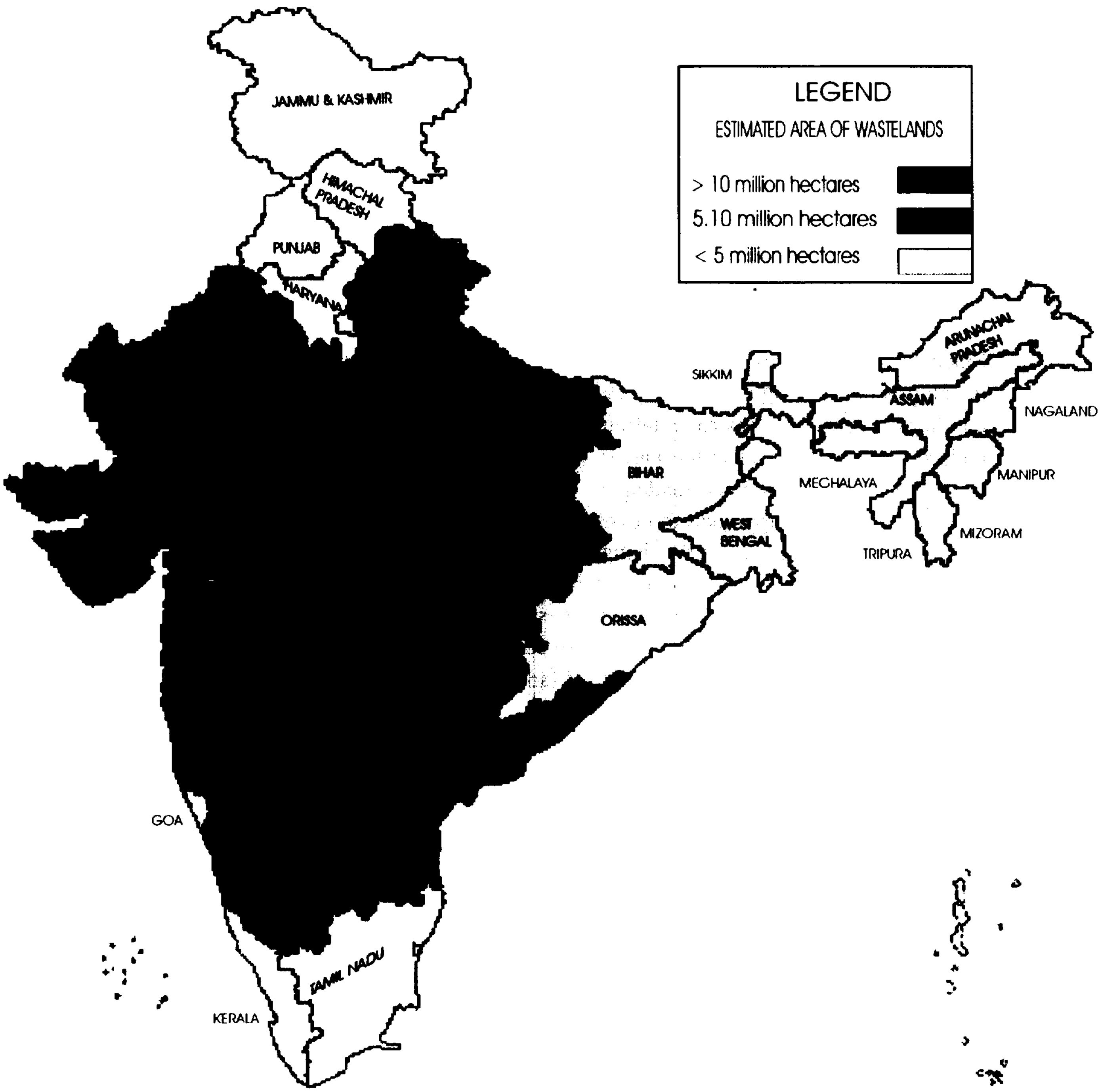
In addition to formal interviews, other data sources included system demonstrations at all the project sites, archival data in the form of reports and filed documents, and some informal contact with personnel outside the formal interviews. For example, substantial informal contact was made with the GIS Project Director in the MoEF throughout the research period, with frequent e-mail contact whilst the researchers were back in the United Kingdom. A national seminar organized by the Indian Society of Geomatics provided additional background data on the state of GIS in India. A further data source was a two-day workshop on GIS implementation in New Delhi in July 1995, which the authors initiated, and whose participants included a wide range of personnel from the field sites and from central and State Government. During the period of the research, impressions from the field visits, both through formal reports and through face-to-face contact, were relayed back to the various project personnel.

3.2 Genesis of the use of GIS in India – an overview

Since the late 1980s, India has been making large-scale investments in the use of GIS for development planning and natural resources management. These investments come after almost a decade of experimentation with computer-based information systems which had been initiated because the earlier manual systems of development planning and monitoring were considered inadequate and not able to provide support for a locally-relevant, integrated approach to development planning (Government of India Report, 1987). An added impetus for the rising investment in GIS comes from the increasing focus of the national Government on sustainably managing natural resources, and the fact that international aid to developing countries is being increasingly delivered with rather strict stipulations on implementing improved environmental practices through the increased use of such technologies as GIS (Madon and Sahay, 1997).

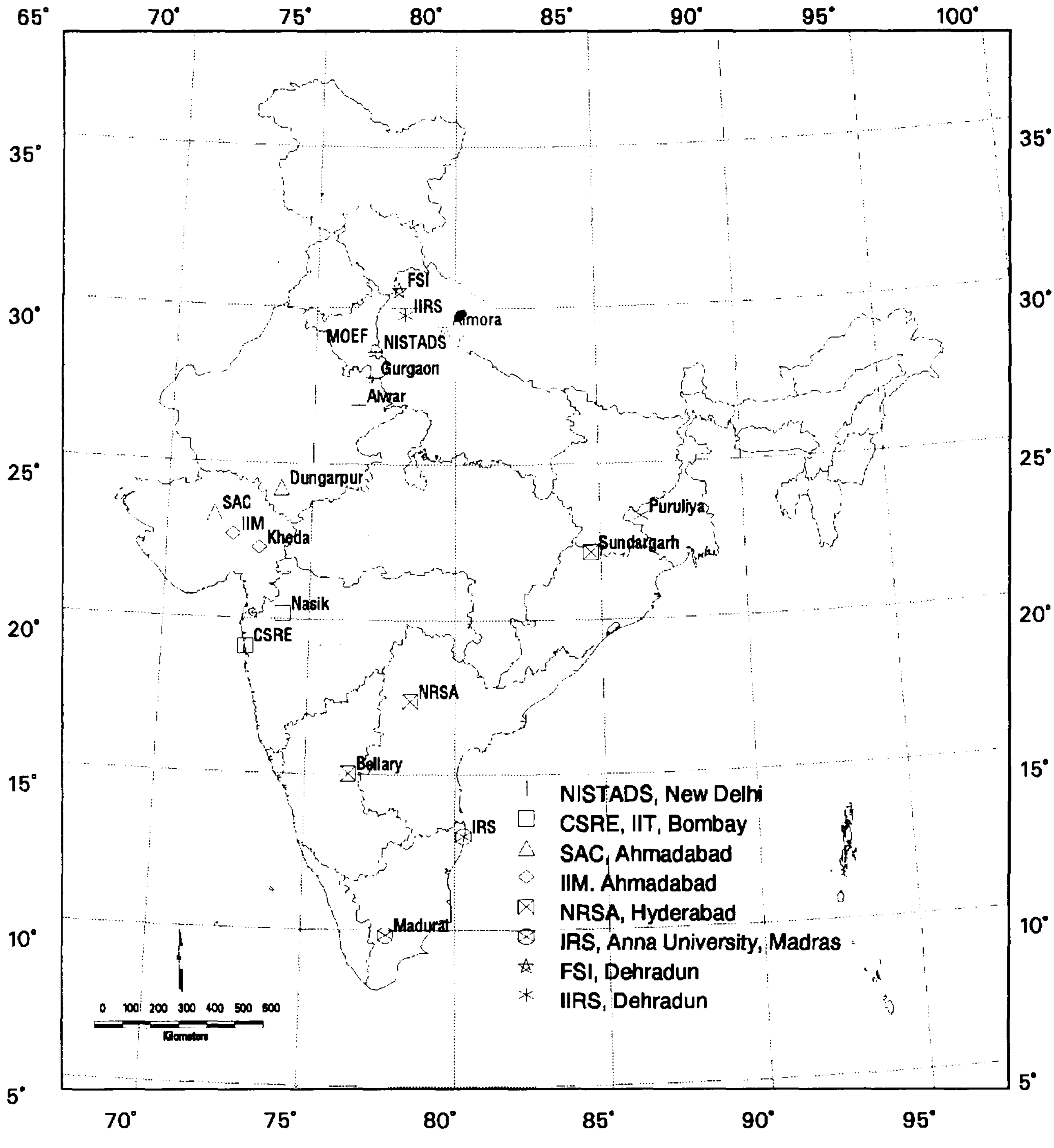
In 1987, the Indian Government, being committed to a policy of modernization and technology-driven change, decided to promote the use of computers at the local level of the administrative unit called the "district," with the aim of integrating the various poverty alleviation schemes initiated under the umbrella of "development planning." However, rather than consolidating efforts, various individual ministries launched independent projects to serve their own administrative and planning functions without providing adequate technical and organizational support. Moreover, these systems were designed in a top-down fashion by the central offices in New Delhi without adequate consultation with state government and district officials who were the potential users of the system (Madon 1993; Madon, 1993a). Over the years, these problems have led to an ineffective use of centrally-designed information systems and the promotion of end-user computing applications in districts. Computers were primarily used to automate routine tasks, such as monthly progress reports and annual action plans, rather than a support tool for decision making activities.

WASTELANDS* IN INDIA



*Degraded land which can be brought under vegetative cover, with reasonable effort and which is currently under utilised and land wich is deteriorating for lack of appropriate water and soil management or on account of natural causes.

Fig. 1: Map of Wastelands in India



- Uppercase labels represent scientific institutions
- Normal case labels represent pilot districts
- Symbols represent correspondence between scientific institutions and pilot districts

Fig. 2: Spatial distribution of scientific institutions and allocated pilot districts

Since 1993, in addition to routine automation tasks, there has been considerable self-learning by local administrators who have begun using computers for more analytical operations to help ensure that development programmes are targeted where they are most needed. For example, the sorting of poor rural households by income level, caste, occupation and other locally relevant criteria. Such developments in the establishment of infrastructure and the processes of learning that have taken place amongst local staff, has helped to create an environment and an awareness of informatics, which is likely to help in the future operationalisation of GIS technology.

More recently, local level planning has taken on an additional dimension – that of natural resources management and sustainable development. The Secretary of the Department of Space stated that "the economics of development planning must expand within eco-systems that have limited regenerative capacities. The need is for a full integration of enviornmental and development issues for decision making" (Kasturirangan, 1994). Indian planning increasingly seems to reflect this additional focus on environment management, and the recognition that no development programmes can be economically and socially viable unless natural systems are preserved.

Aid from international agencies such as the World Bank and the UK Overseas Development Authority, is now explicitly being linked to the use of scientific management practices, including GIS, for development planning. An example of this focus on scientific methods and new technology is reflected in a document of the Planning Commission, Government of India, which within the context of land management, has recognized "GIS as an invaluable planning tool in land use and wastelands development ... for identifying treatment areas and models, making trade-off calculations in choosing from competing land-uses, and carrying out simulations and impact assessments" (National Wastelands Development Board, 1987).

These recent developments in the context of Indian planning systems and policies of international aid have led to the creation of an impetus on the part of the Indian Government to shift the emphasis from planning based on non-spatial parameters, including development schemes and households, to one based on spatial criteria such as "watershed units" and "wasteland distributions." It is intended that individual districts in India will develop strategies that make efficient use of natural resources, through the application of modern management methods and tools such as GIS, to support and maintain the ecological system which can help to provide people with their socio-economic needs.

In an attempt to implement such plans for improved natural resources management practices, various governmental organizations since the late 1998s and early 1990s, as noted earlier, have started a number of GIS initiatives. The Government is also realizing the important facilitating role that can be played by the NGO sector in this regard. In addition to these various governmental and non-governmental GIS projects, a number of other agencies are playing facilitating roles in this process. For example, the Survey of India is responsible for establishing a digital cartographic database of the country, and the National Remote Sensing Agency is collecting and disseminating satellite imagery.

In the next section, an overview is provided of the set of projects carried out under the direction of the MoEF, including a detailed analysis as to why the authors believe the impact of the project has been rather marginal to date.

3.3 The MoEF GIS initiative

3.3.1 Case overview

The National Afforestation and Ecology Board (NAEB), a wing of the MoEF, initiated ten GIS projects in January 1991, in collaboration with eight scientific institutions in India, with the aim of examining the potential for using GIS technology to aid "wasteland development." Wastelands are categorized as degraded land which can be brought under vegetative cover with reasonable effort, but which is currently under-utilized, and land which has deteriorated due to the lack of appropriate water and soil management. In Figure 1 we provide a map of India which provides an estimate of wastelands in the country. The scientific institutions were two remote sensing agencies, three research groups within universities, and three other scientific agencies concerned with forestry, space research, and the study of science and technology in development.

We now provide a brief description of the progress of the projects, starting with the history of their initiation. Phase I of the projects which took place from January 1991 until January 1993, and Phase II from April 1994 to late 1995 will then be described.

Initiation

The initiation of the MoEF GIS project in January 1991 can be traced back to two earlier events, according to a reconstruction of the history prior to the research period. In 1986, the Government of India started the "National Wasteland Identification Project" to identify different wasteland categories in the country. Detailed maps were produced on a 1:50,000 scale for 147 selected districts using remote sensing techniques for data collection. The existence of these maps provided a basis for considering how to develop and manage these wastelands, but the stimulus for the possible application of GIS to this issue was provided by a chance encounter of some GIS experts from Ohio in the USA with Indian officials from the MoEF.

This chance meeting, occurring in the context of a general US mission to India, triggered a sequence of further activities. These started with a USAID (United States Agency for International Development) sponsored visit of an Indian expert team to see GIS installations in the USA, followed by the setting up of GIS training workshops for Indian scientific staff, and the donation of some GIS software. Finally, eight scientific institutions were invited by the MoEF in 1991 to test the efficacy of GIS in wastelands management, and to demonstrate the capability and ability of GIS packages for local area planning.

The Director of the NAEB responsible for coordinating this project, made a conscious effort to impart diversity into the project in terms of software types, hardware and methodologies adopted by different institutions. For example, with respect to methodology, some institutions worked at a 1:50,000 scale, while others worked at the level of 1:10,000; some adopted a watershed as a unit of analysis, while others used a village as the basis. The research sites allotted to the institutions by the NAEB were priority development areas, and represented different national agro-climatic zones. The districts within which the field sites were located were relatively close to the respective scientific centres in some cases, but in other cases they were as far away as a thousand miles. In Figure 2 details are provided of the locations of the various scientific institutions and the specific pilot study sites that were allotted to them for the MoEF GIS projects.

Phase 1

The staff of the scientific institutions saw the objectives of the project to be primarily technological in Phase I, involving the scientific demonstration of the potential utility of using GIS technology for wasteland management. Eight of the ten projects were successfully completed by early 1993 in terms of producing prototype GIS applications based on real data from the field sites in their particular districts.

The detailed models and systems developed by the institutions tended to reflect their view of themselves as scientific research and development centres. For example, there was a heavy reliance on data obtained by sophisticated remote-sensing techniques, reflecting the nature of the interests of the typical research scientist in these institutions. Figure 3, which provides the flow chart of the system development process as depicted by one of the institutions, illustrates this bias in its exclusion of socio-economic variables relevant to wastelands management, such as population and livestock data. In addition, and of crucial importance to later development of the project, many of the scientists involved in the project saw their institutional mandate to be limited to the development of technology rather than to its transfer to administrators at the district level.

Phase II

Although the Phase I projects were completed in early 1993, proposals for continuation were not submitted until a year later, and then only by five of the original eight institutions. This period of transition from Phase I to Phase II was characterized by uncertainty of the objectives, nature and scope of the continuation phase, especially from the point of view of the institutions. While the MoEF attributed the delay in moving from Phase I to Phase II to the institutions, the institutions in turn felt that they had not been adequately briefed on the project objectives; who was going to be the user; which agency would provide sustained presence and support in the field; what were the budget parameters; and what would happen after this phase.

The Project Director saw Phase II as involving the transfer of the developed systems to the district levels for use in real management applications. The institutions felt that the initiative for transferring the system should come from the users themselves or the MoEF, since their staff skills or resources were seen to be inadequate for this task in most cases. Also, as intermediaries, they believed they could not influence the district administration process. The institutions asked for further funding, largely to provide more hardware and software, whereas the Project Director felt that the institutions

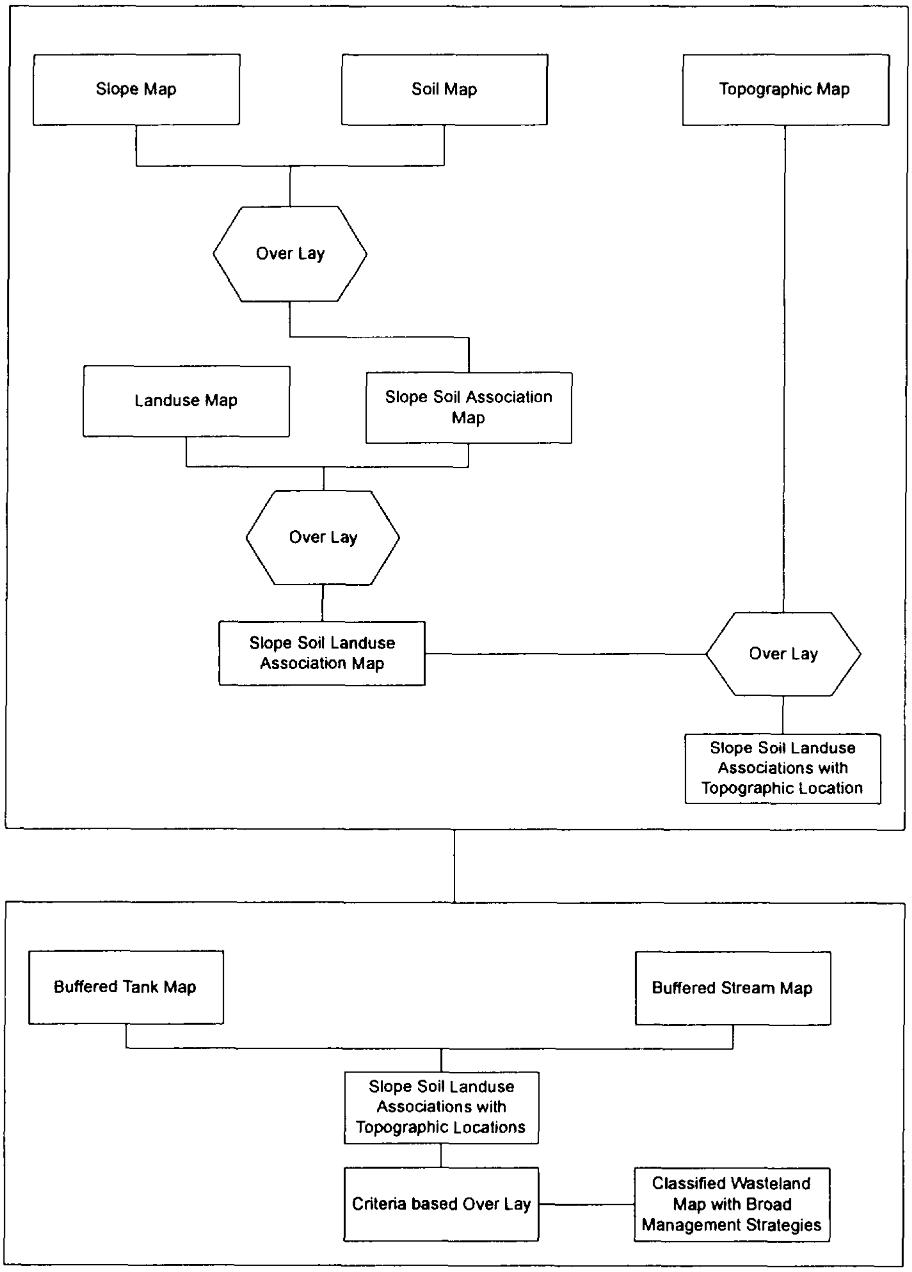


Fig. 3: Flow chart showing spatial analysis

should concentrate on using the existing equipment, and on its transfer to the field. Eventually, five institutions agreed terms for Phase II, and work started in April 1994. Soon after, the Project Director left the NAEB on secondment to another institution, and there was very limited further central direction of the Phase II projects. Despite this lack of coordination from the centre, all five of the phase II projects went ahead in different ways and with different levels of success in terms of the stated project goals.

3.3.2 Analysis of the MoEF initiative

The field research over an extended period led to an identification of many problems in MoEF's attempts to use GIS technology to aid wasteland management in India. An analysis of some key problems is provided, organized within the framework of the social context within which these projects were implemented and how they relate to project implementation processes, including their initiation, operationalization and consequences on district-level administration. The influences of the social context on the processes of implementation are also discussed.

3.3.2.1 The social context

The social context refers to the historical conditions antecedent or given to the process, but responsible for defining the socio-cultural reality within which the technology is used. The authors found two aspects of the social context to be extremely relevant in shaping the process of the project implementation: the structure of the agencies involved, and the nature of the scientific tradition existing in India.

Structure: Structure relates to the form of the relevant groups involved in the project implementation, and the structural framework within which the project was operationalized. NAEB, a relatively new entity within the MoEF, was broadly responsible for implementing eco-development work within degraded forests and adjoining areas, while the rural development wing oversaw rural development work in the non-forest lands. Wasteland development involved activities relating to the NAEB, rural development, and the forest wing of the MoEF, causing sone ambiguity as to the nature of responsibility for the project. This ambiguity was magnified by the fuzzy nature of the definitions of "wastelands" and "forests". A senior official of the MoEF described one aspect of this ambiguity as follows:

"The basic problem comes up in the manner in which the Government defines forests. The revenue (administrative) boundary (is taken to be) the boundary of the forest, which often is not the real case. There is a problem in the basic interpretation of what the forest means."

The institutions involved in the project were primarily scientific research centres involved in the application and development of remote sensing technology. The applications developed for the project reflected this remote-sensing bias, and often resulted in other socio-economic considerations not being given adequate emphasis.

The district administration included about twenty different departments, all potential users of the proposed GIS application, e.g. the departments of forestry and rural development. The sectoral functioning of these departments made GIS implementation problematic, and it was even difficult to obtain a consensus on where the system should be physically located. This issue, which appears relatively trivial at face value, is crucial because it is rooted in more fundamental aspects related to power, politics and responsibility.

Computers were introduced to the districts by the National Informatics Centre in the late 1980s, and the offices there were still at relatively early stages of GIS computerization at the time the research was carried out. Computers were primarily used for monitoring different development programmes, for example the monthly status of financial and physical outlays made to different projects. The transition from these existing monitoring systems to GIS based planning systems represents a major reconceptualization on how work could be done in district offices. A project team member at one of the scientific institutions was of the opinion that the districts were not yet ready for GIS technology because of the inherently problematic nature of their administrative systems.

Scientific tradition: Scientific tradition relates to the prevailing beliefs on how science and technology is viewed in India, and the norms and values underlying these beliefs. The Indian educational system emphasizes the superiority of the technical and scientific disciplines over the social sciences. Obtaining admission into a relatively low ranked engineering college is considered more prestigious than entering a leading university for a degree in humanities. The institutions emphasize the development of quantitative skills and methodologies, while issues relating to the organizational applicability are neglected, and considered to fall under the purview of the social sciences. There is a strong emphasis on technical problem solving, and a clear division between the "technical" and "social" people, with the former being considered superior. Scientists are of the opinion that the "scientific" methods they use are superior to those used by the non-scientists, making it problematic for them to work with users, for example while preparing joint proposals. A project leader expressed this problem as follows.

3.3.2.2 Processes of project implementation

We now discuss some of the key issues involved in Phases I and II of project implementation, including its initiation, operation and continuation.

Initiation: The project was officially initiated in January 1991. However, two sets of activities that took place earlier were relevant to this initiation: the participation of the USAID; and the existence of the national wasteland maps. The USAID involvement in the project was visible as early as 1989, when some of their experts visited India to explore the possibility of establishing a GIS university network. Subsequent visits by USAID officials provided the basis for an expert team to visit different installations in India. Following this, a technical committee recommended the use of different GIS software for wastelands management applications.

There were disagreements between the USAID and Indian officials on the choice of software and aspects of project methodology. There was also a difference of opinion on the utility of the USAID-initiated "participatory approach." While the USAID officials believed that the approach was effective (Hutchinson and Toledano, 1993), some Indian officials felt it was not relevant to their local context.

Wasteland management in India is a high priority development activity, and the Government has spent large amounts of money (about US$ 2 million) to create wasteland maps of the country. Awareness of GIS technology seems to have provided Indian officials with a view of how these maps could be used, and has thus given an impetus to the GIS project. The implementors saw the objectives of the project to be primarily technological, involving the demonstration of the utility for GIS management. A project leader described his interpretation of the project objectives as being "only concerned with applying GIS technology, and not looking at other issues."

The influence of the technology focus in project initiation was noticeable by the manner in which project operationalization later took place.

Operationalization: Operationalization, which refers to the manner in which the project was executed, was characterized by a lack of continuity in management and a strong technical focus. There was a lack of continuity around project management issues, which seemed to arise from the frequent transfers of project personnel, and an undefined responsibility concerning "who will provide the sustained presence."

The transfer of personnel at different levels was a major problem. For example, the project director left on deputation to another organization in April 1994, leaving the project temporarily without a coordinator. Many of the District Magistrates (DMs) were transferred within a year in a post, often just at the point of being convinced by the scientists of the usefulness of GIS. Field staff were often transferred to other districts after having been through time-consuming training. Rapid turnover in the vendor staff resulted in delays in training and installation activities. This frequent movement of key people at different levels created a state of discontinuity with respect to the project, and prevented the growth of a core group of people to maintain and support GIS.

Central to the issue of continuity were questions concerning which agency was responsible for transferring the technology from the laboratory to the field, and in providing the sustained field presence. At the local level, the GIS effort was seen as an external implant; a "supply push" by the centre and the technologists, rather than a "demand pull" by the district. Field staff had limited capability of working with GIS, and the DM was generally busy coping with day-to-day problems of local administration and ongoing political pressures. One senior scientist described his institutional mandate to be limited to the development of technology, rather than its transfer to the field.

The nature of the applications developed and the reliance on remotely sensed data reflected the primary technical focus of the project, and raised questions about its relevance to the decision maker, such as the forest officer. For example, the 3-D terrain models developed at one site, even though pleasing to the eye, seemed removed from existing practices of wasteland management. A junior member of the project team in one of the institutions pointed out that the notion of "optimal" management practices (for example, profit maximization) on which the models were based, were often very different from a project beneficiary's view of reality:

"GIS will say "grow mustard" as it gives most economic yields, but the farmers rather than trying to maximize profits will try and minimize risks. Growing mustard is a risky business because it is prone to insect attacks. However, growing wheat assures the farmer a minimum return, and he will prefer that to growing mustard."

Another project feature was the dependence on data that had been generated using remote sensing technology, for example firewood and fodder availability. This dependence contributed to the relative neglect of other socio-economic factors relevant to wasteland management, e.g. aspects related to population and livestock. This neglect contributed to the users questioning the relevance of the GIS models to their particular problem domain. For example, one District Magistrate reported that he would be happier if the GIS outputs were to support decisions relating to socio-economic problems, such as where to locate a police checkpost or a health centre, rather than on being told where to grow a new fodder plantation. Another issue related to scale appropriateness. The remotely sensed maps at the 1:50,000 scale were seen to be less useful for micro-level planning than cadastral maps at the 1:10,000 scale. Also, governmental security restrictions were seen to impede the easy availability of remotely-sensed images.

Continuation: Continuation concerns the manner in which it was planned to move the project from its first stage to one involving larger scale field-level wasteland management applications. There was a one year delay in the transition from the first to the second phase of the project, a period characterized by a sense of uncertainty as to the nature of the next phase, and it appeared that the next phase would not be significantly different from the earlier one. The institutions felt that the continuation parameters were not specified, and that resources were not provided to enable the transfer from the "lab to the land."

The uncertainty surrounding the project, combined with the lack of enthusiasm on the part of the district officials, and the departure of the Project Director (who until then had been a major source of inspiration to the project), contributed to a significant drop in interest levels, and created feelings of despondency among some of those concerned. Even though a stated objective of the second phase was to transfer the application to the field, no substantial mention of users was made in the proposals. The institutions felt that as intermediaries they could not enable the transfer process, and the initiative for it should come either from the NAEB or the users. Under such conditions of uncertainty and the lack of initiative from the various parties concerned, the next phase of the project commenced, and it did not promise to be much different from the earlier work.

A project review workshop was organized in July 1995, and the participants included the scientific institutions, the authors of this study, and the government officials associated with other national GIS projects. In three of the five project continuation sites, little progress was seen in transfering the systems to the users, and in integrating it with ongoing work processes in the district. However, at two of the sites, a basis seemed to have been established that could potentially engage with GIS use in the future. This "success" seemed to have come about more through the efforts of the individual project leaders than through institutional mechanisms.

3.3.2.3 Influence of the social context on the processes of implementation

We now discuss how aspects of the social context influenced the processes of project implementation. Earlier discussions on the nature of social context and processes of implementation led to the identification of two primary linkages relating to the scientific tradition and structure with the processes of implementation.

Scientific tradition and processes of implementation: Indian scientific tradition emphasizes the division between the technical, the social and the superiority of technology disciplines over social sciences. People involved in implementing the project were primarily computer scientists and remote sensing technologists, trained within a scientific tradition that emphasizes the superiority of the scientific method. The norms and values emphasized by this tradition are incorporated into their mental schema, which are drawn upon to take and legitimize action. For example, the project proposals, in which user related issues were given secondary importance, are reflective of these values. Since these proposals become the basis for the operationalization of the project, they become a medium by which the existing traditions were reproduced. These values, which are related to the scientific method, are reflected in a scientist's description of the utility of the model developed by him or her for the project:

Institutions have a high-tech, R&D profile. As a scientist once said, their job is to work on a particular technology for about a year or two, and then move on to something newer, rather than become involved with its transfer to the field. The organizational R&D orientation contributes to further reinforce existing values that relate to the scientific tradition. The adherence to these norms created problems in project management: absence of responsibilities for transferring GIS to the field; neglect in the monitoring of social aspects in the project; and user problems being given secondary importance.

Structure and processes of implementation: The physical distances between the different agencies, and the marked differences in their interests and motivations concerning GIS, provided a sense of fragmented implementing structure.This fragmentation created problems on how project-related issues were identified and resolved. For example, distances made it problematic to hold joint meetings, which left issues unresolved, and this in a sense reinforced the fragmentation.

The project-based manner of Indian government functioning also influenced the processes of implementation. These projects are typically short term, with individual, isolated resource allocations. For example, the GIS initiatives of the MoEF and other agencies described later, were operating in parallel, even though in some cases there were overlaps in study areas. This sectoral and short-term management style inhibits the intermingling of resources and ideas, and is contradictory to the integrated and longer-term needs of GIS. For example, the project-based funding of the NAEB effort was piecemeal and inadequate. The USAID money dried up even before the project really gained momentum, leaving the GIS effort temporarily in a state of limbo. An NGO employee described the main problem of Indian government departments as the compartmentalization of activities.

In summary, the authors' analysis has helped to highlight various contextual and operational factors that have impeded the implementation of the current MoEF project and, in doing so, has emphasized the linkages that exist between the social context and various processes of initiation, operationalization and consequences of the technology. To further expand this analysis of GIS management in India, some other Indian public sector initiatives are now described, and various management issues and how these compare with the MoEF project are examined.

3.4 Other national public sector GIS initiatives

3.4.1 Department of Science and Technology (DST)

The DST started the Natural Resources Data Management System (NRDMS) programme in 1986 with a view to developing natural resource profiles of different selected regions. The NRDMS was conceptualized as an "information system to aid spatial planning and the management of resources such as land, minerals, water, forests, etc., at smaller area levels, such as districts or below" (Murthy, 1996). An important aspect of the NRDMS initiative was the development of a PC-based GIS software called GRAMS to support the management of natural resources. The vision for the NRDMS programme was primarily that of a R&D exercise. Unlike the NIC effort, which was targeting all districts in the country, the DST was working on a smaller scale in 12 to 13 selected areas representing different agro-climatic zones in the country. Typically, a DST NRDMS district centre was located in a local engineering college and run by two or three DST staff based there. A district-level committee was normally established at each centre, which included functionaries such as the District Collector, who is the administrative head, various department representatives, and experts in natural resource management problems.

In the early 1990s, the DST felt that instead of working in various districts scattered all over the country, they should enhance the visibility of their efforts by focusing on one state, taking up work in all its districts. The State of Karnataka put forth a proposal to implement this concept, which was accepted by the DST. Under this plan, natural resource databases were to be developed and implemented in each district centre in the State for both graphic and attribute data. GIS technology was the primary tool being used to implement these databases. While the basic structure of the NRDMS database had been developed in the DST head office in New Delhi, the design was adapted at the local level in keeping with the data management methods in place at specific districts. Eight key sectors were selected for the database development, including natural resources, infrastructure, ground water (water resources), and other socio-economic indicators. The databases in most cases were being implemented on a PC 386 platform using the in-house developed GRAMS software.

In Karnataka, the office of the Zilla Parishad (ZP) was responsible for overall planning in the respective districts. As of summer 1995, ten centres had been established out of a total of 19 districts in the State; six of which were housed within local academic institutions and the remainder within the local ZP offices. The DST had placed two technicians in each centre (normally engineers with computer backgrounds or experts in various subject areas, often with masters and Ph.D. level qualifications in geology or soil sciences). The typical life span of a NRDMS centre was about five years, after which the local office was expected to become the custodian of the centre and sustain its operations. It was also hoped that the DST staff would be absorbed by the State government after five years, on the completion of the project. In the ongoing projects, the State was contributing about 25-30 per cent to the initial overall project, but after the five-year period, they were expected to take complete financial responsibility.

During the period of the research, the authors visited six of the DST district offices, in addition to interviewing senior DST staff at their headquarters in New Delhi. They found that there had been a serious attempt by the DST staff to involve local institutions in providing human and technical resources for GIS development and implementation. For example, in one of their advanced projects, the DST located their GIS initiative within a local engineering college of national repute. The strategy which was adopted here was incremental in nature and aimed at the key office of the chief executive officer (CEO) of the ZP. Firstly, some problems of relevance to the ZP were identified, e.g. the maintenance of hand pumps. A solution was proposed, supported by GIS maps. This resulted in the CEO becoming interested, and making requests for other maps dealing with such issues as election planning, the location of fair price shops and transportation planning.

Although the approach is at a relatively early stage, some real applications have taken place, and it appeared that a sound basis for future development had been created. However, there were a number of operational problems, the most crucial of which related to data management due to the lengthy and tedious process of data compilation. As a result, the DST was often dealing with secondary data sources, i.e. data which were already available. There were various problems with this data associated to its reliability and the fact that the data in the departments were incompatible with the formats prescribed by the DST in their database development guidelines. However, the DST showed flexibility at the field level, and were in most cases collecting data in whatever format was available and converting it to the required formats. These additional efforts required for conversion and integration, making the task arduous and time-consuming. The database development task was very people-intensive, and in most cases the district line departments were not willing to release their staff to work exclusively on this task. Nevertheless, despite these impediments, the DST were planning many other similar projects, and through this process of introducing NRDMS, were also attempting to initiate changes in prevailing data management practices in district administration.

3.4.2 National Informatics Centre (NIC)

The NIC is a central government body concerned with the promotion and development of computerization within the Government of India at the levels of the centre, state and district offices. Starting in 1987, NIC established offices in all 500 districts of the 32 states/union territories to support local level computerization efforts. At the time of the research, each district office had two NIC officers and was equipped with a PC 386, dot matrix printer and applications software to facilitate reporting on the progress of various district-level development programmes.

A major strength of the NIC is their high speed satellite network – NICNET – a national information highway which operates from 128 kps to 2.2 Mbps. This network, which connects all the NIC district, state and central offices in the country, provides NIC users with a variety of services, including internet access, electronic mail, remote database access, and electronic data interchange. About 15 cities in the country were operating at 2.2 Mbps per node in 1994 (Sheshagiri, 1994), and this was expected to be expanded substantially in the near future. By 1997, NICNET was expected to be expanded to 6,000 development units at the sub-district level of the "block".

The NIC GIS initiative, labelled GISNIC, began in the early 1990s, with the primary impetus for it coming from the NICNET, since the GIS software could be overlaid on this existing network (*Informatics,* 1993). An independent GIS division was established in the NIC office in 1992, and the group leader described their development efforts to be taking place on a "mission mode," a long-term basis, with relatively little pressure to produce short-term project deliverables. To facilitate these efforts, nodal centres of GIS expertise were being situated in state capitals. At the time of writing, 15 state capitals were being equipped with a dedicated GIS pentium-based workstation, a digitizer and a plotter. An initial focus of the group was to upgrade the first version of their in-house GIS software onto a Unix platform and release it to various district offices over the network. Initially, the NIC selected a few districts where software could be used for the generation of thematic maps. By 1996, GISNIC had been installed in about 200 districts, and it was planned for all districts to have the technology, linked to each other through the high-speed network. Training of NIC staff was another key focus, and by the end of 1996 nearly 300 people had been trained in GIS.

Another feature of the NIC GIS activities was the initiation of the Natural Resources Informatics Programme (NRIP) for sustainable development, which was based on the assumption that long-term development is only possible by preventing ecological and environment degradation. NIC believed that for such environmentally sustainable policies to be set in place, planning needs to be reoriented towards natural resources by using decision support technologies such as GIS at the local level (Chandra et al., 1995). In this regard, NIC was attempting to establish comprehensive socio-economic or natural resources databases for each village or cluster of villages, and to include extensive data on key sectors such as geology, geomorphology, soil, land and water resources. Other secondary sectors on which data were to be collected included land use/land cover, wasteland, agriculture, environment, forests, fisheries, minerals, irrigation, and marine and coastal resources.

Under the NRIP initiative, in addition to the creation of spatial and non-spatial databases, NIC intended to facilitate local and national level networking to enable information exchange. In collaboration with various district offices, NIC planned to create "natural resources informatics nodes" at the grass root level and, in collaboration with the district administration, try to develop resource inventory profiles and plans for the sustainable utilization of natural resources. The availability of the NICNET was expected to facilitate the sharing of data across various government agencies. Initially, three districts located close to New Delhi were selected as pilot sites for the NRIP project. In this long-term NIC funded project, the Centre for Remote Sensing in the Aligarh Muslim University acted as the conduit for the transfer of technology and expertise to the district offices. The NIC developed the databases and the applications in collaboration with the centre, who in turn would then be responsible for providing local support to the district administration. At the time of writing, these systems had not yet been operationalized for use by district administration officials.

During the course of the research project, the authors visited two districts identified by NIC as pilot sites for their GIS activities outside the NRIP initiative. GIS software was in place in one of the districts, and in the other district the focus had been primarily on technical implementation, i.e. installing the software and network. Some training had been given to a few NIC district officers whose aime was to develop the GISNIC system further in order to interest local level administrators in its use. Some of the GISNIC systems were in the same districts as the MoEF GIS projects, but there had been little effort at coordination. In one district, the authors encouraged coordination between the MoEF and the NIC, but these efforts did not bear fruit because the senior officials of these two organizations could not agree on the logistics of the sharing mechanisms. In another district, where both the NIC and the Department of Science and Technology were involved in GIS initiatives, there was again little cooperation in resource intensive activities, such as database development.

3.4.3 Department of Space (DoS)

Since Independence, the Indian Government has emphasized the need for developing a strong space programme and has implemented various initiatives through the DoS to attain its objectives. From the late 1970s, various DoS programmes based on remote sensing technology were initiated for natural resource surveys, such as the creation of periodic forest inventory maps (Unni, 1993). The establishment of infrastructure, such as the multi-spectral data analysis system and a data receiving station, has helped to operationalize the use of remote sensing data for project management. The DoS satellites IRS-1A and 1B have enabled the provision of primary data on natural resources with about 36 metre resolution. While this provided the capability to map natural resources at about the 1:50,000 scale, it did have limitations when assessments had to be done at the micro-level of the village. The later second generation satellites IRS-1C and 1D are expected to provide data with a 10 metre resolution, which could resolve some of the existing inadequacies of data.

Technological advancements in the area of storing and processing satellite data using GIS, and the increasing governmental emphasis on sustainable development, has provided the DoS with the impetus to initiate various national programmes oriented towards natural resources management using GIS in conjunction with remote sensing. This emphasis on sustainable development has led to the realization of the need for an integrated, rather than a sectoral, development approach, using natural boundaries defined by river basins/sub-basins as planning units, instead of the administrative units which have been the feature of post-Independence planning.

A specific initiative of the DoS was the National Natural Resource Management System (NNRMS), an integrated resource management system aimed at an optimal utilization of the country's natural resources by developing a systematic inventory of resource availability using remote sensing, and then aiming at its exploitation using other techniques such as GIS. NNRMS has been described as an all encompassing management system for natural resources, utilizing data from remote sensing and other conventional surveys (Indian Society for Geomatics, 1993). Under this programme, the DoS, along with user departments, has taken up national-level projects in different resource management areas, including for example, forestry, agriculture, drought monitoring assessment, and wasteland mapping. A number of these projects include the task of integrating remotely sensed data with other non-spatial data for resource management using GIS. An example of such a project was the development of the Regional Information System for the Bharatpur district in Rajasthan, which was handed over to the district administration in 1995.

At the behest of the Planning Commission, the DoS has also taken up a major programme called the IMSD (Integrated Mission for Sustainable Development), which was being implemented by the Indian Space Research Organization (ISRO). Under this programme, the ISRO proposed to undertake remote sensing based integrated land and water studies for 157 problem districts (45 per cent of India's geographical area), including an earlier set of 21 districts, which were sites for other pilot programmes (Kasturirangan, 1994). This programme, in which GIS technology was expected to be an integral tool, would provide further impetus to the use of remotely sensed data being generated under the Indian space programme.

Another focus of the DoS initiative has been on the development of GIS software. This focus comes from the recognition that the availability of indigenous GIS packages was not only cost-saving compared to purchasing it from foreign vendors, but also fundamental for the integration of various datasets owned by Indian users, and for the customization of their specific needs. The DoS has collaborated with two software industry partners under technology transfer agreements to develop GIS packages – ISROGIS and GEOSPACE. These packages have been installed in different user-agencies on a variety of platforms and operating environments.

3.4.4. Comparative analysis of national public sector GIS initiatives

An examination of the various public sector GIS initiatives described in earlier sections indicates that a substantial amount of work has been carried out by these different agencies on data collection and developing the technical aspects of their GIS. However, their approaches to this development task have been markedly different, ranging from a large-scale top-down approach of the NIC to a R&D bottom-up approach of the DST. However, as with the MoEF projects, there still lies a major problem in producing systems of practical usefulness for user departments, who perceive their interests as being served by the GIS application. We examine some key reasons for this rather limited practical use of GIS.

DST projects: The DST had a key actor at the centre in New Delhi who directed the strategy for their GIS initiatives with a similar sense of vigour and sense of purpose as the original GIS project director in the MoEF project. This actor was highly aware of the need to establish the support of local-level officers, and one approach he adopted was to identify local institutions that were prepared to join his GIS project team and to motivate them to also include other district level functionaries in the development efforts. One example of this was the staff member at the local engineering college who tried, with positive results, to enroll allies by addressing problems that were locally relevant, such as the maintenance of locally located hand pumps.

The NRDMS projects are primarily R&D exercises aimed at the problem of creating natural resources profiles of selected districts. The R&D nature of these projects is necessarily limited in scope and coverage. For example, the projects were initially placed in 13 selected areas based on the criteria that they represented the different agro-climatic zones of the country. Later they were expanded to cover all districts in the State of Karnataka. The individual projects were planned with a five-year life span, and were heavily dependent on the initiative of the local administration for their continued existence. This was often not forthcoming, and the project remained largely limited to a R&D exercise.

Despite hopeful signs from a few of the DST projects, such as the one referred to above, it still seems extremely difficult to create groups of people who would be able to support the longer-term development of these applications. There is always the problem of identifying who is the custodian of the system, and which department will take responsibility for tasks such as database maintenance and updating. For the systems to be really "used" in the true sense, district level management systems need to involve a map-based mode of planning, based on "rational" thinking and coordination between different departments. These represent rather radical changes to the existing administrative systems, and are problematic in bringing about because of the inertia that is traditionally inherent in Indian bureaucracy. In addition, changes of district level personnel remain a major problem where project efforts are dependent on single agents such as the District Magistrate.

Many of the DST projects involve the use of GRAMS, the GIS software developed by a research group at an Indian university. Since this research group was primarily a technical development team and not well equipped to provide field support, they found it difficult to provide prompt support in the remotely located districts. It was also difficult for the local GIS users to obtain reliable and prompt support from the vendors who were located in the cities and found accessing the districts rather difficult. The absence of reliable technical support therefore proved to be a major bottleneck and contributed to project discontinuities. It is also the widely held view that Indian GIS vendors still see their interests as primarily concerned with selling technology for a short-term profit, rather than in providing help in solving the longer-term problems GIS projects normally involve. The vendors in turn argue that they are not paid to do the latter.

The NIC project: The NIC projects do not have the same vendor problem referred to above because they have the presence of technical staff in each district, and also the GISNIC software has been developed in-house. The primary impetus for the GISNIC initiative was technical in nature, stemming from the presence of the high-speed network, and their initial activities were aimed at establishing the technical infrastructure in the state capitals and incrementally to various districts. These included developing in-house GIS software and then upgrading it to a Unix platform, providing digitizers, plotters and dedicated workstations to the selected GIS sites.

While it is of primary importance to have the technical infrastructure in place before starting application development, the effective use of the technology is dependent significantly on the support the district administrators show towards the project. At the time of writing, there had been no significant attempt at enrolling the support of local level administrators. While there is an increasing realization among the NIC planners in New Delhi of the need to focus on organizational aspects of the implementation process, many factors impede their efforts in this. The primary issue, as in the case of the DST projects, relates to the nature of local administration and the existing work-systems, which are not based on concepts of a map-based thinking, and coordinated, rational planning.

Under such a local administration scenario, the initiative for promoting GIS in local district-level departments falls on the NIC staff. This initiative is not easy to take on because of both the backgrounds of the NIC staff and their heavy work load. The NIC staff come primarily from a computer-science background, and their work is primarily grounded within a data-processing and systems administration culture. The NIC office essentially acts as the clearing house in the district to process data on monthly progress reports of the various departments, and then transmits them over the network to the state capitals. The use of GIS, which is more of a spatial decision support rather than a data processing tool, involves a different form of orientation, a map-based way of conceptualizing and formulating problems, which is often difficult for people with strong data-processing backgrounds to naturally take on (Robey and Sahay, 1996).

The NIC offices in each district are manned by two staff, a DIO (District Information Officer) and a DIA (District Information Assistant), who are normally overloaded with work since they are responsible for collating and processing data from twenty or more government departments. In addition to this regular monthly workload, they are usually involved in trouble-shooting system problems, working with different departments who are keen on developing new applications, and reporting work progress to both the district administrative head (often the DM) and the state NIC office. Under such circumstances, it becomes very difficult for them to take on a new and complex technology such as GIS, educate themselves on it, and then sell the new concept to an often reluctant district administration. The GIS work load requires considerable effort to foster and develop, and imposing it on an already overloaded staff is problematic.

The NIC planners in the central office at New Delhi have responded to these concerns by intensifying their training efforts, and by working in collaboration with local institutions capable of providing support. In a few selected districts, the local NIC is attempting to work closely with the district administration officers, introducing them to the potential of the technology. However, at the time of writing, the NIC still appeared a long way from providing GIS applications that could prove useful in supporting day-to-day work at the district level on a sustainable basis.

The DoS Initiative: An important element of the DoS programmes has been, quite naturally, their emphasis on the use of remotely sensed data. The Secretary, DoS, describes remote sensing data as a "classic source of data on natural resources for a region which provides a record of the continuum of resource status because of its repetitive coverage" (Kasturirangan, 1994). While the DoS is trying, in the context of sustainable development, to expand the coverage of remote sensing to include other socio-economic variables under the concept of "geomatics," there is still a widely held perception that the DoS programmes are geared primarily to the use of remotely sensed data. As a result, their relevance to district administration is often rather limited, as they may be more interested in addressing other socio-economic problems, such as locating a new police station or hospital. Another related problem is that the scale on which remotely sensed data is available is not always appropriate for micro-level planning efforts, which requires cadastral-level data to be relevant.

Another aspect of the DoS initative relates to their "distance," part physical and part perceived, from the users. For example, the DoS scientists have an extremely high-tech and high-profile image, and this inhibits their communication between the user departments. Also, since the DoS programmes are spread very widely across the country, it becomes problematic for the DoS officials, who are located mostly in the state capitals, to monitor closely their project activities at the ground level of the district. The physical constraints in accessing the districts make the scientists reluctant to visit the user site and, as a result, they are not highly knowledgeable of the ground-level realities within the district. This understanding gap is reflected in the decision models that are developed, as they generally do not accurately reflect user needs.

Summary

In summary, while we can see a number of ambitious plans being put in place for GIS development, the Indian Government still does not seem to have a coherent strategy of where they want these initiatives to lead. While the Survey of India, utilizing substantial funds provided by the United Nations Development Programme (UNDP), have acquired sophisticated technology, the availability of digital cartographic data is still a major problem. There is limited effort by the Government to establish policies that would make the data easily available to the ordinary user.

Most of the GIS projects tend to reflect a "top-down" approach, emphasizing technical development rather than an applications-driven view. Impressive strides have been taken in the development of a high-speed telecommunications network, and in remote sensing technology using India's own IRS 1A, IB, and IC satellites. Small indigenous GIS systems are emerging, including GRAMS, GISNIC, ISROVISION and GEOSPACE, and they are being applied with some degree of success in pilot projects at the rural district level. However, these exercises tend to remain as pilot projects and scientific experiments, because institutional and social mechanisms are not established to transfer the technology in a manner which would sustain the project over the long-run in the user offices.

3.5 The World Wide Fund for Nature – India (WWF) GIS initiative

In this section, we move away from the public to the NGO sector, and discuss the WWF GIS initiative.

3.5.1 An overview of the initiative

The WWF initiative is being implemented through the the Indira Gandhi Conservation Monitoring Centre (IGCMC), which was established in 1993 under ODA funding within the WWF, India. This centre, which is set up with the objective of providing information support for conservation and biodiversity management in the country, represents an ambitious and interesting attempt by the non-governmental sector to participate in GIS related activities. The IGCMC has five broad sets of activities in which GIS is expected to play a central role: mapping of flora and fauna; management of protected areas; habitat analysis; forest cover classification; and evaluation of the Indian Government's Joint Forestry Management (JFM) programmes.

Mapping of flora and fauna: The mapping of the country's flora and fauna resources is a core research area of the centre and is self-funded. Traditionally, the Botanical Survey of India (BSI) and the Zoological Survey of India (ZSI), have had the responsibility of collecting data on flora and fauna. This was carried out through periodic field surveys, and the results were published in the form of reports containing lists and tables, with a negligible mapping component. In addition to providing lists of available species, the reports also gave details of endangered species or of species facing extinction. IGCMC is attempting to build spatial databases for endangered, threatened and extinct species using GIS technology based on the existing BSI and ZSI report for flora and fauna. The use of such secondary data will be supplemented by some limited field checks to be carried out by NGOs and other research centres. This GIS database is expected to have several layers, providing details of the spatial distribution of different species and the nature of their threatened status. The users of these databases are expected to be the BSI, ZSI, universities and other research centres.

The management of protected areas: This project concerns providing information for protected area (PA) management, a project being funded under the World Bank, Global Environment Facility (GEF) programme. The IGCMC is trying to develop databases for about 300 of the 500 PAs within the country. PAs are those areas identified by the Government as being under threat of losing their biodiversity resources. Once the area is notified as a PA, then it is technically supposed to fall under the purview of the Wildlife Act. However, in practice, despite theGgovernment's notification, an exact demarcation of the PA at the ground level was not done, making the implementation of the Wildlife Act ambiguous. For example, the rights of tribal populations, who have been living in these PAs for centuries, were not defined. These tribal peoples are dependent primarily on the forest for their livelihood, and unless alternative resources are provided to them under the Act, the implementation of the programme becomes extremely problematic.

IGCMC aims to create comprehensive GIS databases to help monitor the status of conservation in the PAs by developing data layers on various parameters, including: forest cover; forest type; dwellings within 10 kms of the protected areas; and how the local populations use the PA resources, including water, flora, fauna. By developing these data layers over time, IGCMC will be able to study the rate of decline of resources and analyze the ecological and human reasons causing it.

Habitat analysis: An interesting area of GIS application is habitat analysis, which involves taking a larger and more integrated view of the problems affecting the environment. For example, the tiger population in India is declining rapidly as a result of various anthrogenic pressures including poaching, diminishing prey base, fast depleting water and feeding resources, and a variety of other complex inter-connected factors that comprise the habitat. Another larger issue concerns the impact of urbanization and industrialization in blocking the tigers' migratory routes from one reserve to another, which further contributes to the rate of decline of this species. Under a project being funded by the WWF (USA), the IGCMC is undertaking a complete habitat analysis for the tiger population using GIS technology as a central tool.

Forest cover mapping: Another area of GIS application relates to the mapping of forest cover classification, a project being partly funded by a US-based NGO. Once every two years, the Forest Survey of India carries out a classification of the country's forests using satellite data on a one to a quarter million scale, and makes a qualitative assessment of the state of forests using visual interpretation techniques, and in recent years using digital methods. The IGCMC was trying to prepare GIS databases, using the last series of the forest maps to scientifically assess the state of the forests in a region, and to carry out a temporal analysis of the changes in land cover. These databases can then be used for gap analysis activities, which seeks to identify the gaps between the biodiversity of the area and its underlying threats. This can help decision makers to prioritize their regional conservation activities.

Evaluation of the JFM: An important area of IGMC work is the evaluation of the Government's Joint Forestry Management (JFM) programmes, which seek to encourage the participation of the local population in conservation efforts and share in the profits generated by improved forest resources. Until recently, the Government's policy with respect to forest conservation was one of trying to coerce the population not to act in certain ways. However, the Government now realizes that it cannot afford to alienate the local population whose subsistence depends on the forests. As a result, the JFM seeks to involve local habitants with a legal and long-term stake in conserving the forests. The objective of the IGCMC project, which is being funded by the Asia Forestry Network, is to evaluate whether the JFM has actually led to the regeneration of forests, and if the pressures of improved conservation in one area are being transmitted to nearby areas.

3.5.2 Analysis of the WWF initiative

The IGCMC GIS initiative reflects the various problems in trying to implement GIS supported information management activities through a NGO. A major problem is the non-availability of data in a single form, and with a single agency. The absence of an information sharing culture provides road blocks to even obtaining published data from government agencies. For example, unrestricted toposheets are difficult to obtain from the Survey of India, because they are said to be out of print. The field maps are sometimes hand-drawn, representing rough approximations of reality, making it difficult to base a scientific analysis. The multi-disciplinary activities of the centre require the collaboration of subject matter experts, for example botanists and zoologists, who often do not have computer skills. Such a collaboration is a novel concept, and one which is not common in India, except in the context of universities and scientific institutions, where the focus is on research rather than on developing practical applications.

NGOs are typically dependent on aid agencies for the implementation of their projects, a dependency which is often quite problematic. While aid agencies provide critical financial support for capacity building, their understanding of the problems involved in running such an information management centre is often limited. These agencies are typically run by bureaucrats who lack an overall vision, and whose primary interest is to lay down stipulations that equipment and consultants should be acquired from the donor country. Financial sustainability of the projects is a major concern with the aid-agencies, who demand evidence of products and markets, and these objectives are often in conflict with the more developmental concerns of IGCMC. These conflicts reflect a classic chicken and egg situation, where IGCMC feels that it first needs support to demonstrate its capability, while the aid agencies demand to see evidence of some capability before agreeing to provide support. The bureaucratic style of working causes long delays in the process of evaluating project proposals, and actually disbursing aid support.

Since the objective of IGCMC is to provide information support for environment management, a major bottleneck they face is the tradition of non-use of scientific, objective data in the Government to support decision making. For example, the present biodiversity conservation efforts of the MoEF are based more on personalities than scientific methods, and frequent changes in personnel and governments further magnify the problem, because new incumbents tend to disregard what has been done by past ones, and start instead from scratch.

The involvement of NGOs like IGCMC in policy making processes is often resented by the Government, who see it as an encroachment into their domain. There is often the misplaced fear within the Government that if data become freely available, they would be used by foreigners and big companies to wrongfully exploit the country's resources. But the reality is that at present, such exploitation is rampant because of weak regulatory mechanisms. In the absence of scientific data on the environment, the environmental impact assessment (EIA) of large projects is carried out on a trial and error basis, with only the staff submitting the EIA reports being capable of evaluating the feasibility of the proposal. The implementing agency is thus unable to really evaluate the report, and the accuracy of the contents is suspect because the data are old, inaccurate, and sometimes even misrepresented. A general lack of environmental awareness in the country, and the relative impotency of pressure groups to force the local governments to take corrective measures, make the IGCMC's information support functions very difficult to implement.

Then there are some concerns specific to the IGCMC. Trying to establish a scientific information management centre within a traditional NGO such as the WWF, is like trying to fit a square peg into a round hole. NGOs have a certain vision of how they should carry out the activities they have been doing for a long time. Information management has traditionally not been part of that vision, and NGOs often try to adopt their past traditional methods to also initiate improved information management practices. The lack of expertise in new problem domains of information management creates bottlenecks in project implementation, because, for example, the need to alter organization structures and existing proceduresin order to adopt new technology is ignored. As a result, information management activities are accorded a very low priority, with poor salary structures and inadequate infrastructural support.

3.6 Some concluding remarks on GIS initiatives in India

A number of GIS initiatives in India has been described, originating both from the public and NGO sectors. While the initiatives discussed cover all the large-scale national GIS programmes, they do not include all GIS projects in the country. For example, Lahiri (1993) has described a specific case of the attempts of a college at the university of New Delhi to develop a GIS application to provide a status report of the physical infrastructure in the State of Bihar.

In summary of the initiatives described above, it can be seen that while there are a number of agencies in the governmental and non-governmental sectors that are involved in GIS projects, there is little effort to coordinate, and little or no mechanisms established to enable sharing and transfer of data. There are examples of projects being initiated by different agencies concurrently in the same district, with the implementors oblivious of the presence of the other. This lack of communication between agencies leads to large duplication of efforts in collecting data and creating databases. While significant amounts of data are currently available, little of it is in machine-readable form, and the costs of converting the paper maps into a digital format is very high. Nor are the different agencies technically and organizationally equipped to undertake such large data conversion projects. Data quality problems remain, and the availability of cartographic data is an issue, given the Government's concerns on security and policies of restricted access. Remote sensing data are more readily available, but at the present scale, may be unsuitable to solve many of the micro-level problems. The rate of change, especially in the cities, is extremely rapid, and this compounds the problems of obtaining relevant and updated data.

The existing data management practices in the districts are largely manual and non-map based, with little utilization even of paper maps. For GIS to be effective, a considerable degree of organizational and institutional integration is required, which in the present context poses a real challenge, and success will be hard to achieve. A number of questions would need to be addressed before such integration can take place. For example: should a top-down approach, or a bottom-up user applications driven one be adopted? or what combination of these two approaches should be adopted? and what policies need to be established to enable such integration? Some of these question will be addressed in Chapter 6 when the implications for GIS project management are discussed. In the next chapter, the macro-level social and institutional challenges to implementing GIS in India are examined.

CHAPTER 4

IMPLEMENTING GIS IN INDIA: SOCIAL AND INSTITUTIONAL CHALLENGES

In this chapter, we move away from the project level focus of Chapter 3 to discuss the more macro-level challenges of implementing GIS technology in India. These challenges arise from the social and institutional conditions within which the introduction and use of GIS technology takes place. One question that naturally arises is why the primary analytical focus is on these social and institutional conditions, and not instead, for example, on the technical features of the software. In Chapter 1, while discussing the focus of this study, the authors emphasized the interconnections between the social and technical aspects of GIS, and the problems associated in trying to treat them as independent dimensions. While acknowledging this interconnection, it was argued that in IT implementation projects, especially within the context of developing countries, the social and institutional aspects of project implementation often supersede technical considerations and influence the outcome of projects more significantly.

To emphasize the above point, the authors narrate a small incident that occurred when one of them was presenting a seminar based on this research study in a scientific institute in the Netherlands. At the end of the seminar, an Indian scientist who was in the audience was rather irate, and criticized the seminar on the grounds that nothing new had been said, because if the acronym "GIS" were substituted with any other technology, the story of the project would probably have not been much different from what was presented in the talk. In this casual statement, what the scientist seemed to imply was that the management style associated with Indian government, in a sense, seemed to supersede the characteristics of the technology being introduced. This comment was rather intriguing, and initiated a process of reflection on other more profound questions, such as what features characterize this Indian government style, and what makes this style persist across different project and technology situations, or how is this style reflected in project management.

The authors attempt to address some of these rather complex questions in this chapter, which is organized as follows: in section 4.1, the factors that have historically impeded past computerization efforts in India are analyzed, and see how they compare with current issues in GIS management. This can help to critically examine the comment of the Indian scientist that in Indian Government projects, the technology in question is relatively unimportant in determining project outcomes. The significance of the social and institutional conditions are further emphasized by discussing in section 4.2 how similar constraints have impeded GIS projects even in the context of developed countries. The above discussions provide the basis to examine in section 4.3, the kind of tensions and conflicts that are created by the differences in the social values that exist in developing countries as compared to the assumptions that are seen to be inscribed in

GIS technology. Then, in sections 4.4 and 4.5, the relation between social and institutional conditions in India and the managerial agency are examined specifically. In 4.4, discussion is taken up on how social and institutional conditions shape management attitudes in India, which in 4.5 is examined in the context of the GIS project under study. An analysis of this relationship between social conditions and the managerial agency helps to better understand why the Indian Government's management style tends to persist over time, space and different technologies.

4.1. Past computerization efforts in India

Madon's (1993; 1993a) longitudinal analysis over the last five or six years of district-level computerization in Indian government highlights the primacy of institutional and social factors over technological as bottlenecks to an effective adoption of new technologies and associated work methods. Some specific areas of concern pointed out by Madon include: the dearth of institutional reforms accompanying the introduction of new technology; the abrupt and discontinuous manner in which technological transitions are planned; human resource development issues; and the problem of obtaining reliable technical support in districts. These issues are now elaborated upon.

Institutional reforms: Early attempts at computerization at the district level in India were with the broader aim of facilitating processes of bottom-up planning and encouraging initiatives based on local problems. However, a major constraint to these computerization efforts was the paternalistic style of authority in the administration. The introduction of computerization threatened to replace authority based on hierarchy with that based on expertise. The district was constrained in terms of the norms that were established by the centre, for example in terms of how beneficiaries were selected for governmental assistance under various poverty alleviation schemes. These rigidities tended to stifle micro-planning efforts, which require local initiative and judgment in interpreting outputs related to individual households, schemes, villages and resources. Computer technology, instead of facilitating local decision making capabilities, tends to serve as a tool to automate monthly reporting activities.

Technological transitions: Technological transitions reflect the process by which organizational systems change from a certain way of doing work to other ways in order to accommodate the new technology. When new technology is interpreted as a continuation of existing technical capabilities, the transition becomes smoother compared to the case where the change is seen to be a radical departure from existing capabilities (Robey and Sahay, 1996). Continuities of technology build upon an established base of knowledge, whereas discontinuities require the creation of new knowledge before the transition can occur. The early computerization efforts in the districts reflected discontinuous changes because prior to that there was literally no culture of computer-supported work in the government departments. The role of the users was limited to providing data on floppy disks to the NIC office, who were then responsible for processing it, and generating monthly reports for onward transmission to the State headquarters over the network. Technical expertise remained confined within the district NIC offices, with minimal attempt to educate the user departments in computer technology.

Human resources development issues: Another bottleneck with past computerization efforts has been the limited demand for analysis of data by district officials. For example, district planning has been largely monitored on the basis of physical and financial progress, with negligible consideration being given to qualitative performance. The task of planning is primarily viewed as an impersonal and mechanical task; for example, annual plans are typically made by adjusting the previous year's plans by a specified percentage rather than seriously considering afresh the activities planned for the coming year. Another factor contributing to this lack of demand for data analysis was that the departments had novice users, with a limited understanding of the potential of technology in their work. There were negligible incentives provided by the management to the users to educate themselves on computers. On the contrary, they saw the process of interacting with technology as an additional burden to their ongoing work, and were wary of trying to participate in training activities. There was also the problem of qualified people being unwilling to work in remote district offices, and only those belonging to a particular district were ready to work in the local office there. Obtaining such a match was often not easy.

Technical support: Poor technical support was identified as a key factor for the ineffective use of earlier computerized systems. One major cause of this was the physical separation of the district administrative and NIC offices, which made it difficult to access support. Also, the NIC staff were often overloaded with routine work, and thus providing support was low on their list of priorities. Magnifying this problem was the fact that many of the district offices were located in remote areas, often involving more than a day's travel for the vendors who were based in state capitals. Frequent power failures put additional pressure on the smooth running of the system. Also, the contracts for support were often not clearly spelled out, and vendors could get away with delays. Thus, support was a major problem, with the government infrastructure not adequately equipped to provide required support, and the private sector vendors often being too sales-oriented and not giving adequate importance to long-term support issues.

Summary

The above discussion on the impediments to past computerization efforts helps to illustrate two key issues. One, it highlights the point made earlier, and which was also implied by the Indian scientist referred to in the introduction, that while technical and institutional issues are inextricably inter-connected, the latter seems to supersede technical concerns in determining project outcome. For example, the issue of institutional reforms reflects the changes that are required in the working of district administration to facilitate the introduction of new technology. Such an introduction confronts the user with a new technology and also requires that he or she adopts a different style of computer-based work. While it is relatively easy for the user to learn the technical features of the software (for example, through training), it is much more complex to change institutional conditions wherein computers are not part of the work culture.

The second point to note is that while the issues discussed above come within the context of management information systems (MIS), they are highly relevant to the case of GIS implementation. In fact, these issues assume added significance because of the further complexities inherent in GIS. For example, the need to introduce institutional reforms to enable the adoption of new technologies is greatly magnified because GIS involves a radically different way of working when compared to how government organizations have traditionally carried out their work. For example, the map-based way of conceptualizing and formulating problems is different from the traditional way of looking at issues in the form of lists and tables. Processes of technological transition need to be planned meticulously, because introducing computer supported spatial analysis systems in an environment where even paper maps are not commonly used, is bound to create a number of social and institutional issues, for example the need to create awareness amongst the decision makers of the potential of GIS. These examples indicate that, as in the past, social and institutional conditions create major complexities in introducing new technology into government working. We can thus see a ring of truth in the scientist's comments that government management styles tend to remain unchanging, and impact all forms technological introduction.

It is not only in the context of India and other developing countries that social and institutional constraints impede effective implementation of IS and GIS projects. Case studies documented in the context of many developed countries suggest that broader social and institutional factors constrain project outcomes in a significant way (Masser, Campbell and Craglia, 1996). While the nature and intensity of these impediments may be quite different from those visible in the context of developing countries, they are nevertheless crucial and, in many cases, more important than technical considerations. In the next section, we discuss some technology implementation issues within developed countries, and see how they compare with those of developing countries.

4.2 Key challenges to IS and GIS implementation in developed countries

A persistent theme in the literature on information systems in the developed world is the potential for computer-based information technologies to be used in addressing a variety of social and organizational problems. Yet the literature is replete with reports of unfulfilled potential. Individual case studies reveal a myriad of problems, primarily institutional and social in nature, associated with the implementation of information technologies (Swanson, 1988; Walsham, 1993; Robey and Newman, 1996). The early IS literature of the seventies and the early to mid-1980s, reflected a primary technical focus to understand implementation problems. However, as researchers were confronted with case studies showing that the same technology often has contradictory consequences in different organizations, the focus started to shift towards understanding how social and institutional contexts influence the processes of technology implementation.

The recent GIS literature in developed countries also reflects this increased sensitivity to understanding the organizational issues influencing implementation. For example, Roe, (1991) writes that the capability of GIS technology is not effectively exploited because in most cases organizations over emphasize the technology and pay inadequate attention to how the technology is integrated within the organization.

In the same vein, Campbell (1990) also notes that technical conditions are a necessary but not sufficient condition for the take up of GIS to increase rapidly.

Crosswell (1991) conducted a content analysis of 39 articles to identify the nature of the main obstacles to GIS implementation. In this article, which has been described as a milestone in GIS literature (Craig, 1991), Crosswell noted that organizational and social factors tend to be more significant than technical factors in GIS implementation. Some of the important factors identified in the study included: apathy/fear of change; funding availability and justification; planning and managing support; and data standards and data integration. Levinson (1989) points to some other institutional considerations in the planning of GIS projects, such as whether the system is single or multi-purpose; whether the system involves more than one agency; will the GIS be used to automate line or support functions; who is the system being developed for; and the extent of integration required with organizational functions. Crosswell describes the institutional setting for GIS to be defined by the size of the organization, the extent to which system planning exists, the distribution of responsibility for land related functions amongst agencies, level of management involvement, and the level of inter-agency data sharing.

The need for institutional change to accompany the introduction of GIS technology has been emphasized by many researchers (Lee, 1991; Sommers, 1989). While the technology must fit into the organizational work arrangements, it is equally important for the institution to make significant adaptations to accommodate new technology. These adaptations include aspects of organizational structure, the centralization and decentralization of resources, the mechanisms to facilitate inter-departmental coordination, and the process of transition from manual to GIS-supported processes, which have to be planned in a systematic and phased manner. To address these various issues, it becomes important to appoint a GIS project coordinator, and to give him or her the authority to elicit support from the various stakeholders, in addition to providing an adequate budget. Bringing about these change processes is always difficult to implement, because both people and organizations often prefer a state of inertia to that of constantly responding to different environment demands.

The need to take into account user requirements before starting on any GIS project has been highlighted by many writers because of the high time and cost investment involved in developing systems. Marble and Wilcox (1991), drawing from an old carpenter's adage, advocate the need to "measure twice – cut once," which implies the need for careful design to prevent GIS systems from failing. The GIS designer has responsibility for the complex task of taking into account initial organizational concerns, while also alleviating the fears of staff who feel threatened by the technology. Smith (1989) sees it important to avoid the "grand design" approach wherein everyone's needs are accommodated, because it may be better to do something effectively than not at all. An iterative design process to GIS systems development has been advocated over the classical product-life cycle approach because of the flexibility in the process, and the fact that it allows risks to be more evenly spread out over time (Perquet and Bacastow, 1991).

Commenting on the use of GIS within the context of public sector organizations, Cane (1990) notes that GIS development is always more difficult than anticipated, and that it takes about twice the planned time. While data transfer from regular MIS systems is rather straightforward, the capture of digital data is far more complex and requires significant investments of time and money. The rapid changes taking place in the nature of GIS technology mean that we are always dealing with an unstable product, placing organizations under constant pressure to initiate new changes. Since the use of GIS typically involves a variety of agencies, it is important to establish national and regional level policies on data standards and data exchange. These are normally not in place, making work at the project level quite problematic. Within the same public sector context, Obermeyer (1993) feels there tends to be a professional bias against geographical analysis and communication, which further magnifies the problems in making effective use of GIS. Bamberger (1991) emphasizes the need to obtain an organizational buy-in and adequate funding support before taking on large-scale GIS projects in public sector agencies.

In summary, it can be seen that even in the context of developed countries, a number of different social and institutional conditions influence IS and GIS implementation. These conditions share some similarities with those seen in developing country contexts, even though there may be differences in how they specifically manifest themselves, or in the intensity with which they occur. For example, introducing institutional changes to aid GIS adoption is complex both in developing and developed country contexts. However, an already prevalent culture of computerization in developed country organizations can make the process of initiating social change relatively easier than is the case of developing country settings.

While acknowledging the significance of understanding the role of these factors and conditions in shaping the failure or success of implementation projects, it is also important to be sensitive to the limitations of such knowledge. While a knowledge of them helps to sensitize the GIS project planner to issues of significance, by themselves they do not tell us why these conditions occur and what can be done about them. Understanding these reasons is complex because they are bound up in deeper reasons related to the social context. For example, public sector projects are implemented within the context of the government bureaucracy, and associated with it is a certain organization structure and a style of working. Whether it is a biotechnology or an information technology transfer project, such contextual conditions are given and antecedent to the process, which shape project outcomes in certain ways. For example, the inter-department cooperation required on multi-disciplinary initiatives is quite often difficult to obtain, and this can have an adverse influence on project outcomes.

To try to understand these complex issues of why people act in the way they do, it is useful to first consider how this agency is developed and was articulated in the first place. Managers are simultaneously members of multiple social systems related to family, community, and other religious and intellectual groups. Embedded in these various social systems are different norms and values, which the managers draw upon in developing and expressing their agency with respect to a specific project. So, our view is that in examining the challenges in project management, we need to understand the broader social context within which these challenges are shaped and expressed. Without such an understanding it is difficult to reach the core of the issue which is "why do these problems occur in the first place?" Management implications, based on an incomplete understanding of the problem, tend to be superficial and ineffective. For example, an implication such as "the need to encourage inter-departmental data sharing" tends to be rather meaningless if we do not understand why sharing does not occur in the first place; what can be done about these more fundamental reasons; and whether anything can be done about it at all. If the answer to the latter is no, then it raises serious questions about the appropriateness of any new technology within the particular developing country context.

Another important dimension, while examining challenges in implementing GIS concerns the characteristics of the technology itself. Specifically, it is important to examine what are the fundamental assumptions about the nature of work that are inscribed in the technology, and analyze how they relate to existing values about work and social life in the context in which the technology is being introduced. GIS technology is a product of the developed world, and it embodies certain assumptions about how people view work and social life in the West. These are often in direct conflict with those existing in developing countries. An example of such a deeply held value relates to time, with the attitudes towards it being quite different in India as compared to some Western countries. While in the West, time is seen as a commodity, something which is quantifiable in money terms, the same is not true in India. Such differences have important implications in the context of project management; for example, time delays are not seen as being as serious in India as they would be in the West. In the next section, some of the core assumptions and beliefs that are inscribed in GIS technology are discussed, and how they relate to social attitudes in India.

4.3 Assumptions and interests inscribed in GIS technology

GIS technology represents a body of theoretical and practical knowledge that designers draw upon to create applications that supports the storage, analysis and representation of electronic maps. To understand the applicability of such systems, it is important to ask the question "what kind of rules govern the development of this technology?" This question is historically and culturally specific, since the rules of cartography, map making, and map usage varies in different societies. GIS technology, a product of the Western world, finds its historical roots in the science of cartography and map making. This science, which is developed within a positivistic epistemology, embodies assumptions that objects in the real world being mapped are real and objective, and they enjoy an existence independent of the cartographer (Harley, 1992).

The positivistic assumptions underlying GIS technology, like many other computer systems, reflect the broader societal interests and attitudes of the Western developers.

In Western society, explicit data and "rational" decision making processes are seen as the legitimate bases for planning and management. By contrast, these are not widely accepted norms in India, and value is placed on intuitive approaches and goals such as the maintenance of personal relations. It is possible to over emphasize the above divergence between Western and Indian societies, since the decision makers of the former also value intuition and personal relations, and some Indian decision makers are comfortable with explicitly rational styles; nevertheless, there is a marked contrast in the dominant underlying attitudes in this area.

A second divergence between Indian conceptualizations and those of the West, which is of particular relevance to GIS technology, concerns the existence of a map-based culture. Typical Indians will rarely, if ever, use maps in their daily life; for example while travelling, and even those people whose work is closely linked with spatial issues, such as district-level administrators, tend to use maps infrequently. In contrast, children in Western societies are brought up with maps, and the explicit display of spatially-related data is a common feature of daily life. The map-based culture of Western societies is taken for granted by Western developers of GIS technology, and the assumption that users will be comfortable with maps is inscribed into the technology. When GIS technology is "transferred" to India, these implicit assumptions embedded in the technology can prove to be highly problematic.

A final example of the Western values in GIS technology concerns the embedded assumption of coordinated action. The multi-layered nature of GIS systems, where data on different characteristics are brought together as overlays in the same map-based system, assumes that management issues will be addressed in a coordinated way. For example, the management of land resources in any country can be thought to involve a range of disciplinary specialisms, including agriculture, forestry, wildlife management, human settlements, and many others. In India, however, these issues have typically been handled in relative isolation by the different agencies involved. Over 20 different government agencies operate at the district level in India, each dealing with a particular functional area. Again, it is possible to over emphasize the divergence between Western societies and India in this regard, since uncoordinated action is certainly encountered in Western administrative practice, and different Indian government agencies do interact to some extent; but it is undoubtedly the case that district level management in India has tended to be relatively uncoordinated, which contrasts with the cultural attitudes to co-ordination that are inscribed in GIS.

In the above discussion, some of the core assumptions and beliefs that are inscribed in GIS technology have been highlighted, and some of the tensions it creates with respect to prevailing attitudes in Indian society, such as the notions of rationality, coordination and spatial thinking, have been examined. This analysis is further expanded by examining such questions as "why do such attitudes towards rationality and co-ordination exist in Indian society in general, and in Indian managers in particular?" The analysis is thus situated within a wider historical and socio-cultural perspective.

4.4 Nature of management attitudes in India

In any given context, managers are simultaneously members of multiple and overlapping social groups, for example family, community and organization. Management attitudes are shaped significantly by the different sets of norms and values that are emphasized by these groups, which the manager draws upon in the process of creating and legitimizing his or her agency. The authors apply this conceptual schema to the present case, by identifying "national", "communal", "religious" and "intellectual" social systems as significantly shaping the formation and expression of managerial attitudes in India (Sahay and Walsham, 1997). The different values and norms that are emphasized by these social systems, and the nature of their influences in shaping a managerial agency are then examined.

4.4.1 National systems

Historically, the ties between the individual and the State in India have been weak and unimportant, primarily due to the presence of suchpowerful intermediate groups as the family, caste and village, which have catered to individual needs (Saha, 1993). Nandi (1990) describes Indian society to be organized more around its culture than around its politics. While membership of these traditional groups was used to secure favours from the Government, national politics was an independent world with its own interests and allegiances, and with minimal reference to public concerns. Saha (1993) describes India as a remarkable phenomenon where the State and society coexist apart from, and to some degree independent of, each other as distinct entities.

The adoption of socialism in India has been described as one aspect of the overall endeavour to preserve the Hindu social organization, attitudes and perspective (Saha, 1992). The Hindu desires of contentment, absence of desire and stability oppose the dynamic striving for success and unlimited consumption, which capitalist systems emphasize. Historically, socialism has taken the form of incipient nationalism with a negative reaction to foreign investors. Socialism is compatible with the Indian tradition, which values philanthropy, although charity in India is often valued more because it confers merit to the dispenser rather than for its role in alleviating the distress of others.

The twin themes of developing a "socialistic pattern of society" and the attainment of "self-reliance" have dominated the nature of economic thinking in post-independence India. The task of economic welfare has rested primarily with the State, leading to an establishment of State planning paraphernalia, which has primarily benefited the bureaucracy. Businessmen form pluralistic relationships with administrators, appealing to them on the basis of kinship, personal friendships and sometimes monetary payments. These relationships create compulsions within the administration which are quite removed from the criteria of rationality. Jain and Dwivedi (1990) describe the Indian bureaucracy to suffer from strange paradoxes, where a rigid adherence to procedure combines with a ready susceptibility to personal pressure and intervention.

4.4.2 Communal systems

Traditionally, Indian society has been stratified on functional lines, with caste being the basic structural feature, a division which has also derived its sanctions in the religious literature. Hinduism, which is both a religious and social system, emphasizes a framework that embodies caste rituals, and these have governed the lives of Indians for hundreds of years. The system of stratification has also been reinforced by the governmental policy towards reservation in jobs and university admissions for people belonging to "backward" castes. While some of the old rigidities are eroding, particularly in the cities, the presence of caste is still felt in virtually all domains of Indian economic activity; for example, modern entrepreneurs are still mainly drawn from the trading castes. It seems unlikely that a social structure historically organizing the political, economic and ritual life of people can be expunged easily.

The caste system has contributed to the growth of some dominant value systems related to functionality, status, power and relationships with other people. Naipaul (1964) is critical of this functionality, a value which he says is even sanctioned by the Bhagavad Gita, which says that "To die in one's duty is life: to live in another's is death." Naipaul describes this functionality in different aspects of Indian social life "the man who makes the dingy bed in the hotel room will be affronted if he is asked to sweep the gritty floor;...the clerk will not bring you a glass of water if you faint;...study these four men washing down the steps of this unpalatable Bombay hotel. The first pours the water from the bucket, the second scratches the tiles with a twig broom, the third uses a rag to slop the dirty floors down the steps into another bucket, which is held by the fourth." Naipaul describes every man in India as an island, tied to his individual function, and having his private contract with God.

Social relations tend to be hierarchical, and people are status conscious, finding it easier to work in superior-subordinate relationships that are personalized rather than equal on contractual terms (Sinha, 1988). Kakar (1978) observes that an Indian is less sensitive to the goals of work and productivity that are external to a relationship, and more to the unfolding of emotional affinity. The power play in organizations tends to be very personal wherein those close to the superior are bestowed with favours, while those who do not yield tend to be distanced and discriminated (Sinha, 1988). Roland (1984) defines this relationship as a form of "affective reciprocity" which is characterized by giving; the superior is seen to be "kind" and the subordinates "submissive." The preference for accommodation over confrontation leads to few open conflicts, but can result in a "cold war" state.

4.4.3 Religious systems

To many, India appears as a confusing tangle of myths, and many different gods and goddesses worshipped in countless forms. Radhakrishnan (1993) writes that beneath the surface level expression of Indian faith can be found a system of unifying beliefs that has guided the lives of ordinary Indian families for generations. Religion is a specific attitude to the self where intellect is subordinated to intuition, dogma to experience, and outward experience to inward realization. Interpretation of religious texts, for example the Gita and the Vedas, are seen as the primary sources for the enrichment of thought and life.

Some authors (for example Saha, 1992) have argued that the basic notion of Hindu religious texts is one of extreme pessimism, based on the idea that everything is temporary, and that evil is inescapable; for example, the belief that tamas (evil) dominates in the current dark age. Contributing to this outlook is the powerful influence of mysticism, which puts forth the belief that all perceptual phenomena are illusory, and that reality actually lies behind all appearances. The impact of this thinking is found in various spheres of social life, for example in the conceptualization of duration (Saha, 1990; Nakamura, 1964). Classical Indian literature shows a contemptuous rejection of common-sense time, and little efforts were made by scholars to quantify duration and chronology (Saha, 1990; De Riencourt, 1960). Indian managers tend to easily accept uncertainty, to undervalue time, and to take each day as it comes (Singh, 1990).

Dharma refers to the laws that detail guidelines for proper personal conduct, and transgressions to Dharma invite consequences as provided by Karma, the law of cause and effect. Karma can be viewed as limited to some extent, because its efforts can be transgressed, for example through prayers and sacrifice. The individual, the holder of metaphysical knowledge, is unconcerned about the consequences of evil around him, and also immune to the consequences of his own evil deeds. Saha (1992) quotes from the Upanishads: "As water adheres not to the leaf of the lotus flower, so evil action adheres not to him who knows this, that the self is Brahma." The possession of metaphysical insights or devotion to a deity cancels past misdemeanors and often this is interpreted by the knower or worshipper as a sanction to continue doing evil deeds.

4.4.4 Domestic systems

The domestic system is a dominant structure in the Indian context, based on the joint or extended family concept and reinforced by the similarities people have with each other in terms of caste, language and kinship. The basic source stems from paternal authority, and rules of paternalism or the authoritative superiors tend to govern social and organizational activity (Jain and Dwivedi, 1990). The rules of conduct of different members in this joint family are firmly defined; for example, the eldest son is expected to take care of his parents when they become old.

Change in Indian families is not actively sought after, and the domestic system contrasts with Western family socialization, which values independence, speaking out, direct communication and relatively unrestrained expressions of resentment and anger. A criticism against the Indian joint family system is that it creates excessive paternalism, and the head of family induces "infantilization" among other adult members. However, Chakraborty (1985) argues that this system also has positive aspects, which are often ignored: the development of values and self-denial and fortitude of the head who keeps the show going; and the sense of sharing that is fostered among the children living in the joint family.

Indians often view work as a duty to their families (Sinha and Sinha, 1990). There is a preference for personalized, family oriented relationships, which is manifest in social networking based on the consideration of "own" and "others", where the members of the in-group are typically one's own family and personal alliances (Kumar and Singh. 1976). Family becomes one of the strongest in-groups and "others" are normally distanced. A lot of time and energy is taken up in developing personal networks, which often tend to dilute many of the formal channels of communications in organizations. In general, Indians tends to be collectivist, and people are invariably seen to be linked to the rest of the social body by a network of highly diversified ties. This embeddedness, however, rarely goes beyond one's family, caste, kinship, linguistic and religious group (Sinh, 1988).

4.4.5 Intellectual systems

A dominant and paradoxical feature of Indian intellectual thinking has been the supremacy accorded to non-rational forms of reasoning (Saha, 1992). Even though the principals of rational analysis were known in India in ancient times, cultural ideology has emphasized non-rational forms of reasoning such as those dealing with karma, rebirth, and the belief that reason is unable to discover the truth. Divine forces often supersede logic, and texts on mathematical and physical sciences begin with passages acknowledging the supremacy of God. The cultural disregard for reality and logic influences the average Indian's mode of thinking, reflecting subjective and emotional biases. The typical Indian locates the idea (or truth) to be residing within himself, occurring as a form of revelation in an unconscious way.

Despite proficiency in the non-physical disciplines of mathematics, and sophistication in abstract metaphysical thinking, India has not achieved comparable levels of technological development (Saha, 1992). Indian society is noted at the same time for the originality of many of its conceptions and experimental processes, and for extreme unreliability in carrying out the work itself. Haldane (1965) describes many Indian scientists to show little pride in their professions even though they are proud of their salaries and positions. There is an ambivalence towards technology, with premier research institutes like the CSIR (Council for Scientific and Industrial Research) paying more attention to the development of technology rather than to its application (Valluri, 1993). Indian scientists tend to avoid physical work, and prefer to acquire management qualifications to obtain status enhancing office jobs rather than working on the shop floor.

Managerial thinking in India is often characterized by a clash of cultures, because many managers have been trained in the West or in Indian colleges that have adopted Western education models (Jain, 1991; Garg and Parikh, 1988). Managers tend to internalize two sets of values: those drawn from the traditional moorings of the family and community, particularly values related to affiliation, security, dependency and social obligations; and those drawn from modern education, professional training and the imperatives of modern technology, such as those relating to personal growth, efficiency and collaborative work. Such tensions between the western and Indian views of the world often creates a fragmented identity of conflicting values and behavioral orientations with the emotive element straining with other rational considerations, creating confusion in roles and task structures.

Summary

In the preceding discussion, we have described a conceptual schema to understand the nature of managerial agency. This schema includes a description of five different types of social systems of which managers are typically members within the Indian context, and we have examined the various norms and values embedded within these systems that contribute to shape managerial agency. We apply this conceptual scheme, in section

4.5, to understand the nature of management action with respect to the GIS projects under study. In traditional societies as India, where family, social and communal systems are extremely rigid and powerful, the norms and values are difficult to change and remain relatively invariant. Managers are thus subjected to social and institutional influences when they implement GIS projects today, which are quite similar to those felt when computer projects were being initiated five years ago. In making this statement, the authors acknowledge the danger of being seen to ignore changes occurring in Indian society, for example, as a result of pressures of globalization and modernization. The authors thus qualify their statement by adding that, while changes are taking place in India, there is much inertia in traditional governmental organizations, and in society generally.

4.5 Social and institutional challenges in GIS project management

If we take a higher-level view of the various GIS initiatives in India, and specifically with respect to the MoEF and other national GIS projects, two issues stand out: the major obstacle to project implementation seemed to arise from the gap between the users of the technology and its developers. The potential users in all the GIS initiatives discussed in Chapter 3 are the district administration. However, which specific agency within the district would be the system custodian was not clear in most cases. The developers in the various projects included: the eight scientific institutions in the MoEF project; the NIC computer personnel in the NIC case; the remote sensing technologists in the case of DoS; and the scientists in the DST initiative. The technology developers in most cases were not seen to seriously engage the users in the process of developing GIS applications and as a result the users felt that the applications did not realistically reflect the field-level situation. Also, the focus of the scientists was primarily on technical development, and adequate importance was not paid on transferring systems and know-how from their laboratories to the user offices. As a result, the developed systems were primarily viewed as academic and scientific exercises with marginal field-level relevance.

Earlier discussion on management attitudes in India emphasizes the point that implementation problems, such as those dealing with the technologist-user gap, cannot be addressed with superficial solutions such as saying there is a need for closer cooperation between the two groups. Such problems are rooted in much deeper and complex social influences of the type discussed earlier in the chapter. It is thus vital to examine these deeper causal influences in the relative failure of the technology implementation projects.

More specifically, the authors examine two sets of attitudes which they feel contribute significantly to this technologist-user gap. The first concerns the scientists' attitudes of treating technology as an end in itself rather than as a means to solve an application; for example, wasteland development in the case of the MoEF projects. The second attitude concerns the notion that the methods the scientists employ are objective, and thus superior to the non-scientific methods used by the users. In the next section both these attitudes are discussed in considerable detail; what is the nature of this attitude, and how is it shaped by larger social and institutional conditions?

4.5.1 Technology – means or end?

4.5.1.1 The nature of the attitude

An attitude of the developers that seems to dominate many of the GIS initiatives in India is that the technology is treated as an end in itself, rather than a means to solve an application problem. Since the various agencies are at the relatively initial stages of experimenting with the technology, a primary focus of the scientists is on technical development, viewing the project as an opportunity to be exposed to the state-of-art in mapping and computing technology. This view is expressed in the nature of their technological preferences, including the purchase of up-to-date hardware and software, which is seen as crucial in developing a modern R&D environment. A primary focus of many of the agencies is also on actually building the GIS software from scratch, and thus a lot of time and financial resources are spent on the technology *per se*, rather than on understanding the applications the GIS is supposed to support.

In the various projects, one finds high levels of technical excellence and ingenuity in conceptualization, and an interesting diversity in approaches being adopted by the various group leaders. The institutions involved experimented with different hardware, software and methodologies in the formulation and implementation of the projects; for example, some projects adopted a watershed as the unit of analysis, while others used a village as the basis. Paradoxically, despite these high levels of technical excellence, the applications seem to only marginally reflect the users' decision needs; for example, how forest officers currently make decisions regarding wasteland management. Also, as noted in Chapter 3, many of the software implementers are first and foremost remote sensing technologists, and they tend to give primary importance to using data generated using remote technology.

The belief in the superiority of the scientific method resulted in some of the scientists de-emphasizing the need for users to be involved in the application development process. Problems arising out of the lack of user involvement in the application development process are often further reinforced by the reluctance of the developers to take responsibility for transferring the systems from their laboratories to the user offices. Some of the scientists do not seem to see the task of transferring technology as their responsibility, and give the impression that they preferred not to work outside the domain of their laboratories. The lack of user involvement in the process and the reluctance of the scientists to take primary responsibility for the transfer process, contribute to the development of systems that are often divorced from local reality, and which tend to remain in the laboratories at the end of the project, rather than in the user office. There is thus the sense that technology development becomes an end in itself, rather than a means to solve a local problem. We examine some of the social and institutional forces shaping such attitudes.

4.5.1.2 Social and institutional forces shaping such attitudes

The objective of the wastelands project of identification and reclamation of degraded land, as a means of poverty alleviation, reflects the national themes of socialism and technological self-reliance. The Indian Government's post-Independence emphasis on attaining technological self-reliance, to some extent contributes to the primary preoccupation with technology *per se*, and the associated tension with the application and social nature of the project. These tensions often lead to conflicts between the international aid agencies and the Indian ministry officials. This is typical of the relationships between the Government and foreign agencies, one which is often characterized by mistrust, with the latter being accused of not parting with latest technology, and the former being told that they are looking at the project primarily for the acquisition of technology and not so much for its application.

The sense of indifference, which is historically seen to characterize the relationship between the Indian State and people, also contributes to the development of attitudes which seem to be in tension with expressed project goals. For example, in the MoEF project, the involvement of the wasteland (farmers or forest departments), who were the project beneficiaries, was not considered necessary in the process by which the scientists develop models to provide the users with land-use recommendations. The neglect of the end also reflects the Hindu view towards philanthropy, where the dispenser – in this case the institutions and their technology – is considered more important than the cause – in this case, wasteland development and poverty alleviation.

The emphasis of form over content, a characteristic of Indian government projects, and also sometimes an integral element of rituals in Hindu religion, also contributes to understanding this attitude with respect to technology. In the MoEF case, for example, despite developing an elaborate project paraphernalia involving reports and presentations to the Secretary, there seemed to be an absence of actual accountability on project monitoring; for example, no firm time deadlines were set or mechanisms established for project evaluation and feedback. The disregard for monitoring time deadlines and for documenting project activities, such as the meetings between developers and users, can also be seen to reflect the often indifferent attitudes of Indians towards time and to the documentation of history (Saha, 1990).

Functionality, a value fundamental to the Indian caste structure, and which has historically been legitimized by religious texts and the national bureaucracy, also contributes to technology being treated more as an end rather than a means. This view of technology is also supported by the Indian intellectual system, which tends to give primacy to knowledge development rather than its application. Many of the technologists view their institutional mandates to be limited to the function of developing technology and not its transfer to the users. The very nature of a GIS project necessitates the involvement of a number of agencies to support the application systems. For example, wasteland management decisions requires data on soils, population, rainfall, human population and forests, which are typically under the control of different departments. Thus, for the project to effectively address the management problem, it is imperative that these departments work together in an integrated manner. However, a narrow view of functionality, both in the nature of the working of these organizations and in the thinking of individuals impedes this form of integration, and leads to tension between what is required and the nature of management action.

To summarize, the authors have discussed how some aspects of the social and institutional structure contribute to the development of attitudes towards technology that often impede effective implementation of GIS projects. A scientist is, at the same time, a member of various social systems, including national, religious, communal and intellectual. For example, the scientist as a member of the national bureaucracy identifies with national themes of socialism and technological self-reliance. However, such an identification can create a tension with the beliefs that are embedded within the intellectual system of which he/she is also a member, for example the intellectual need to be associated with modern, state-of-the-art technology being developed in North America. This tension contributes to managerial agency that reflects an ambivalent attitude to technology; and despite technical excellence, the decision models developed show marginal relevance to the perceived practical reality.

4.5.2 Notion of the objectivity and superiority of science

4.5.2.1 The nature of the attitude

In the projects studied, there often seemed to be a belief among the technologists that the methods they adopted for project management were scientific, and thus objective and superior. The leaders of a majority of the projects were experts with primarily remote sensing or computer science backgrounds – disciplines traditionally regarded as being highly scientific and objective. These scientists would typically have received their education and training in prestigious technical institutions in India, and sometimes abroad. As a rule these experts were drawn from the central government cadre, which is highly valued, and selection to it is sought after by a large pool of qualified scientific manpower in the country. In contrast, the users were generally drawn from the social sciences stream, and educated in less prestigious institutions when compared to the technologists.

The day-to-day work of the scientists involved the development of "objective" mathematical models and algorithms, which were thought by them to be computationally superior to the previously used manual methods and, in some cases, to human beings. These models for the optimal estimation of land-use parameters involve the adoption of decision making criteria which, while representing theoretically optimal practices, or soil conservation methods, are quite different from those that are actually used in practice. Aspects of model elegance seemed to be emphasized; for example, the use of pop-down menus and 3-D pictures over simpler and more realistic representations of user decision making processes.

The scientific environment of the laboratories within which these GIS applications were developed also contributed towards reinforcing the notion of methods objectivity. The institutions involved in the GIS development work are prestigious centres of national scientific research, having established credibility, for example in the domain of informatics and space research. Since GIS technology enables the application of informatics for the management of natural resources, and involves the utilization of remotely sensed data, these institutions were given the primary responsibility for the development of GIS applications. The modern, state-of-the-art image surrounding GIS technology, coupled with the high-tech, R&D profile of the institutions, and their accepted credibility as centres of technological and research excellence, also contributed to the notion that the methods adopted were scientific, objective and superior.

In contrast, the methods employed by the users were generally seen to be non-scientific and non-professional. The use of maps and computers are still not an integral part of the everyday work processes, with users having very limited direct access to computing. There tends to be a belief among scientists that the district administration shows little individual initiative, being basically involved in catering to the personal whims and fancies of local politicians and bureaucrats rather than in scientific and professional activities. The frequent transfers of District Magistrates, who are often supportive of technology initiatives, leaves the scientist to deal with the lower level staff, who often do not have the responsibility to take decisions, or the motivation to learn a new technology. We now consider some of the social and institutional forces influencing these attitudes.

4.5.2.2 Social and institutional forces shaping such attitudes

The national thrust on technological and scientific self-reliance has contributed to science and technology taking on an exalted status in post-Independent India, and the establishment of various technological education and research institutions, which over time have built up prestige and credibility. The institutions involved in the development of GIS applications are examples of such prestigious national research centres, and scientists working in these institutions also take on this superior status.

The caste system in India gives supremacy to the holder of knowledge, a value which is reinforced through religious texts. Scientists, in this case, are the holders of GIS-related knowledge; knowledge that is quite sophisticated, acquiring almost a divine-like status. The holders of this knowledge are seen to be superior to the users in the district who are not considered to be technologically sophisticated. The methods adopted for project management, for example the de-emphasis of knowledge transfer to the users, coupled with the lack of GIS-related infrastructure in the districts, reinforces the processes whereby the GIS knowledge remains limited to the more exclusive scientific community.

Functionality, a value which is fundamental to the communal system, also contributes to reinforce the notion that the scientific method is superior to the non-scientific method of the user, and magnifies the division between the two groups. The very nature of GIS projects requires close and extended interaction between the developers and users. Attempts by the central coordinating body to develop such closer cooperation, for example by issuing project directives, tend to be largely ignored, because of the functionalist view taken by the scientists that their tasks only include scientific activities, for example model development, and exclude non-scientific tasks such as interacting with users.

The Indian intellectual system contributes to the notion of superiority of science and technology over the social sciences, a belief which is also strongly reinforced by the domestic system. The scientists have typically been educated within this scientific tradition, and they internalize some of these values and norms of the superiority and objectivity of science, and this finds expression in the actions they take with respect to the project. The scientists see themselves to have a higher status than that of the users. For example, a user remarked that in meetings at the district level, when he had to answer questions posed by the local administration, he felt humiliated, since this involved a lowering of his status that had been acquired through his scientific knowledge and his employment in a prestigious scientific institution. He felt more comfortable to be answering questions to select audiences in international scientific conferences.

Paternalism, a value fundamental to the Indian domestic system, emphasizes the superiority both in status and knowledge of the parent over the child. In this study, the relationship between the scientists and the users, where the former see themselves to be superior in knowledge and status to the user, has some parallels to the Indian parent-child relationship seen in the domestic system. The scientists frequently mentioned the need for constant "hand-holding" of the users so they could come to terms with GIS. Scientist-user interaction tends to be hierarchical in nature; for example, scientists tend not to give the system demonstrations themselves, but direct a junior staff how to do it in their stead.

4.6 Summary

In the analysis presented above, we have taken the view that the problems of GIS project management in India are grounded in deep-rooted historical, social and institutional issues, which cannot be addressed by simplistic managerial remedies. An important aspect of our analysis concerns the gap that exists between the technology developers and potential users, and how this relates to much broader aspects of Indian society and culture. This gap results in systems being developed that are not seen to be relevant by the users, and which remain as academic and pilot exercises with no real operational use in local administration.

To try and address these problems, the authors feel it is important to understand what are the more fundamental attitudes of the agents shaping this divide, and why these attitudes exist in the first place. Two sets of managerial attitudes relating to how technology and science is viewed in India, which are believed to contribute significantly to creating this divide,. Have been identified and discussed. Various social and institutional influences which helped to shape and reinforce such attitudes have been examined. The influences are varied, not just stemming from the actors' professional affiliation, but also from the various social systems, i.e. national, religious, intellectual, domestic and communal, of which the actors are also members. The actors draw upon the different and often conflicting norms and values embedded in these various overlapping systems to create, express and legitimize their actions with respect to specific GIS projects.

The authors' conceptual scheme on the nature of Indian societ, which was first described in this chapter and then applied in the context of the Indian case, has two broad sets of implications. Firstly, it can help towards understanding technology management issues in other contexts with appropriate modifications. This can be done by initially identifying different social and institutional conditions present in a particular context; and secondly, by examining the manner in which they influence managerial agency.

This conceptual scheme is applied in Chapter 5 to the case of Malaysia, wherein some of the social and institutional challenges to implementing GIS in the Malaysian Government are discussed. A second implication of the conceptual scheme is that it can help develop a variety of appropriate recommendations for GIS project management. To implement projects more effectively, managers can attempt to develop strategies that shield them from, or change, some of these broader influences – or at least try to create solutions that are compatible within the existing context. This approach is used in Chapter 6 to develop implications for GIS project management in developing countries.

CHAPTER 5

GIS IN MALAYSIA: THE IMPLEMENTATION CHALLENGE

In this chapter, some challenges in implementing GIS in Malysia are discussed and then compared with what is seen to be happening in India. This discussion and analysis is based primarily upon empirical work carried out during a three-year period (1993-95) when the authors visited Malaysia three times, once in each of the three years. During these three visits, a total of 60 people representing a wide cross-section of organizations and management levels were interviewed. The organizations included government departments involved in implementing GIS projects, research and scientific institutions which were attempting to establish the technical feasibility of GIS for specialized applications, government policy makers who were expected to be users of the GIS outputs, and a number of facilitating agencies such as international bodies (UNDP), vendors and university researchers who were also consulting to theGgovernment.

More specifically, the organizations included: eight government departments/ministries – forestry, environment, agriculture, mining, land, primary industries, town and country planning and survey and mapping; four scientific institutions, including two dealing with forestry R&D projects, one with remote sensing, and the other with agricultural research; GIS researchers from three national universities who were also consulting to the Government; and four agencies attached to the Prime Minister's office, which dealt with economic planning, training, international aid and public-sector computerization. Two GIS vendors were visited who were actively involved in marketing and supporting GIS technology within government agencies. In addition to these organizations, which were all located in Kaula Lampur, two district-level offices outside the capital city were visited to examine the impact of GIS upon local governmental planning processes. Within these organizations, interviews were carried out with people directly involved with GIS in various capacities, including users, developers, policy makers and researchers. These interviews provide a broad overview of different GIS initiatives in Malaysia and the challenges being experienced in the conceptualization and implementation of various projects.

The remainder of the chapter is organized as follows: section 5.1 describes some aspects of the Malaysian context and discusses some of the Government's past experience with computerization initiatives. This provides the backdrop to examine, in section 5.2, the initiation and evolution of GIS within the Malaysian public sector, and the current status with respect to the use of the technology. This is followed by a description, in section 5.3, of some specific GIS initiatives within the Malaysian Government. In section 5.4, some of the challenges inherent in using GIS effectively in Malaysia are taken up. In making this analysis, the conceptual scheme has been drawn upon as presented in Chapter 4, which highlights the need for sensitivity to the broader context within which GIS implementation takes place. The underlying concepts of that scheme have been applied to make sense of the Malaysian experience. Finally, in section 5.5, a comparison is made of Malaysia and India with respect to some GIS implementation challenges.

5.1 The Malaysian context

Malaysia is a country of roughly 19 million people living in 13 states and two federal territories that span an area of 330,000 square kms. Malaysia provides a unique situation of co-existing people from a variety of racial backgrounds, although the Malays have been the dominant majority group controlling the political system since Independence in the early 1960s. Malaysia has been experiencing significant economic growth over recent years, and the Prime Minister has ambitious plans for advancing the country socially and economically in the future. Evidence of this economic prosperity is found in Kuala Lumpur, the capital, a city landscaped with high-rise buildings, and which acts as the nodal point to connect the country with the rest of the world. Rapid economic development has made land an extremely premium commodity in Malaysia. There are a number of categories of reserved land in the country, and with rapid changes in land-use patterns in the country, these categories are constantly increasing (Anderson, 1994).

Also contributing to this pressure on land is the dependence of the Malaysian economic system, which is largely based on a model of free enterprise and on the development of primary products, such as forestry, natural gas, palm oil and rubber. The importance of primary products to the national economy has made rural and agricultural development a critical element of Malaysian public policy. For example, the State of Sabah generates more than 50 per cent of its income and 10 per cent of its jobs from forests that cover 60 per cent of its land. Hastings (1996) quotes a Sabah Forestry Department official as stating their policy as being "to boost forest-based industries and revenue while preserving the stability of the fragile ecosystems."

The early period following Malaysian Independence was characterized by a strong tendency to centralize rural development and policy making. The first two Malay five-year plans (1956-65) gave priority to the betterment of the poor, with primary emphasis on the development of physical infrastructure. The planning function, despite claiming to be decentralized, was rather centralized, and even the State and district development officers who disbursed funds for local development projects were federal functionaries. While the initial plans concentrated on infrastructure development, later plans had as their primary objective the improvement of the rural poor, and the enhancement of their absolute income rather than a focus on wealth redistribution. While the incidence of absolute poverty has generally declined, a phenomenon that has emerged is the existence of pockets of poor groups within society. For example, in certain states, such as Terengganu, the incidence of poverty was about 30 per cent in 1990. So, while absolute poverty has considerably declined, relative poverty in terms of income differentials is pronounced and expected to grow (Madon, 1996).

In recent years, the pressures of industrialization and technological change are very visible in nearly all walks of Malaysian life. The public sector has also been caught up in the throes of change arising out of the need to increase productivity through the application of Western management models and new information technologies to support their work-processes. GIS is one of these new technologies the Malaysian Government is experimenting with in an active manner for a variety of applications, including natural resources and land management, and infrastructure development relating to highways and telecommunications. In the next section, the initiation and evolution of GIS technology within the context of the Malaysian public sector is discussed.

5.2 Initiation and evolution of GIS in Malaysia

Growth in information technology has been accorded an extremely high priority by the Malaysian Government in their quest to achieve the ambitious "2020 vision." This vision reflects national aspirations, under the personal and charismatic leadership of the Malaysian Prime Minister, Dr. Mahathir bin Mohamad, to become a "developed country" by the year 2020. A central component of this vision, which has been inspired by Daniel Bell's description of an information society, is to transform Malaysia into an "information-rich" country, wherein information flows will be transparent and accessible to all citizens. To help implement this vision, the Malaysian Government established a central committee in 1992 to formulate a national strategy on IT. The committee elicited proposals on different policy options for the Government, institution building and other programmes. Various expert groups were established as a part of the strategy to prepare specific proposals in critical areas including IT development and management, human resource development, telecommunication and data services. At that time, GIS was not included as a part of the formal national IT strategy.

This 2020 vision is central to understanding IT development in the country, because it provides a framework within which the Government can develop and implement national IT strategies, and it also helps to legitimize decisions enabling large amounts of investments in IT infrastructure development, including in GIS. For example, a brochure announcing a recent international IT-related symposium in Kuala Lumpur stated that "There is a widely acknowledged need in Malaysia to adopt computer and communications technology to accelerate development. Effective use of IT to support land and resource management can help ensure the best use of the country's finite land resources ... accelerate infrastructure development to meet the goals of vision 2020" (NALIS 1994). Similarly, the mission statement of the Forestry Department states the need to "achieve superiority in information management as the vehicle to achieving Vision 2020" (Samad, 1994).

The 1990s in Malaysia have been characterized by dramatic increases in governmental spending on public sector computerization projects, as reflected by a number of high-profile IT-related developments. The importance of IT to Malaysian development can be gauged from the fact that the country's Prime Minister and Deputy Prime Minister are the Chair and Deputy Chair of the national IT council. The fact that the Prime Minister and his family are using the internet also puts pressure on other government officials to become more computer literate. There is a dramatic increase in IT spending, which is indicated by the fact that governmental expenditure on computerization projects increased from 47.8 million RM (about US$ 19 million) in 1987, to 299.4 million RM (about US$ 125 million) in 1994 (MAMPU, 1995). Many different sectors, including trade and industry, security, administration and finance, land and agriculture, education and social support, and state and local government, have taken on large-scale computerization projects within their specific departments. An example of a high profile and publicly visible project was the setting up of the Civil Services Link (CSL), which was personally inaugurated by the Prime Minister in August 1994. The CSL, which typifies the nation's quest for an "information society," is aimed to make government-related information freely available to the public over a computerized network. An ordinary man or woman is now expected to be able to walk into a public space, such as the lobby of a hotel or a post-office, and use a publicly available computer terminal to access government information related, for example, to housing loans.

While there were pockets of mapping related activities taking place within some agencies as the Department of Agriculture in the early 1980s, larger-scale and full-blown GIS initiatives within the public sector only began in the early to mid-1990s. This is relatively later than some of the other countries of the region, such as India, which began experimenting with GIS projects in the mid to end-1980s. While earlier GIS developments in Malaysia were largely oriented towards environment, land and natural resources management projects being implemented through the public sector, we find that more recently a number of projects have been initiated for purposes of urban management, telecommunications infrastructure development and highway planning through private sector organizations. An example of these developments is the recently commissioned high profile project for the development of the Fuzhou-Quanzhou Expressway by the consulting company Kinta Kellas Plc, which has used GIS extensively in the conceptualization and design of the project (Ahmad, 1994). These shifts in the nature of applications being developed, and the increasing role of the private sector, reflect broader changes taking in place in Malaysian society relating to growing urbanization and the associated pressures on land, and the increasing affluence of certain segments of the population. These developments also reflect the national government's desire to transform Kuala Lumpur into an international hub, which would help intensify the interconnections between global events and day-to-day Malaysian social life.

While major GIS activities within the public sector began in the 1990s, a number of significant developments took place in the 1980s which have made this possible. A significant impetus for these current GIS-related developments has been the Malaysian Government's plans, dating from the mid-1980s, for the establishment of a national Land Data Bank, and the efforts of the Standards and Industrial Research Institute of Malaysia (SIRIM) to publish standards for the exchange of digital data (Visvalingam, 1990). In September 1990, the Malaysian Government jointly hosted a seminar with the United Nations to examine the role of GIS in regional planning. This seminar provided the stimulus to establish the Malaysian Centre for Remote Sensing (MACERS), a high-profile scientific research centre, by the Ministry of Science and Technology, and at that point a need for a similar centre for GIS was also established. The Malaysian Institute for Public Administration, called INTAN, which is responsible for the continuing in-house training of civil servants, also organized a workshop to discuss the role of GIS in enabling decision support applications within the public sector.

In the early 1980s, some mapping related systems for public sector application were also established. One of the earliest systems was called NIDAS (National Integrated Data System), established jointly by the Penang Land Office and the Centre of Policies Research at the University of Science in Penang. The NIDAS system was developed by the university to help demonstrate the technical and economic feasibility of integrated data systems, which could then be used as a prototype for a national system (Yaakup, Ibrahim and Johar, 1995). As a result of this project, the Klang Valley Regional Planning Information System (KEVIS) was also established.

Also in the early 1980s, the Department of Agriculture started using the Canadian system called COMPIS (Comarc Planning Information System), and the Department of Land set up the Land Data Bank for Sarawak. These systems were primarily textual-based with a limited mapping component. Towards the late 1980s, the Department of Survey and Mapping created applications called CALS (Computer Assisted Land Surveying) and CAMS (Computer Aided Mapping Systems) to support their mapping and surveying activities. These different developments, coupled with the establishment of MACERS in 1989, helped to provide a strong impetus to national GIS development, and now GIS has been positioned by the Government as a key technology in the national arena and for the fulfillment of the 2020 vision. The National IT Council is specifically examining how the growth of GIS can be fostered in the country by implementing macro-strategies such as the setting up of a National Geomatics Council, and a National GIS Institute. It is estimated that there are now more than 200 GIS systems working in different government departments. Amongst the more active government departments are agriculture, survey and mapping, forestry, and MACERS. In the next section some of these governmental initiatives are discussed in more detail.

5.3 Some GIS initiatives in the Government

In this section, discussion on five of the large GIS initiatives taking place within the Malaysian Government is taken up, namely the Ministry of Land and Cooperative Development, the Department of Agriculture, the Department of Survey and Mapping, the Department of Forestry, and the Department of Environment. Finally, under the category of "others," some smaller pockets of GIS ongoing work within the Government are dealt with.

Ministry of Land and Cooperative Development (MoLCD): Following the decision by the Cabinet in 1987 to establish a Land Information System for Malaysia, the MoLCD assumed the responsibility of coordinating efforts towards achieving this aim, and constituted a task force for this purpose. This led to the MoLCD proposing during the early 1990s the concept of a national level GIS infrastructure called NALIS (National Land Information Infrastructure System), whose design and implementation was to be coordinated by them. The NALIS concept, which represents a large, integrated and rather centralized system, is described by the Ministry of Land and Cooperative Development as their vision to establish a system that will provide a single window to all land-related data, regardless of where the data is located, thereby facilitating the exchange and sharing of information. The NALIS infrastructure is expected to allow the efficient sharing and exchange of land-related information among different governmental agencies, which could contribute to streamlining the process of national land-use planning and management.

The MoLCD appointed a local consulting company to conduct a feasibility study for establishing NALIS, and this company later included some foreign consultants to help them with the project. An elaborate structure was established for conducting the study, including the project coordinator, a technical and a steering committee, with the responsibility of making recommendations to the Government of Malaysia. The project team made a study tour of Canada, since the NALIS system was envisaged as being based on the Land Information System being developed in British Columbia. In addition, national data standards in South Africa, the United Kingdom and thenited States of America were also examined. As a part of the feasibility study, a questionnaire was used to poll 345 government agencies that were potential suppliers and users of geographic data, and who were expected to use the NALIS infrastructure, which would basically comprise computer systems and a 2 MB telecommunications link to exchange GIS-related data. The questionnaire was used to better understand user requirements with respect to the data currently held by the agencies and their future needs.

The study team recommended the feasibility of setting up the NALIS system and made a number of recommendations relating to technical, organizational and legal issues, and how the MoLCD should proceed further in the matter. One of the recommendations was to conduct a pilot project in a 243 square km area in the federal district of Kuala Lumpur by 1995, and once that proved successful, to expand this system to the other 13 state offices by the year 2000. The cost of the pilot project, a large proportion of which was to be funded through private-sector investments, was estimated at 33 million RM (about US$ 13) and the total project at RM 500-700 million (about US$ 200-300 million). The thinking in this project was to keep the data physically located in the server of the participating departments, and software systems would be installed by the MoLCD, enabling the conversion of data into a common format which could then be transferred and shared over the network.

In November 1994, an international symposium called NALIS'94, under the theme of "A Shared Vision 2020", was organized jointly by the MoLCD and the Association of Land Management Malaysia, wherein the feasibility study report findings were presented and the NALIS concept made public. Feedback was elicited on this proposed concept from participants representing organizations from Malaysia and from more developed countries such as Australia, Canada, Germany, Singapore and Sweden. The members of the different agencies that were met during the research expressed rather strong but mixed opinions on the feasibility of NALIS to act as a national data-hub. While some felt that NALIS was institutionally very complex to implement because of the reluctance different departments would have in sharing data, others felt that it was a good idea as it would make data more accessible and break down some of the existing departmental monopolies on digital data.

Some agencies felt that it was possibly a little premature to implement an integrated and large-scale system as NALIS because the culture of data-sharing was not strong within the public sector. Resistance was expected from the State offices to participate in these data sharing efforts, since land was a State matter in Malaysia, and thus they would not want to give their data to the federal office. To address this potential resistance, the MoLCD had obtained the blessings of the Cabinet for the implementation of NALIS, and also planned to make extensive tours to the State office to sell the NALIS concept, and assuage some of the existing fears about it through education. Financial incentives, like free digitization of existing paper maps, were also offered by the MoLCD to encourage different agencies to support the project. However, at the time of the research, ground-level details on how the implementation would proceed were yet to be finalized and agreed upon by the different parties concerned.

Department of Agriculture (DoA): The DoA was described as the oldest agency to be engaged with GIS activities in Malaysia, and maybe even in Asia. The DoA was seen to be one of the more sophisticated users of GIS within the Malaysian Government, and their scope and importance was steadily increasing with the recent national mandate to convert forests into agricultural land. While the DoA has district and State-level offices, the GIS activities are centralized at the Federal office in Kuala Lumpur, and the local offices only participate in data-collection activities. The federal DoA office sees itself as the national "guardians of data" related to land-use and soils, which were the two main activities of the Department. This guardianship is due to historical reasons, since the DoA has been using aerial photographs of soils and land-use since 1966, and was the first agency in Malaysia to begin with GIS on their Compis system in 1981, and with Oracle in 1984. By the early 1990s, the DoA had started using Arc/Info and ERDAS systems for their spatial planning activities related to soils and land-use.

In their role of guardians of soils and land-use data, the DoA had prepared about 136 maps on a 1:50,000 scale by 1994 which were used to identify land to support their agricultural development activities. The maps were being sold by the DoA to other government departments, the military, universities, research institutions and the Economic Planning Unit in the Prime Minister's office, which is one of its main clients. The DoA, as a policy, does not sell data in digital form, and only provides its customers with paper copies of the maps. The DoA, as a part of its vision to corporatise and become financially self-sustaining, is thus slowly adopting more of a service oriented role, whereby map-production and selling are seen as vital revenue-generating activities of the Department. Many of the maps are classified, and not to be sold to the private-sector. This restriction is justified by the Department on economic rather than on security concerns, because they do not want foreign companies to buy their data, do some value added work on it, and then sell it back to the Government at a higher rate. The DoA, as a commercial service to other departments, also digitizes its paper maps, and in return, sometimes also keeps a copy of the digitized data. Some scepticism was expressed by DoA officials regarding the feasibility of the NALIS initiative because of the difficulties involved in establishing such a complex national-level infrastructure for data sharing. The DoA was also naturally reluctant to lose their rights of selling soils and land-use data to other departments to the MoLCD.

Department of Forests (DoF): The GIS activities of the DoF are essentially at the stage of acquiring equipment, conducting pilot studies, and creating databases. By 1994, the Federal office of the DoF in Kuala Lumpur had purchased three machines, including two for data processing work and one exclusively for GIS. The Department was in the process of creating the databases, and had entered the data for about 15 different layers, including forests, roads, rivers and soils. Data inputs for the database creation task were coming from a variety of sources, including remote sensing images of forest cover and forest classification from MACERS, and for soils and land-use data from the DoA. The DoF was only supplied with paper copy maps by the DoA, and thus had to spend a lot of time and money in digitizing the paper-maps before entering it into the database. This digitizing also represented a duplication of effort, because these maps may already have been available in digital form at the DoA, and the redigitizing also created problems in matching the new data with the existing layers.

There is high visibility of international consultants and aid-dollars within the DoF. For example, the ASEAN Institute of Forest Management has been established with funding from the Canadian International Development Agency (CIDA) as part of a 10-year programme to enable equipment procurement, consultancy, training, research and education. The DoF is also expecting a large European Union project worth more than ECU 3 million to fund the acquisition of hardware, software, consulting services and training. The plan is to develop a large integrated system at the Federal office which would be connected to state level forestry offices through the network. However, there was no clear strategy about who would be the users, and what kind of applications would be developed. Another major bottleneck is the extreme shortage of GIS-literate manpower to operationalise such a large-scale plan for GIS implementation, especially in the state offices, since staff often do not want to relocate from the capital to other more remotely located cities.

Department of Environment (DoE): GIS was introduced in the DoE in 1991 as a result of the exposure the top management in the department received to GIS technology through vendor sponsored presentations and sponsors. As a result, GIS activities were started in the DoE with a fair amount of top management support and commitment. The department acquired a workstation-based Arc/Info system, which became operational in 1992, and since then the GIS group has been working on developing small prototypes and projects that could be used to demonstrate the applicability of the technology for environmental management. The main users of the outputs were expected to be government agencies involved in producing development plans, such as the Department of Town and Country Planning. Through these GIS activities, the DoE hopes to support the larger plan to make government planning more comprehensive, and move from a sector-based approach to area oriented planning, by more explicitly taking into account environmental factors.

The department would eventually want to link up their existing MIS systems with the GIS databases and to expand their departmental GIS usage to the 13 regional offices using Arc-View systems. The databases created in the Federal office in Kuala Lumpur would be made available to the regional offices, who would also be responsible for completing the attribute data for environmental variables, for example by collecting point data on air and water quality. Such an approach is expected to help the department in carrying out environmental impact analysis, and to develop decision support tools for environmental management. However, at the time of the research, the DoE had not reached the stage of actually carrying out detailed spatial analysis, but rather were using the technology primarily for visualisation purposes. In 1996, a key member of the GIS project team left the organisation and this has slowed down the project efforts. A primary focus of the current efforts of the GIS group was to create the data layers and sell the concept of GIS-supported decision analysis to their various offices. The GIS group felt that the early enthusiasm of the top management meant they had very high expectations of the value of GIS and were impatient to see quick results, but were often unwilling to wait for the long intervening period during which the databases could be established and staff could gain experience in the technology.

Department of Survey and Mapping (DoSM): The development of land resources has been given a key status in Malaysia, especially due to the current pressures on land-use as a result of the rapid modernisation and technological change. Malaysia has a National Land Code which provides the legal framework for land-related dealings, and amended in 1992 to enable the application of computers for land registration. This amendment paved the way for the Computerized Land Registration System (CLRS) to be implemented through a Swedish consulting organisation, the Central Board for Real Estate Data.

The DoSM has two main divisions of mapping and cadastral, the latter being concerned with land demarcation and registration data. The mapping activities are primarily handled at the Federal office, and supported by CAMS (computerized mapping system). The cadastral activities of the DoSM take place also at the State offices in addition to the Federal office. The CLRS (computerized land registration system), which supports the cadastral work is also being installed in the State offices on a Arc/Info platform. The DoSM's model of working is based on the British Ordinance Survey, albeit with greater restrictions to data access than the UK. The users of the CLRS outputs are expected to be the public, various government departments and the State land offices. The DoSM produces standard sheets describing the cadastral lots, selling them to other departments in hard copy format.

Another important sphere of activity of the DoSM has been in trying to establish national standards to enable the exchange of geographic data. The department has been invited by the Standards and Industrial Research Institute of Malaysia (SIRIM) to develop standards to enable communication between the providers and receivers of geographical data for GIS applications. The existing data standards (MS 1074) are seen to be rather limited in the light of increasing demand for spatial data by various GIS users, and the fact that existing data do not have topological properties of connectivity and adjacency (Zin, 1994). For the establishment of these new standards, a working group (WG 12) was established, which proposed the development of Malaysian Geographic Information Exchange Standards (MGIES). How effectively the recommendations of this working group are implemented, and their acceptance amongst other government agencies, are yet to be seen.

A number of other standards are also emerging to facilitate the task of integrating spatial and non-spatial data, such as relational data access (RDA) for relational database access; spatial data transfer standard (SDTS) for spatial data exchange; and a variety of other standards for database querying, network protocols and user interfaces. However, while there may be agreements on the technical scope of the standards, the challenges to implement them organisationally are much more complex and difficult in the Malaysian context, where many different agencies are involved in their individual GIS development activities. Also, bringing about organizational change in a traditional department like Survey and Mapping, is rather complex because surveyors have been traditionally seen to be resistant to changes in old practices of surveying and to adopt new work processes supported by GIS. Surveyors often hold rigid views, seeing maps as reflecting objective reality, and as described by one surveyor, "maps are maps are maps." Thus, the department tends to emphasize minute details and exceptions in maps, tending to look down on planners, who are viewed as being more willing to tolerate "inaccuracies" in their work.

Other initiatives: GIS activities are also taking place in a number of other government agencies, but mostly confined to the level of acquiring systems and conducting pilot studies. The Geological Survey of Malaysia began a GIS initiative in collaboration with the UK Geological Survey in an attempt to computerize the various geo-technical elements in a geological database called GIST, which could also be used later for modelling and projection exercises. This pilot project, which is being executed with some UK ODA funding, is part of the corporate vision of keeping "stakeholders (primarily the Ministry of Industries) happy by providing the right information on geo-technical parameters in a GIS format." Another major benefit expected to accrue from the pilot project is the development of a uniform data model that would encourage communication between engineers and geologists, something which is rather limited at present. In addition, awareness of GIS and spatial thinking was to be promoted in the Department through the pilot project. The time frame for the project was to have the infrastructure established and the comprehensive GIST database in place and fully operational by the year 2000. The maps generated from the database could be used by the Ministry of Industries for its land development activities, and would also to be sold to private companies.

The Department of Mines (DoM) is another agency at a very initial stage of experimenting with GIS. The DoM had been given an Arc/Info system in a training mode by a vendor, and were planning to buy a workstation to support the system. At the time of this research, the department had not begun anything substantial with the GIS, but did have plans in place to start digitizing the existing paper maps of mineral deposits. A major bottleneck to developing GIS initiatives was the lack of trained manpower who could be deployed exclusively for GIS development. Also, since the public sector is in the process of being trimmed down, the DoM was finding it extremely difficult to justify fresh hiring of GIS professionals. As a result, GIS development had not been given a very high priority in the departmental scheme of things.

The Economic and Planning Unit (EPU), the planning wing of the Prime Minister's Office, was also involved in a pilot GIS study as part of a UNDP project initiated in 1992. The pilot study remained primarily a technical development exercise carried out by the GIS group which included two UN employees, one a volunteer. There was marginal involvement of the other user wings of the EPU with this pilot project. The primary objective of this study, which was to create awareness of GIS and spatial planning among the EPU staff, could not be fully met because of resource constraints, and due to frequent transfers of EPU staff, making it difficult to develop a core group that could support the project over time. The EPU, especially the Regional Economics wing, was meeting map requirements and other GIS-outputs through MACERS, seen by many to be the technical arm of the Prime Minister's Office.

MACERS is primarily a research and development centre dealing with space science and remote sensing technology. It is a prestigious scientific centre of the Malaysian Government, and has been given a significant amount of resources to develop GIS capabilities, an has also been given approval to augment the number of GIS staff from 80 to 150. This approval was given because of MACERS being a research organisation, and therefore not subjected to the same degree of manpower cuts as some other public sector agencies were experiencing. As part of its new corporate vision, MACERS was in the process of formulating strategies so that GIS could be effectively deployed to primarily develop image processing products for sale to other departments in its aim to become financially sustainable. By closely aligning itself to the Prime Minister's Office organisationally, MACERS felt it would be able to effectively handle some of the inter-agency co-ordination issues.

A number of other GIS projects were also taking place at the government level. For example, the Federal Department of Town and Country Planning was at an initial stage of a GIS project, and was employing the services of a Japanese consultant for a land readjustment study using an Intergraph system. Handling spatial data using computers was a relatively new concept for the department, and taking on large projects was difficult due to the lack of available spatial data. There were pockets of GIS work going on within the Ministry of Primary Industries, mainly in the rubber and palm oil sectors. However, this work was primarily limited to the rubber and palm oil research institutes, and attempts to computerise the operational activities of the sectors were rather *ad hoc* and fragmented. Attempts were underway to consolidate GIS requirements for the different sectors of the Ministry, rather than allow pockets of unconnected projects. This integration was not expected to be easy since these different sectors tended to operate as independent units.

5.4 Challenges in implementing GIS in Malaysia

In this section, some challenges in effectively managing GIS projects within the Malaysian public sector are discussed. A key theme is the tension between the attempts to centralise the national GIS activities versus the efforts of different departments to develop their own GIS projects, a tension which is brought sharply into focus through the proposed NALIS initiative of the Ministry of Land and Co-operative Development.

The significance and implications of this NALIS initiative will be taken up first, and some of the reactions of different agencies to the feasibility of this idea is examined. Some of the project level challenges related to manpower and data will then be analysed. This analysis is based on the authors' understanding of the broader social context in Malaysia, and they examine, as described earlier, how these influence the shaping of the challenges, drawing on their earlier conceptual scheme.

5.4.1 The significance and implications of NALIS

Over the last few years, different agencies, including MACERS, the MoLCD, and the EPU, have each been mooting the idea of establishing a central agency under their respective guardianships, to co-ordinate the access and sharing of digital data. At the time of this research, it did seem that MoLCD's NALIS proposal would be accepted, as it had already been accepted by the Malaysian Cabinet. The MoLCD was in the process of trying to transform an extremely complex vision of a large-scale integrated NALIS system into reality. Past attempts to implement such large-scale and integrated systems in a centralised manner have not been too successful in many developing, and also developed countries. The complexity of implementing such large-scale systems, of which NALIS is an example, arises from a number of factors, both institutional and technological in nature, some of which are discussed below.

A major institutional bottleneck arises from the fact that for NALIS to be successful, it would require many different agencies to be in harmony with each other, and in agreement on a number of issues, including details of what is to be shared, the mechanisms for sharing, including cost considerations, and legal issues relating to copyright, ownership and security. Reaching an agreement on so many different issues is extremely difficult for a variety of organisational, economic, security and cultural considerations. For example, a department presently enjoying the exclusive benefits of selling its data in hard copy format to other departments, will obviously be reluctant to place its data into a public domain whereby it could be accessed at marginal cost, and in digital form, by other agencies. Another institutional issue concerns the fact that land is a State matter, and data on land transactions are primarily handled by the State office, which would obviously be reluctant to provide such data to the Federal office for both administrative and political considerations. Bringing about changes in these operating conditions would require major amendments to the legal system, which for historical and administrative reasons are extremely complex to put into effect.

A number of technical constraints to implementing such an integrated and large-scale system also exist. The different agencies expected to be linked to NALIS are all using different kinds of GIS software, with a variety of operating platforms and operating at various levels of computer sophistication. Such diversity in the technical configurations makes it extremely difficult to install systems capable of taking data from these different source and converting them into some kind of common format, which could then be easily transferred over the network. This problem is magnified by the fact that most of the agencies do not at present possess digital data, and there are few standards in place that would allow the conversion and sharing of data between agencies. In addition, there are network constraints because of the very high requirements of bandwidth to transfer images over the network.

Thus, while in theory the NALIS vision may seem beneficial to providing a single window for the sharing of digital data, and would help to coordinate the efforts of different departments, in practice, it is institutionally and legally very complex to implement. For example, there are other national level committees in operation, such as the National Mapping Council and the Standards Committee, which may have overlapping domains of responsibility with NALIS. Thus it becomes extremely important to clearly delineate the areas of operation of these groups to prevent conflic; and this is something that is not always easy to carry out. However, the MoLCD has taken a number of steps to address such issues, the most significant of these being the approval of the National IT Council, which implies the personal blessings of the Prime Minister and the Deputy Prime Minister for the project. To overcome some of the resource constraints in implementing such a large system, investments from the private sector are being sought. However, private sector participation raises additional issues concerning ownership of data and other security considerations. The NALIS implementing team is focusing on the challenge of trying to obtain a large-scale organizational buy-in for the concept by reducing departmental fears that they would lose ownership of their respective data sets.

5.4.2 Some project level challenges

There were a number of different challenges being experienced by individual projects. Two issues that are universal across the different projects relate to human resources and data management. These two issues are now taken up in more detail.

Human resources: Human resource challenges were seen to be key for the effective implementation of different projects. Respondents from nearly all the organizations visited described the non-availability of GIS personnel to be a major impediment to the use of GIS. The sudden spurt of activities in Malaysia has created a large demand for GIS trained professionals, but the existing education and training systems are not capable of catering to this demand. There is no university offering a degree programme focusing on GIS, and enrollment for GIS courses when offered by geography or surveying departments is extremely low. Since the Malaysian Government is fairly liberal with scholarships for students wishing to go abroad for graduate studies, many students travel to the USA for advanced courses in GIS, with a fair number continuing to work there. Training is largely limited to short orientation programmes offered by vendors with the sale of software. Systematic training for government staff is non-existent. Even INTAN, the apex institute for training officials from public-sector agencies, did not offer any courses in GIS at the time of the research.

Making it more difficult to obtain GIS trained personnel in the public sector, is the fact that the private sector is growing so rapidly, and companies are offering salaries and working conditions unmatchable by national universities or government organizations. MACERS, in its recent drive to recruit 150 GIS professionals, was trying to match private sector salaries, and in the process recruiting GIS experts from other departments, such as from agriculture and environment. This could potentially create a void, at least in the short-term in those departments, because typically the GIS efforts are built around individual initiatives. Also, with the opportunities for consulting with the Government increasing, many university staff are leaving steady and permanent lecturing jobs to start their own consultancy firms. With the role of the private sector expected to grow rapidly in the future, this shortfall of in-house GIS staff in public sector agencies is likely to increase.

Another human resources related issue concerns the role of international aid agencies in Malaysian GIS efforts. Since a number of the public sector initiatives are being supported by international aid agencies, project implementation was often primarily undertaken by expatriate consultants with a marginal involvement of local staff. As a result, local expertise could not be developed and projects suffered serious setbacks after the consultants left the scene. Also, since training was often offered by these agencies in their home countries, senior officials prefer the option of a training course to take advantage of a foreign trip, rather than send those junior staff who would be involved with the day-to-day progress of the project. In some cases, the opposite was the problem, with only very junior officers attending training, who had little say in how the technology could be used in their organization. The lack of awareness of the complexity and requirements of GIS technology meant that some of the senior managers regarded GIS training as no different to learning word processing or spreadsheets, and expected the trainees to be fully conversant with the technology within a few days.

The existing exigencies of work in many organizations made it difficult for staff to spend time on learning new skills. Manpower resources were limited, and the existing recruitment freeze and downsizing trends meant that extra staff could not be recruited for GIS related work. There is also the tendency within public sector service for pesonnel to be transferred quite frequently, further compounding the problem of developing a core group to work on GIS projects. While there was a fair amount of training effort directed at the staff in more technical departments such as remote sensing and survey and mapping, in user departments, for instance, mining or geology, training resources were far more limited. As a result, GIS knowledge tended to be limited to the technically literate. This emphasizes the need for people with "hybrid skills," implying experts with a knowledge of both the domain area, like mining and computer technology. However, the existing systems of education and training in Malaysia, as in many other countries, do not actively cater to the creation of such a skill base.

Data management: Another major constraint being faced in GIS projects relates to the availability of data. Since GIS was a relatively new phenomenon in Malaysia, there was inadequate availability of spatial data, especially in digital form. There were institutional bottlenecks to share digital data for a variety of historical, cultural and technical reasons. For example, the Department of Agriculture has historically been the custodian of soils and land-use data, and it is quite natural for the department to want to retain control over that data. To this end, the department only sold paper copies of the maps to other departments, and the purchasing organizations had to spend a good deal of time and effort in redigitizing these paper maps. With this primary focus on the digitization of maps, the agencies were unable to devote more time to creating GIS applications.

Agencies dealing with multi-disciplinary issues, such as the environment, were forced to go to many different departments for their data requirements, which was a very time-consuming and often frustrating task. The task was made more difficult because there was no central agency to help in the procurement of different data, or provide information on what data were available and where. The problems of data availability were compounded by the fact that in Malaysia, because of the perpetual cloud cover, aerial photography rather than remote sensing is more appropriate in order to obtain maps of the required resolution. Since aerial photography is extremely expensive to implement, the Survey and Mapping Department are expected to prepare new maps every five years. As a result, the available digital data is fairly outdated, especially in view of the rapid changes taking place in the Malaysian landscape as a result of new constructions.

Additional data-related concerns arise within organizations that do not have a strong culture in dealing with computerized information management systems. In such organizations, the concept of a "corporate database" is virtually non-existent, making it extremely complex to introduce the notion of spatial GIS databases that try to integrate the different departments. In organizations that have traditionally dealt with lists and tables, the idea of a map, and more so a computerized map, becomes very difficult to conceptualize and incorporate into the day-to-day work.

5.4.3 The role of the broader context in shaping these project level challenges

Some of the broader contextual conditions in Malaysia that are helping to shape the project level challenges discussed above, are taken up in this section. More specifically, two characteristics of the present Malaysian context are examined. The first concerns the federal structure of the Government, and the second relates to the current environment of privatization and corporatization in Malaysia and the associated information technology fever arising from the national 2020 vision.

Federal structure: Malaysia has a federal structure of governance and issues related to land and forestry are State matters. For example, with respect to land, the Federal Government provides for and constitutes the Law – the National Land Code – through the national courts. The Federal Land Commissioner handles legal aspects pertaining to land dealings. However, the State offices are responsible for the operational details, actually carrying out land transactions, keeping records of land titles and other records. The State offices are involved in a wide range of land transactions every day. Similarly, with respect to forestry, the Federal office in Kuala Lumpur formulates the legal framework, but the State Department is responsible for the day-to-day activities of forests, including decisions on sensitive matters of logging.

GIS development activities have to be viewed within the context of this federal structure, because it has direct implications on how systems are conceptualized and implemented. For example, the NALIS initiative is centralized in nature, and it would also involve land-related data being maintained or accessed by the Federal office. This raises a number of issues. Firstly, would the State Department be willing for this to happen given that historically, land management has been within their domain? Secondly, there is the issue of relevance. If land management is to still be within the purview of the State office, what would the Federal office do with much of the data, for example on the daily purchase and sale of land? An agency such as the EPU, which is responsible for developing the strategic directions of national economic planning, requires data that are more aggregated and analytical, rather than those dealing with routine transactions. Thirdly, if through NALIS the system by which land is administered in the country is going to be redefined, then this would require major amendments to the legal system, including the taking into account of GIS-generated outputs. Bringing about such changes in the legal system is extremely complex and time consuming. The complexity arises from a variety of reasons that stem from historical, political and social considerations.

Another aspect of the federal structure with a bearing on GIS implementation relates to the working of the public services. One is that the civil service is an "open" employment, where bureaucrats are subjected to frequent transfers; for example, a civil services officer can be very easily transferred from the Industries to the Human Resources Ministry. Because of this frequent rotation, it is extremely difficult to develop a core group who could sustain a GIS project, which typically requires three to five years to implement. Another related issue is that the public service is currently under pressure to reduce numbers and become more corporate-like in its functioning. As a result, it is almost impossible for different agencies to hire new experts with GIS skills, thereby considerably hampering the progress of new projects. This leads us to discuss the next aspect of the Malaysian context, which relates to the climate of corporatisation and privatization, and how it impacts upon the progress of GIS projects.

The term "corporatization" in the present context refers to the efforts of the Malaysian Government to induce their organizations to behave as profit seeking corporations rather than government funded service organizations. As a result of these initiatives, these organizations have to undertake activities that are cost-recovery and revenue generating in nature. Maps are therefore generated to be sold and provide revenue to the department, making them cost-effective and not completely dependent on government funding for their existence. In the drive for this efficiency, organizations are downsized and investments in IT infrastructure are legitimized. Privatization, on the other hand, is a related but slightly different concept. Essentially, it deals with the increasing involvement of private sector companies in activities that were exclusively within the domain of public sector companies. For example, the NALIS infrastrucure that is to support the national GIS network is supposed to be funded to a large extent by private sector funds. This has interesting implications, because while private sector involvement is being encouraged towards greater efficiencies and funding, the Government will still prefer to retain control. This has interesting implications for data management issues.

Corporatisation and privatization imperatives: The Malaysian Government's 2020 vision and the quest to become a developed country has contributed to creating an atmosphere that promotes corporate and private initiatives, including an emphasis on using IT. For example, the remote sensing research centre MACERS, was in the process of a large corporatisation initiative, whose goals were to make the centre self-sustaining, and meeting the operation costs by internal operations rather than by relying on Government support. An important component of this corporatisation initiative is the shrinking of the public sector, which numbers about 800,000 for a total population of 19 million (MAMPU, 1995). This downsizing process, which is being introduced along with increasing levels of automation, has had significant implications on the nature of work in many departments. For example, the automation of the land registration system in the Federal Land Office is expected to lead to a staff reduction of about a third.

These corporatisation and downsizing initiatives have meant that a number of activities traditionally under the control of the public sector, e.g. telecommunications and highways, are being privatized. Even training programmes for public sector employees are being carried out by the government training institute in close collaboration with private sector companies. With respect to GIS, an impact of the privatization drive has been that computer generated maps are being seen by many departments as a source of revenue. For example, the Geological Survey Department saw maps as a vehicle for advertising their resources to prospective foreign companies interested in investing in Malaysia. Since maps were being viewed as revenue-generating resources, it implied in some cases that the departments were reluctant to share their data with other agencies, especially in digital form. There is also the point of view in departments such as forestry, that it is important to project to the international market that resources, especially the sensitive ones like forests, are being managed in a modern and scientific manner. Additionally, the use of GIS helps project this image and attract international funding for local GIS projects.

Another important issue the privatization initiatives brings into focus relates to secrecy and ownership of data. A major portion of the funds required for the NALIS initiative is expected to come from private investors, and in fact the managing director of a private company is also a member of the National IT Council which is defining the scope of NALIS. If a private company is contracted to establish the NALIS infrastructure, then it would theoretically imply that ownership of data could be taken over by the company, because it would be controlling the processes that generate the data. This raises many complex issues, for example, if the comany does some value added work on the data, how would the profits from this added value be shared by the private company and the agency from where the data originated? To address such questions, major amendments would be required to the legal system, which as mentioned earlier, is extremely difficult to bring about.

In summary, the authors have examined two broad contextual conditions currently existing in Malaysia, and how they are creating both challenges and opportunities with respect to GIS projects. In making this analysis, details of Malaysian social and cultural belief systems were not examined, or how they influence GIS projects, as was done in the Indian case. There are two reasons for this. Firstly, unlike the Indian case, managerial action was not examined at the level of detail which would enable relating action with broader social structures. Secondly, the authors admit they are not as knowledgeable about the Malaysian social and cultural value systems as they are with the Indian situation, thus making it difficult to comment on issues at that level of detail. Thus, the comments are restricted to a more macro-level and, at this level, the implementation challenges existing in India and Malaysia are compared

5.5 Comparing implementation challenges in India and Malaysia

It is interesting to compare the experiences of India and Malaysia in implementing GIS because while there are some similarities, there also are some clear differences. In general, India started off with GIS activities a little earlier than Malaysia, and initial experimentation with the technology in the country was primarily through the scientific and research institutions, such as the Department of Science and Technology and the Department of Space. In contrast, Malaysia's early GIS activities were through agriculture, and then forestry, both of which are user departments. Initial Indian GIS efforts placed a strong focus on remote sensing because, ever since Independence, the Government has emphasized the building up of a strong remote sensing and space science infrastructure. This initial focus led to GIS projects emphasizing the use of data that had been generated by remote sensing. The involvement of space science institutes in India meant that the projects showed a strong inclination towards research and development rather than on applications. In Malaysia, the use of remote sensing data is more limited because there is a constant low-level cloud formation over the country, making aerial photography more useful than remote sensing. Also, since GIS projects originated primarily within user departments, the systems are more problem driven, for example developing applications for modelling land-use patterns in agricultural development.

The emphasis on technical development in India can be gauged by the fact that in India, nearly four different indigenous GIS packages have been developed by various research groups. In contrast, no packages have been developed in Malaysia, and all software has been purchased by vendors of foreign developed systems. However, because of this stronger focus on acquiring expertise from the West in Malaysia, there seems to be a greater dependence on consultants from countries like Australia, Canada, UK and USA, as compared to India. This dependence has important implications on the importance given to creating local in-house expertise, which influences how GIS projects fare in the longer run.

Another interesting difference in the approach of the Malaysian and Indian cases concerns the emphasis on decentralization compared to centralization. While acknowledging the fact that there are elements of centralization and decentralization in both their initiatives, it is felt that the Indian experiments reflect a larger degree of decentralization compared to Malaysia, although the different sizes of the two countries is obviously an influence here. For example, in India we find most of the GIS projects are geared towards district-level administration and for creating profiles of natural resources in local areas. In Malaysia, however, we find that most of the GIS projects are being implemented at the federal level to support the functioning of central initiatives, with very little participation by the district agencies. The NALIS initiative typifies this approach of developing centralized integrated systems. While in Malaysia there are a number of GIS projects taking place within various agencies, there are also major initiatives taking place to co-ordinate and centralize efforts through the abundant committees that keep being set up to oversee different activities, for example, mapping, standards and land management. In India, however, there are negligible efforts made to coordinate GIS projects, even though there are sometimes different initiatives under way on in the same district. Coordination, if any, happens by accident, rather than by design of the different coordinating bodies.

While both India and Malaysia are in the process of liberalizing their economies, the presence of the corporate and private-sector culture is more strongly evident in the Malaysian public sector. This difference helps to shape GIS projects in quite contrasting ways in the two countries. The increased involvement of the private sector in Malaysia implies that more resources are made available for GIS projects, but this also raises additional issues of data ownership and privacy that have to be addressed. In India, resources for GIS projects come primarily through international aid-agencies, and these bring into focus age-old problems related to technology transfer projects; for example, the conflicts between aid officials and Indian government employees, the reasons for which were discussed in an earlier chapter.

The Malaysian Cabinet, including the Prime Minister, are very actively involved in the IT-related developments of the country. There is a concretely articulated national 2020 vision wherein the role of IT is seen to be central. The setting up of a National IT Council under the chairmanship of the Prime Minister and the discussions around establishing a National Geomatics Strategy, are all reflections of the importance that is being accorded to IT and GIS within Malaysia. While in India – despite the efforts of individual departments – there is no coherent and articulated statement on how GIS development should proceed. The lack of political stability in India, which is very much in contrast to Malaysia, makes it extremely difficult to establish a long-term and unified approach to development. Then, of course, we should not overlook the fact that India is a country of 950 million compared to 19 million in Malaysia, and covers a much larger geographical area. Very different cultures, government and social structures operating in different parts of the country, contribute towards creating a highly diversified environment which discourages any form of homogenized system development. All this makes establishing coordination between the various GIS projects in India an immensely complex and mammoth task.

Other differences in the Indian and Malaysian experiences come from the fact that, while in both countries there is a strong focus on natural resources management, the situation is shifting in Malaysia to an increasing focus on urban-management applications associated to highway planning and telecommunications. In India, the private sector involvement in GIS is very marginal. However, within the public sector projects, there are similarities related to the frequent rotation of civil services employees, the absence of a strong information management culture, and very limited use of electronic maps.

In summary, the above discussions have helped to highlight some of the challenges that planners in India and Malaysia experience in trying to implement GIS project. This comparison helps to identify how different contextual conditions can help in shaping various strategies and approaches to the conceptualization and implementation of GIS projects. This understanding helps to address, in Chapter 6, the complex issue of how to manage and implement GIS projects in developing countries.

CHAPTER 6

IMPLICATIONS FOR EFFECTING GIS IN DEVELOPING COUNTRIES

This chapter addresses the question of what planners can do to implement GIS technology more effectively in developing countries. In the foregoing chapters, various impediments were identified and discussed to effectively applying GIS technology in developing countries, ranging from such institutional factors as lack of cooperation between different participating agencies and the structure and content of the technology transfer process, to the more local considerations such as an absence of a map-based way of conceptualizing problems and the existing gap between developers and users. Based on an understanding of these different impediments, a general comment can be made with respect to the management of GIS projects in developing countries, and that is on the requirement to develop stable networks of people who see their interests as bing aligned to the needs of the technology. It is also necessary to sustain such groups over time, since GIS projects usually take many years to implement successfully. The authorsuse this requirement of developing and sustaining stable networks of people, technology and resources over time, as the key underlying concept in sugging some implications for GIS project management in developing countries.

In developing these implications, it is important to note from the outset that GIS projects involve the participation of highly diverse groups, including: international aid agencies; bureaucrats and technocrats from many different ministries and government departments; the user agencies; the owners of the natural resources for whose management GIS technology is being applied (these could be individual farmers or communities owning the land, or government agencies like the forestry and rural development departments); and vendors responsible for selling and supporting the technology. These different groups have heterogeneous interests and motivations for using or not using the technology. Aligning their interests together with the technology is indeed a complex and time-consuming proposition.

The interactions between these different groups take place within a particular social and institutional setting, further adding to the complexity of the problem, because the features of this context are often in conflict with the assumptions that are inscribed in the technology on how work should be done. We refer to the need for deep-seated changes of social attitudes and structures, and such change do not happen quickly. For example, India is not primarily a map-based culture, but GIS requires users to adopt a map-oriented approach to their work. A transition of this sort, on the part of a wide range of Indian government administrators, would be a significant social change and, if it is to happen, will take years rather than months to achieve.

Bearing in mind the above qualification on the inherent complexities and the time-frame involved for effecting significant change, we can nevertheless use the discussions in earlier chapters as a basis to identify some issues and approaches which offer positive directions for the future. These approaches are discussed under two broad categories relating to "institutional" and "social" implications. In section 6.1 of this chapter, institutional implications are discussed, which address issues relating to the mechanisms senior level policy makers can establish when trying to enable the different participating groups to collaborate, and to see their respective interests as being promoted by the technology. In section 6.2, social implications are discussed, which address issues more at the level of the individual or group; for example the measures that can be taken to promote a map-based way of thinking, or to enhance communication between groups of developers and users of technology.

6.1 Institutional implications

In this section, three broad categories of institutional measures are discussed which the authors feel policy makers could take to establish and strengthen collaboration between the different user groups participating in GIS projects. The first set of measures concerns the relationship between the officials from a donor body, such as an international aid agency responsible for initiating the transfer of technology, and government officials of the recipient developing country. More specifically, the discussion concerns some specific collaborative measures which could be established so that the transfer process could be made more relevant to the needs of the host country in both structure and contents. The second set of implications deals with measures to enable inter-agency coordination between the various participating organizations within developing countries, including between the various government departments and ministries, and also between the government user departments and local vendors of GIS. The third set of implications is aimed at the level of individual institutions that are the primary users of the GIS, specifically the kind of measures that could be incorporated into work processes so that the technology is seen to be relevant and valuable to day-to-day work processes.

6.1.1 Implications for technology transfer

Given the general history of failure of past efforts to transfer GIS technology to developing countries, one has to be rather cautious while developing implications to make this process more effective. Taylor is highly critical of such transfer efforts and writes that "approaches which depend upon foreign donors, expatriate experts or foreign firms are least likely to succeed" (1991a: 80). In Asia, unlike many countries in Africa where most applications are of this type, we find more efforts in using indigenous approaches to developing and implementing GIS. For example, in India, a considerable amount of scientific effort has focused on the development of indigenous software packages rather than depending on foreign vendors for GIS software needs. Such a focus is in line with the Indian Government's post-Iindependence policies of developing self-reliance. Taylor also commends China's efforts to indigenize GIS by developing "pragmatic raster-based systems, utilizing remotely-sensed data with databases of a manageable size (rather than) 'Cadillac vector-based systems' designed for North American or European realities." Taylor suggests that it may be more appropriate for developing countries to look at the Chinese model as a source for GIS technological transfer, rather than to Canada, Europe or the USA.

While the Chinese option may be technologically more relevant to developing countries than the European or North American models, there are other political and financial factors to be considered. GIS technology rarely ever comes by itself in a transfer project, but is packaged together with aid-dollars, consultants and work methodologies. Since developing countries are so dependent on this aid-package, they are often coerced into accepting technology which may be inappropriate to their local conditions. This broader political and institutional context is thus largely given, and is often beyond the scope of influence of individual managers working on GIS projects. Given this problem background, we now focus discussion on implications for managing technology transfer projects originating from the more common North American and European sources.

A key problem noted in many technology transfer projects concerns the issue of sustainability, and how GIS initiatives can be continued after the aid-package driving the GIS project has dried up. For sustainability to be achieved in practical terms, it is key that aid projects, along with the transfer of GIS, also seek to promote the creation of conditions within the institutional, social and political domains that could support the use of the technology in the longer run. The intention here is not to suggest that the transfer project should replace the nation's own internal development processes, but rather to critically examine ways by which the transfer process can be more meaningfully embedded within existing socio-economic planning processes, so that the various involved parties can relate to each other in a collaborative mode.

Different approaches to sustainability have been emphasized by various authors in the past. Hutchinson and Toledano write that in their GIS efforts in India, they were guided by the principle that "those who are intended to adopt the technology must be involved in the design, execution and evaluation of the project in which it is demonstrated" (1993: 455). While in theory this principle may have some merit, in practice it is very difficult to implement for a variety of related issues; for example: do the local user departments, who are the intended adopters of the technology, have the required technical and organizational infrastructure in place to receive and sustain the technology; and, are the criteria for the design and execution of the project, which are more often than not specified by the aid agencies themselves, in agreement with the goals of the receiving agency?

To make Hutchinson and Toledano's (1993) principle of locally relevant design and execution of projects operational, it is important to embed the GIS transfer projects within larger ongoing development processes. Such an approach to sustainability is also suggested by Harris and his co-authors (Harris et al., 1995) emphasize the need to "to demonstrate a GIS application where local knowledge, community needs, and specific histories are appreciated and incorporated within the development process." On a practical level, these ideas of "local empowerment" can be attempted by making the GIS projects a part of existing long-term governmental development schemes in the area, rather than positioning GIS as a "stand-alone" initiative whose "birth" and "death" is directly related to the initiation and completion of an aid project. From the case studies in India, the authors found more optimistic signs of use in some of the GIS projects that were closely integrated with existing development projects in the region. For example, in one case, the GIS outputs being generated as a result of the pilot project were being used by the district planner to support a long-term land development initiative in the area.

Since the community provides the broader context within which the use of GIS is institutionalized, approaches to technology transfer must include a critical examination of how GIS projects satisfy both the institutional and community objectives (Brooks, 1992; Kottak, 1991). To achieve this, it becomes necessary to define priority areas or regions in which to embed specific GIS projects. For example, establishing economic development projects within communities that rely on the natural resources of protected areas, then implementing development projects within such communities, tends to serve the local community needs of economic growth and the institutional conservation objectives. Thus, working with communities that depend on the natural resources of protected areas offers many opportunities to establish sustainable networks, and such environments tend to serve multiple interests and encourage collaborative enterprises.

Such approaches to sustainability, which involve embedding GIS efforts within existing development projects, and which potentially satisfy both community and institutional objectives, takes into account Taylor's warning that "if the immediate relevance and utility of GIS are not apparent, it is unlikely that the technology will be adopted" (1991a:80). The ongoing development project within which the GIS is embedded can help to provide a common frame of reference for the different involved parties to communicate with each other, and to define development objectives that can utilize GIS. To the international agencies, the existing project provides a concrete basis to evaluate the progress of the GIS projects. For example, it allows them to see whether the GIS outputs are actually being used by planners, and if they are contributing to the success of broader socio-economic development programmes. The district user also finds motivation to support the GIS projects, since he or she can see the utility of the GIS outputs in performing his or her day-to-day activities, rather than as an additional and "meaningless" skill that needs to be learnt. Such an approach to GIS management thus supports Chrisman's view that the development of GIS must "ensure a fairer treatment of all those affected by the use of the information" (1987: 1367). Such an approach is also useful from a resource perspective because some of the costs of a GIS project, for example training expenses, can also be absorbed by the larger development programmes, and thus contribute towards making the project more sustainable in the long run.

Another important issue with respect to the transfer of technology problem concerns the coordination between different donor agencies that often operate concurrently on GIS related projects in a particular developing country. For example, in Hanoi, there are at present about seven international aid agencies operating on environmental related projects in which GIS is being considered as a key tool. We often find in such situations that these agencies do not "talk" to each other, which can potentially lead to a duplication of efforts. This lack of coordination also contributes to reinforcing the sectoral approach of functioning in the recipient country because departments, instead of using systems that are already in place in their country, would rather approach a different donor agency to acquire their own system. Sharing experiences and resources between different donor agencies operating in a country could help to improve the effectiveness of using their aid-dollars by targeting projects where they are most needed.

6.1.2 Implications for inter-agency coordination

The need for inter-agency coordination arises at two levels: between the different national agencies implementing GIS projects (in the Indian case these would include the MoEF, DST, NIC and DoS); and between the different departments that are involved with a particular GIS project, (in the Indian MoEF project, these would include the participating departments of forestry, rural development and agriculture. At both these levels, a key area for coordination is with respect to data management, including the processes of creating and maintaining the databases. Some of the mechanisms will be taken up that could be established to enable these inter-agency coordination processes, especially through the means of a national "geomatics policy" at the national level, and by developing specific data management strategies at the project level. In addition to these inter-agency coordination efforts for data management purposes, an examination will also be made of the need for more effective communication between the vendors of GIS and government user departments in order to improve the level and quality of technical support.

6.1.2.1 Data management coordination efforts

National level: A key mechanism to enable coordination between various national agencies is believed to be by the establishment of a national policy on geomatics to facilitate processes of data management, storage and access. Geomatics involves the collection, storage, processing and transmission of spatially-referenced data, together with its combination with traditional non-spatial data, in order to provide an improved basis for planning, decision making and action, particularly through the use of GIS technology. While data is needed in all applications of informatics (computers, communications and related technologies), geomatics are particularly noted for needing large quantities and types of data which are expensive to collect, store and apply. Geomatics databases contain data on many different thematic layers and various socio-economic variables. Different departments also have heterogeneous requirements of data in terms of scale and accuracy. In addition, there are different requirements of detail normally required at various administrative levels, such as the centre, state and the district, but the data at these levels of detail should be compatible. It is a very costly and time-consuming process to generate and check the accuracy of these data, whether by remote-sensing, aerial survey or census-type approaches, and to keep them updated as conditions change. It is clearly highly desirable that data be shared where possible, but major problems can also crop up in this area.

The problems that arise in attempting to share data between different agencies involved in GIS applications include: a lack of knowledge of what is available in other agencies; concerns of national security and the confidentiality of data; the cost and time involved in making data available to other agencies; and fears of loss of power and status if certain categories of data are shared. Even where the above problems can be overcome in principle, a technical infrastructure needs to be established that will enable the provision of efficient access and data transfer mechanisms, such as through the provision of digital data on portable media, disks, or even better over a computer network link. Setting standards for data exchange is crucial when establishing and maintaining both the institutional and technical infrastructure for data sharing.

The problems associated with data sharing are sufficiently severe, in both technical and organizational terms, that it is common in practice for the data in GIS applications to be developed from scratch, even when they are available elsewhere. This involves a very costly duplication of effort and a waste of available resources. One of the main reasons why this situation occurs is that the data sharing and access problems outlined above often do not fall within the authority and power of the officials to resolve, except at the highest level. Issues of national security, the power of different agencies, the provision of networks for data exchange, and the setting of standards, are matters that can only be addressed at the level of national policy. A coordinated top-down policy does not, of course, guarantee its effective implementation at all lower levels, particularly in a country of the size and complexity of India, for example. Nevertheless, it may be considered as a necessary condition, if not sufficient, for the effective utilization of GIS to aid national development.

Simonett (1993) suggests that decentralized GIS sites may not be appropriate given the present stage of GIS maturity in many developing countries, and has proposed a model for a "National Environmental Information Centre" to be established as a central GIS facility to serve as a policy support mechanism for the government. In deciding how such a centre should be positioned with respect to the existing governmental infrastructure, Simonett emphasizes the need to provide the centre with autonomy and open access. Autonomy relates to freedom of the centre from the parent organization, and access refers to its capability to freely interact with other sectors at an operational level. Simonett does, however, acknowledge that in setting up such a centre, the traditional national computing and survey departments (in the Indian context they would be the NIC and the Survey of India respectively), would be bypassed. However, such an overriding of departments may be necessary, given the extremely political nature of the tasks the centre would have to perform, and thus the crucial need for autonomy and access becomes evident. Such a centre would have two main institutions: a steering committee that takes responsibility for the political and international coordination, including tasks of ministerial cooperation, donor harmonization, and education and training. The other institution would function as an inter-sector information group responsible for coordinating between the professional staff from the various ministries at the operational level.

Various models already exist by which other countries have established, or are trying to establish, national policies for geomatics. In the Malaysian case described in Chapter 5, we discussed how the Ministry of Land and Cooperative Development was championing the implementation of the NALIS system as a data hub for land-related data in a top-down, centralized manner. The Singapore Government has implemented ILUS, a land-hub information system to act as a "one-stop-non-stop" land data exchange centre (Yuk Wah, 1994), housed under the Ministry of Law. The Qatar Government has established a steering committee, which includes senior officials from different ministries, to oversee GIS development efforts including data exchange. Other models for establishing national geomatic standards for data storage and exchange are found in developed countries such as Canada and the USA.

The specifics of the model to be adopted for the national geomatics strategy will vary from country to country due to differences in the social, institutional and political conditions within which GIS is being used, and the primary purpose for which the technology is being deployed. However, there are some broad areas the proposed policies would need to address, especially those related to aspects of data sharing, data exchange standards and data access. The government would need to charge an appropriate agency or agencies with the ongoing task of putting in place the technical and organizational infrastructure to implement these policies. It is also imperative that an appropriate agency or agencies be charged with the ongoing task of creating and maintaining a "meta-level" database which describes what data are available at the various administrative levels such as centre, state and district, where they are available, and how they can be accessed.

The effective creation and implementation of high level policy in the area of geomatics requires a clear statement of political commitment, the provision of appropriate financial resources, and the setting up of related mechanisms to enable collaboration between the agencies working in the area. One specific approach in the Indian context, for example, could be the creation of a National Geomatics Council within the Planning Commission at the highest government level, supported by sub-committees to advise on detailed technical and policy aspects. In addition to data issues, such a national council could also be entrusted with the responsibilities of a full range of geomatics policy issues, including other crucial areas such as GIS education and training.

Project level: At the project level too, various organizational, technical and economic factors contribute to make the task of defining data responsibility in a GIS project a very complex one: the absence of a computer-based data management culture in many government departments; the high volume of data required; the technical requirements of memory, time and connectivity to store these large volumes of data; the involvement of multiple organizations which provide the spatial and non-spatial data; the high cost and time investments in the acquisition and maintenance of data; and the relatively long-term and irrevocable commitments made in creating a GIS database. There are two primary tasks in defining data responsibility. The first is to identify who is (are) the custodian(s) of data. The second is to formulate a formal memorandum of understanding between these different custodians to detail various aspects of data management, including the procedures for updating data, creating a data dictionary, developing organizational data standards, and creating data archives.

The multiplicity of issues and the variety of data that are required for a GIS project make it advisable to establish a rigorous data management programme for subsequent stages of the project in order to utilize time and financial resources more effectively. Developing data management strategies at the initiation of the project can help to structure the data needs of each agency in a clear, integrated and efficient manner. The significance of this task is high, for example, in projects involving environment and natural resources, because a large proportion of the required data may be currently unavailable, or available in inappropriate formats, thus creating the need to conduct expensive and time-consuming primary-level surveys.

Data management strategies should also address the more operational concerns of planning and monitoring the flow of data through a GIS project. This task includes two main items: the spatial and non-spatial data elements of the GIS database and the associated decision logic and analytical procedures for aggregating the source data to produce derivative data; for example the procedure and logic by which a soil type and slope map are combined to derive a soil suitability map. In the context of natural resources management projects, some of the specific concerns managers would need to engage would include the need to develop a careful understanding of the real data requirements for the project, such as obtaining the right blend between the use of natural resource and socio-economic data, i.e. that on fuel and fodder as compared to data on population, livestock and social infrastructure. Other considerations include optimizing the use of the more macro-level (small-scale) remotely sensed data for micro-level planning applications; identifying existing sources for required data; developing cost-effective measures to convert existing data to ones that can be used by GIS; and critically examining the decision logic used to create derivative maps to see if they realistically represent the process by which users currently make decisions.

6.1.2.2 Coordination efforts to improve technical support

Poor technical support has been a major bottleneck of past computerization projects in many developing countries. Often the physical separation between the technical support and user offices is large, making it difficult for the user to obtain help when needed. In India, where attempts are being made to place GIS in district offices, the problem becomes more acute as the vendor offices are often located in selected state capital cities at some distance from the districts, and there is very limited capability at the local level to cope with GIS-related technical problems.

The GIS developers in India are either government departments (the DST, DoS or the NIC), or GIS software is distributed by private sector organizations of foreign companies (ESRI and Intergraph). While the government departments do not have the adequate organizational infrastructure and resources to provide support in remotely located district offices, private sector distributors are seen to be too sales and profit oriented, and give inadequate importance to the issue of long-term support and customizing service to satisfy user needs. Poor technical support leads to major delays in project implementation and increases the levels of user frustration towards the technology and towards the project implementers.

Addressing these problems of technical support is not easy, and requires a number of proactive steps to be taken by both the vendors and user departments while implementing GIS projects. The measures at the user level include a careful definition of hardware and software requirements, ensuring selection of appropriate software, and drawing up sensible and more comprehensive support contracts with the vendors. At the vendor level, measures include efforts to understand the needs of the user in more detail, and to approach the issue of GIS support in a manner that is significantly different from how they currently provide support with respect to sales of other hardware and software. The parent companies of local distributors (for example, ESRI, USA) can also play a proactive role in this education process by emphasizing to the distributors the different kinds of expectations they have with respect to GIS marketing, and also in supporting these expectations by providing appropriate incentives.

Firm support contracts between the vendor and the users can to some extent safeguard the interests of both parties. For example, in the Indian district offices, recent contracts for hardware support have incorporated a clause of financial penalty for every day the vendor delays in responding to a request for technical support made by the user. This clause has helped to significantly improve the level of technical support. In addition to including such clauses, the GIS support contracts should also be made more comprehensive by including aspects other than system maintenance. For example, training and education is typically treated as an item "in the margins" when developing a request for proposals and the final order contract. This problem could be addressed by carefully drafting these contract documents so that the vendor is legally bound to provide sustained GIS education and support, and the users are obliged to make appropriate financial commitments towards enforcing the contract. For such measures to be implemented effectively, it is crucial that the feelings of mistrust and ill-will that have traditionally characterized relations between the private sector and government departments are replaced by ones of trust and cooperation. To influence such processes of social change is an extremely complex and long-term task because they are rooted in larger historical and social structures.

6.1.3 Implications for organizational adaptation for GIS

A key implication for changes required in the user departments trying to use GIS technology more effectively concerns the need to provide projects with more stability and continuity. From the study of GIS implementation experiences in various other contexts, it has been found that the task of database creation in itself can require a minimum of three to five years. Given these circumstances, it is important to develop effective and sustainable partnerships between the concerned parties, where the partners are sensitized at the outset to the significant commitments of time and money that are required in the process. This understanding of the long-term nature of the GIS project can curb feelings of frustration that can develop in the absence of instant results, which tend to nullify the effects of earlier efforts in the project.

Project continuity can be enabled through initiatives such as the development of a core group responsible for the project, the prevention of premature transfers of officials, and the clear delegation of responsibility for the different project tasks to the various actors. For example, the project coordinator needs to specify responsibility on how technology is to be transferred from the laboratory setting to the field site, and who will be the custodian of the system. GIS developers often feel that their primary role is development of systems and not its transfer, while the users are themselves not competent enough to handle the technology independently. Under such circumstances, it is necessary to identify alternative ways of organizing the transfer, which are compatible with the prevailing social and institutional conditions existing in the specific context. For example, in the Indian case where individual and institutional roles are defined rather rigidly with respect to functional boundaries, it is difficult to motivate the scientist developing the technology to see his or her job scope to also include the transfer of the developed systems to the users. Under such conditions, it may be more effective to create a transfer wing in the institution, with the explicit responsibility to effect the transfer of technology to the users, or entrust this task to other third parties, such as non-governmental organizations and locally based educational institutions.

Building awareness of GIS technology through training and dissemination of education material can also contribute to the process of providing project continuity. In the context of many developing countries, GIS represents a relatively new technology, and people outside the exclusive GIS community have had negligible exposure to it. Also, the implementation task is complex and long drawn out, and the implementing agency is faced with the twin objectives of developing and sustaining participant interest over time, where in the initial years no tangible benefits are forthcoming from the system. The task of awareness building can be approached in various formal and informal ways: providing demonstrations of the systems developed in the pilot stage to users; continuous education and training throughout all stages of the project; and developing the projects in gradual, incremental stages where the outputs at each stage are seen to be relevant to the concerned parties.

Developing mechanisms to enable continuity in GIS projects is difficult because they are bound up with complex and deep-rooted issues related to bureaucratic structures and inflexible management styles that typically exist in government GIS user departments. Major constraints to the computerization of work in government departments arise from the paternalistic and top-down style of authority which often prevails in government administration. The senior managers in government departments are typically bureaucrats. For example, in India, the Indian Administrative Services (IAS) officers are the heads of the districts where the GIS systems are being located, and they are often not oriented towards the use of technology in the work. Decisions in government offices may normally be taken on political grounds rather than using Western-style analytic decision processes implied by GIS technology. Significant changes are required in these management styles to integrate the use of GIS into existing work processes, since it requires norms of authority based on hierarchy to be replaced with that based on expertise. This implies new ways of working, and requires a different type of culture wherein the development and application of expertise is encouraged through appropriate incentives, rather than being stifled by authority. For GIS to be effective, local initiative and judgment in interpreting GIS outputs would need to be encouraged to enable local authorities to tackle relevant problems by more appropriate means.

6.2 Social implications

GIS project management involves the setting up of both a technical and social infrastructure to support the effective utilization of systems. However, it is commonly found in GIS projects in both developing and developed countries that the management emphasis is primarily on setting up technical systems such as the acquisition of hardware and software, while social aspects are given marginal importance. Therefore, a key implication in this regard is the need to improve the balance between the emphasis that is placed on the technical and social aspects of GIS projects.

Since GIS applications are normally developed by technocrats, a strong technical bias seems inevitable in the early stages of the project. A majority of GIS projects in developing countries typically start as exercises to test the efficacy of the technology, and then the intention is normally to apply the technology in specific application areas, for example in the management of land resources. As the project progresses to the application stage, where the objective is for users to apply the technology for a specific purpose, social aspects assume a central significance. Some of these aspects are: the users' existing work processes, and how they may be influenced by adopting GIS; the hopes, expectation and fears users have regarding GIS; education and training; and the changes in organizational structure and procedures that need to be initiated in order to utilize GIS more effectively.

It is important that GIS project planners treat social issues, such as those discussed above, with the utmost seriousness if implementation is to be successful. We discuss three key areas for management action:the need to establish more effective mechanisms for communication; greater investment in human resources development; and improving processes of project management.

6.2.1 Communication mechanisms

A GIS project typically involves a set of actors, who despite having different agendas and roles, come together as a team for purposes of the project. These different actors, for example the technologists or the users, influence the project at various stages; the aid agencies play a more significant role during project initiation, while the role of the scientific institutions is more crucial during the technical development period, and the government user departments should logically be the primary source of focus in the applications stage. The implementers need to approach the project in a holistic way, which accounts for these different interests and influences, and develop mechanisms that maximize the synergy between the actors.

One key set of mechanisms which can contribute to the development of this synergy relates to the generation of effective means of communication, including the formal and informal ways by which interaction occurs between actors. It is crucial for the GIS project coordinator to inform the developers and users clearly about the mission of the project, and the broad parameters within which they have to operate, including the scope of work, details of the budget, time-frame and equipment procurement. Inter-institutional agency sharing of experiences, using forums such as user groups, can also contribute to improved communication, and can also help to establish mechanisms for solving problems by developing local expertise. Such improved and increased communication can also help to improve the evaluation and monitoring of completed projects, because it is often found in developing countries that noone is really accountable or responsible for the outcome of projects, and the reasons why projects succeed or fail are typically not known to those who plan new projects.

Closer and more pro-active interaction between the users and the developers can help bridge the gap between these two groups, and to ensure that the right questions are asked in the GIS decision models, and locally relevant solutions based on criteria that are appropriate to the project beneficiaries are incorporated in the decision models. Improved communications between the planners and the vendors would also help to improve the support function, for example by enabling a more accurate definition of hardware and software requirements, and by giving greater emphasis to education and training. There are various mechanisms by which communication can be enabled and developed at different levels between the various parties, and these are normally best identified and designed by the actors themselves. For example, in some contexts, communication could be facilitated through the creation of user groups, while in more hierarchical settings, formal communication through memoranda and committees may be preferred. However, it is essential that the GIS project coordinators see their responsibility as including the encouragement and facilitation of these formal and informal communication processes.

A major impediment to many past GIS development efforts has been the communication gap between the developers and users of technology. The careful and systematic monitoring of social interactions that occur between the users and developers can help to bridge some of the existing gaps, and also contribute to maintain project continuity. Monitoring relates to the activity whereby actors consciously document the interactions they have with each other. For example, when a user is shown a system demonstration, he or she can express both favourable and unfavourable reactions to it, and also the reasons why such feelings arise. If these responses are not documented in a systematic fashion, they get lost with time, and cannot be meaningfully incorporated into aspects of system design. A systematic documentation of such interactions provides an historical record of some of the social aspects of the project, which is useful in providing members with a sense of continuity with past events – and is particularly relevant in situations where there are frequent transfers of project staff. Monitoring also helps to keep in perspective how the system uses changes with time, an issue that is important in IS projects in general, where it is often found that applications are utilized for purposes other than those for which they were originally intended.

6.2.2 Human resources development

Another crucial bottleneck of past computerization efforts in developing countries has been the limited demand for computerized outputs by local authorities. For example, in district administration in India, the local planning function has largely involved the monitoring of development plans on the basis of physical and financial parameters, with negligible importance being given to qualitative performance. The task of planning in many institutions has been viewed primarily as an impersonal and mechanical exercise wherein future annual plans are prepared by simply marking up existing plans by a fixed percentage rather than basing it on local needs. Another factor contributing to this lack of demand is that many developing country institutions have novice computer users, with a limited exposure to computer applications in their work processes. The process of interacting with and learning new technology is seen as an additional burden to day-to-day work, as there are limited financial and organizational incentives for users to become technically literate.

Given our past experiences with the extent and nature of human resources development problems in computerization, it is important to seriously address GIS manpower issues. There are two key issues related to this problem. The first concerns who provides the impetus to the training effort. The second concerns the content of the education and training programmes. In India, an important research finding from previous computerization experiences has been that technical innovations are most effective when they are initiated from the state government or below, and are unlikely to take place if they are driven from the centre (Madon, 1993a), thus implying a preference for a bottom-up rather than a top-down approach. In the past, the role of the state government has been crucial in guiding the transition from non-usage of computers, to carrying out routine data-processing applications, to the conduct of simple "what-if" kinds of analyses. The implications of this learning, at least in the context of India, is that the impetus for GIS-related human resource development issues should be built around a core group of people and technical and physical infrastructure at the state offices of organizations like the NIC, DST, DoS, or other user departments. Concurrently with the state impetus, it is important to gradually develop the capability of the local level officers who have to engage with processes of decision making at the field-level. By developing such local capability, the field officers would be able to interact more intelligently with the technical developers to ensure that their decision processes are more accurately represented in the GIS models. This would help redress some of the common problems that arise because developers create systems which they think are appropriate based on academic and theoretical considerations, rather than on how users actually make decisions, and how work is carried out in the field.

In formulating strategies for human resources development issues, planners have also to be knowledgeable about a variety of other factors, including the level of computer and GIS maturity amongst the users, and the nature of applications for which GIS is being deployed. In general, there are two forms of knowledge related to GIS: conceptual and operational (Sahay and Robey, 1997). Conceptual knowledge reflects the capability that people have to think in spatial terms, and involves developing an understanding of geographical concepts related to topology, geo-referencing and geo-coding. This capability would allow the user to visualize problems in spatial terms, and translate his or her need for geographical products into workable GIS solutions. In contrast, operational knowledge relates to the more procedural aspects of GIS, for example, the practice of digitizing, or entering data into the database and performing menu or command-driven operations to generate map-outputs from the system.

Strategies for education and training need to very carefully incorporate these distinctions between operational and conceptual knowledge, including: what elements comprise these different forms of knowledge; and who should be exposed to what level and types of knowledge. For senior level officers, conceptual knowledge would be more relevant as it would help provide them with the capability to articulate a vision for GIS use in their departments, and set in place suitable mechanisms to establish strategies for data management and project continuity. Then, to translate these visions into workable GIS applications, staff are required to have far more operational knowledge. Knowledge requirements also vary according to the stage of maturity in terms of GIS use in the department. At the initial stage, the primary focus is on defining the variables and creating the data sets. The next stage would involve the generation of thematic maps for representation and visualization purposes. Later stages would involve analytical operations at different degrees of sophistication, from simple overlays to more complex modelling and simulation exercises. At these different stages, the mix of operational and conceptual knowledge requirements vary significantly, and the training and education programmes need to be adapted accordingly.

In conducting these training programmes, it would be useful to expose the planners and technologists to case studies of GIS projects carried out in other contexts. Through these case studies, the planners can be sensitized to the reasons why projects have failed or succeeded elsewhere, encouraging them to incorporate some of these learning experiences into their own planning processes while being aware of the differences in operating conditions. Such an approach would also be beneficial for cost and time considerations, because planners could directly move to defining the substantial aspects of the project, rather than spending time and energy on figuring out generic details of GIS projects, and thereby "recreating the wheel" each time a GIS effort is initiated. New electronic media, such as the internet, could be used as a repository for GIS training material and cases, which could be accessed by people in other countries. An interesting example in this regard is the recent efforts of ESRI, USA, which is in the process of starting a "virtual campus", that would allow people from any part of the world to take training courses over the world wide web.

A number of policy measures are also essential with respect to GIS education, a task that could be the responsibility of a central institution like the National Geomatics Council discussed earlier. The NCGIA in the USA provides an interesting model of such a central institution, as it is trying to establish some national standards for GIS education and research. A key objective of such a centre would be to try and market GIS as a viable and exciting career path for graduate students from developing countries, and one which could be seen as being capable of guaranteeing long-term employment. To promote such perceptions, GIS would need to be positioned not as a stand-alone set of skills in danger of becoming obsolete in the future through technological advances, but rather as a set of tools that would be useful in various application domains such as natural resources and environmental management, areas that are going to hold large-scale employment potential for university graduates in the coming years. It would also help significantly if governments were to recognize GIS-related skills for the purpose of employment, for example by creating central and state government cadres for people with GIS skills, and by including GIS as a subject for testing in entrance examinations for jobs in the civil services, forestry or agriculture sectors.

Bringing about such fundamental shifts in thinking within existing educational and employment structures is no doubt very complex, and to bring it about would require intensive collaborative efforts between the GIS centre, government departments, universities, GIS vendors, and also international organizations like UNIDO and UNITAR. Important and fundamental reforms would be in the area of university education, where the centre would play the role of imparting extensive and sustained pressure on universities and policy making bodies, such as the University Grants Commission and the Ministry of Human Resources Development in India, to incorporate GIS education within existing curricula. Issues of concern would include the relevance of curricula, for example the need to include management and implementation issues within GIS studies, and also in expanding the scope of programmes to include interdisciplinary subjects like forestry and management, rather than limiting it to the exclusive confines of university computer science and geography departments.

Major reforms would be required in the education and training programmes conducted within the government. Since civil service officers are key decision makers with respect to the adoption of new technology, it is important to try and include GIS technology and management aspects into their training programmes before they take up their field appointments. In India, some steps have already been taken in this regard, and the IAS officers are given some training in GIS and remote sensing before taking up their field posts. However, GIS training is part of a much wider public sector educational issue which is concerned with the styles of decision making and the related use of IT-based systems. To change these larger systems requires political commitment at the highest level, and the provision of large and sustained amounts of financial resources. It would be foolish to imply that educational processes may be changed easily or quickly, but it is clear that this type of deep-seated change is needed if GIS and other IT-based systems are ever to be widely used in developing country governmental departments.

Policy efforts should also be directed at establishing coordination mechanisms between the GIS centre and international institutions like UNITAR, UNIDO and ITC in the Netherlands, which are extensively involved with GIS education in developing countries. Such collaboration would help enrich the nation's own education programmes, for example by tapping into the resources of international agencies for training material, data and case studies. An interesting approach in this regard is by UNIDO, which through a long-term programme on technology transfer, is in the process of establishing focal institutions in developing countries as a source for GIS capabilities. These focal points could then in turn act as a point of contact for conducting training and education to other institutions in the country. Collaboration with such global institutions would also help in developing research linkages with international experts and for obtaining funding support for research studies

6.2.3 Project management

Project management is an important area for improvement, and in the earlier discussion we have highlighted a number of ways by which it can be improved, for example in providing continuity and improving communication. An important project management issue concerns the system configuration that is adopted: centralized versus decentralized, and top-down versus bottom-up. Taylor (1991a) suggests an important necessary, but not perhaps sufficient, condition would be to let indigenous scientists and decision makers acquire a greater degree of knowledge and control of this technology. To obtain this "socio-economic command," Taylor writes that it is important to try and match the tasks which can be performed by the technology and the reality of the current application situation. The choice of a centralized or decentralized configuration would be dependent upon a variety of factors, including the manner in which the work takes place in reality; the maturity of the users; the level of technical support available; and the level and extent to which data are available, and with whom.

Another project management implication relates to planning the processes of technological transitions for users, which reflects the manner in which systems of doing work change from a certain existing method to other ways. When the new technology and ways of doing work are seen as an extension of existing systems of expertise, then the processes of transition are likely to be smoother and easier to achieve, as compared to situations where change is seen to be a radical departure from existing capabilities. In the context of many developing country organizations, the introduction of GIS represents a radical departure from existing ways of undertaking work, because it involves moving to a map-based computerized system of work from one that is non-map based, and rather weakly supported by computers. This radical change is capable of creating sharp discontinuities in work-life.

Using GIS effectively also requires transitions at various levels including staff skills, organizational procedures, and technical systems. With GIS, the skill base of the existing staff requires to be expanded to include the capability among planners to conceptualize their problems in spatial terms, and to be able to think in reference to maps rather than the lists and tables which many developing country administrators are used to. At higher levels of sophistication, planners need to develop the capability to formulate and represent their problems in a manner which can be addressed and solved by GIS, and then to interpret the solution in terms of overall planning objectives and priorities. To facilitate these transitions, it is important to plan the user's exposure to the technology in a gradual and systematic manner. For example, a project can start by exposing the users to fundamental concepts of a map and database, which can then be built upon to the idea of an electronic map, and spatial concepts such as adjacency, proximity and geo-referencing. Armed with these concepts, the user is in a better position to appreciate the potential of GIS, and how his or her work could benefit by its use.

Another factor critical to the transition to GIS technology concerns the creation of integrated databases. For GIS to be effective, it is important to compile databases that are both relevant to application problems at the local level, for example by providing accurate profiles of locally available natural resources, and which can also feed into the central government's policy formulation processes. Fulfilling these dual, and sometimes conflicting, objectives is increasingly complex from both the technical and institutional perspectives. This involves a transition process for the agencies involved to move from a stage where there is relatively little collaboration and communication with each other, to a situation where the operations of different organizations become partly interdependent on each other through the needs of the integrated GIS database. GIS project planners thus need to systematically plan for these transitions in work systems, along with other changes in technology. Sometimes, by merely establishing simple communication channels between members of different departments through informal and formal means, can help create a mindset that would encourage sharing and support the transitions to more integrated GIS applications.

6.3 Conclusions

The authors' approach to developing the above implications was not aimed at implying normative prescriptions, but was directed more at the level of sensitizing the GIS planner to key areas of concern, and suggesting some broad strategies for action. The authors believe that the specifics of action are best decided by the planners themselves based on their understanding of local social and institutional conditions within which they operate. The need to be aware of these conditions has been emphasized, and to incorporate this understanding into the design and implementation of projects. The approach in this regard has been to identify the different groups of people who are involved in GIS projects at the international, national and local levels, and their specific responsibilities with respect to GIS. Implications have been suggested that are aimed at enabling the creation of relatively stable networks of groups who see their interests as being promoted by the technology, and the steps that could be taken to sustain these groups over time.

In this discussion many areas of change have been identified if GIS are to be adapted and effectively applied to support governmental decision making. For those familiar with the chaotic nature of many developing country governments, and the strong sense of inertia in their work procedures, the appeals for policy change may be perceived as naive. The chaos in governmental working is exemplified in the case of India where there have been six prime ministers in the last ten years, and the current ruling structure comprises a coalition of about a dozen different parties with very diverse ideologies and motivations. Such an unstable governance structure makes longer-term planning efforts, involving a three- to five-year time frame (as is the case in GIS projects), very complex and problematic to implement.

However, although the difficulty of achieving systematic and planned change in such complex and deep-rooted systems is recognized, we do not accept that change is impossible. Over the last decade, India has also undergone major changes in political approach, for example towards a more open economy. In addition, computerization is a major issue of debate in both the public and private sectors, in a way which was not the case ten years ago, so it would be wrong to assume that the next ten years will necessarily involve stagnation on policy matters. In addition to any internal initiatives for change, India, like many other developing countries of the world, is increasingly subject to international pressures resulting for example, from globalization trends. For example, with respect to GIS, there is an increasing international concern on environmental issues, and GIS are being promoted by many environmental agencies as providing a valuable platform for action and analysis in the environmental arena. India, and many other developing countries, are not immune to this pressure, not least since it is often directly related to financial aid.

Within these conditions of political change and international pressures to apply GIS technology, a crucial implication for high-level policy makers and politicians is to consider critically the more fundamental question of whether GIS is really "appropriate" to their problems and working systems. A relevant question in this respect is whether the promotion of GIS "rational" decision making procedures reflect an attempt at indoctrination of developing countries to Western technology and attitudes or, putting it another way, is it a form of cultural imperialism. The answer to this question must be "yes" to some extent, but a detailed discussion of the desirability and morality of this approach is situated in deeper historical and social systems, and is linked with the national and political aspirations of different countries. For example, GIS technology may be considered more desirable in the case of Malaysia where the national 2020 vision is to explicitly become a "developed country" in the future, than in the case of India where funding could perhaps be better utilized in providing support for poverty alleviation and for basic living facilities for the poor. However, even in India, GIS may have a significant role to play in such poverty alleviation, if it were effectively applied.

CHAPTER 7

GIS: FUTURE PROSPECTS AND CHALLENGES

7.1 Introduction

In the earlier chapters, various problems and opportunities were highlighted that are associated with the use of GIS technology in developing countries, especially within the domain of environmental resources management. At one level, it does seem that GIS technology has established a physical presence in many developing countries through the efforts of various international organizations, national governments, non-governmental organizations, researchers and scientific institutions, especially within the remote sensing domain. This presence is evident by the variety of GIS initiatives that are being taken up by government departments in various developing countries, especially in the Asian region, where substantial projects are in progress in China, Bangladesh, India, Indonesia, Malaysia, Nepal, Sri Lanka, Thailand and Viet Nam.

However, at another level, and judging by the experience to date with GIS, the broad comment can be made that the presence of the technology remains primarily restricted to the scientific and academic domains. Therefore, while a number of pilot projects and academic exercises exist, there is little of substance taking place within the user domain, namely where an environmental planner uses GIS outputs to support his or her day-to-day decision making processes. One can go a little further and make the general comment that while there is a lot of promise associated with GIS technology because of its inherent technical capabilities, the problems and challenges involved in harnessing this promise seem to outweigh this potential at present. However, given the huge amounts of investments that are being made on GIS projects, and the serious environmental pressures developing countries are experiencing, it becomes vital to understand how the potential of GIS can be harnessed effectively to address some of these environmental problems.

One of the authors of this book was recently involved in a training programme on GIS applications for water management in Hanoi, Viet Nam. At the end of the 10-day course, after the lecturers had described the potential of GIS, and discussed various methodologies and models for water quality management, a participant approached him and said "I do not believe GIS would be useful to us because it belongs to another world. Our world is divided into two parts, the developed and the developing, and GIS is only going to increase that divide." While that may be a rather simplistic and deterministic way of framing a complex issue concerning the potential consequences of GIS from the perspective of a developing country planner, it nevertheless reflects the critical need to situate issues relating to the use and impacts of the technology in a broad social and historical context within which it is disseminated and used. Otherwise, as Pickles (1995) argues, "the contingent nature of technical outcomes is ignored, and the struggles waged over the choice and application of any particular technology are ignored."

In the early 1990s, Taylor (1991a) critically analyzed the contribution that GIS had made to the socio-economic growth processes in developing countries, and concluded that it could be best described as being "marginal." About five years later, we find ourselves broadly supporting Taylor's analysis. The question which naturally arises is why do these impacts remain marginal, despite the very significant investment in efforts of various international agencies, national governments, NGOs, and many different scientific institutions and academic researchers? Again, Taylor's comment in this regard is insightful, wherein he says that for GIS to be useful in a developing country, it needs to be "... indigenized and adapted to the needs and capabilities of the particular situation in which it is to be used, (and) approaches which depend upon expatriate experts or foreign firms are least likely to succeed." This is an important point to explore further, given the fact that most GIS projects in developing countries are primarily based on international technical, financial and managerial assistance. There are thus two relevant issues in this regard: what does indigenization involve; and, secondly, is it possible at all? We discuss these two issues now in greater detail.

7.2 What does indigenization involve?

Indigenization, in broad terms, concerns the readaptation of the technology in a manner that it more closely reflects the needs of the social context in which it is to be used. To understand what this task involves, it is important to note that GIS technology is primarily a product of the post-industrial societies of the Western world, a reflection of man's quest to control Nature and the environment in more systematic and scientific ways. Pickles (1995) describes new data handling and imaging technologies such as GIS, as representing the next logical step in the advance of science and society, and the stimulus by which mankind seeks to overcome the barriers of distance and time, and to exercise greater control over society, space and Earth. Thus, to understand the scope and extent of the indigenization task, it becomes critical to understand better what are some of the assumptions on the nature and structure of social life that are inscribed in the technology, and what kinds of tensions these assumptions raise with social values existing in a particular context where GIS is implanted for adoption and use. Latour (1987) argues that in a particular social context, technology can itself be regarded as a non-human actor, since it embodies the motivations and actions of its designers, and can be thought therefore to act as an agent on behalf of their interests. It thus becomes crucial to understand what sort of rules govern the development of this technology, and how these systems become disseminated in other contexts, in our case developing countries.

To understand some of these rules and assumptions, it is essential to situate GIS technology in an historical perspective and examine its origins, which can be traced back to the conceptions of the science of cartography and map making. Harley (1992) writes that the rules for cartography can be understood in terms of a positivistic epistemology, where the designers have promoted what we can call a standard scientific model of knowledge and cognition, where the object of mapping is to produce a "correct" relational model of the terrain. The technology embodies assumptions that objects in the world being mapped are real, objective and measurable, and to some extent enjoy an existence independent of the cartographer. Harley describes the acceptance of the map as a "mirror of nature" which contributes to the notion of "linear progress," i.e. that by the application of science, ever more precise representations of reality can be produced. Cartography can thus deliver a "true, progressive or highly confirmed knowledge."

Another key assumption that GIS technology embodies is the notion of a "map-based" reality. GIS requires users to have the ability to view relevant problems in spatial terms, and express them in a manner in which it can be addressed by the technology, for example by utilizing concepts related to geo-referencing and geo-coding. Such a map-based mode of thinking has significant implications on how space is conceptualized, and the structuring of social relations over given territorial areas (Gregory and Urry, 1985). Harvey (1989) argues that when maps are stripped of all elements of fantasy, religious beliefs and the experiences that created them, they tend to represent functional systems depicting the factual ordering of phenomenon in space and point of time. Maps then represent "totalizing devices produced by mathematical principles that tend to eliminate the social experiences that go into building them."

In addition to the assumptions of objectivity and a spatial reality described above, GIS technology embodies assumptions of rationality and coordinated action. These assumptions of rationality are often embedded in the very language used to describe the potential of the technology; for example, Pickles (1995) writes that we often read such statements as: "new electronic technologies (like GIS) permit the extensive surveying of new and more complete sets of data at great speed, decreasing cost and greater efficiency." These statements reflect rationalistic assumptions of efficiency, standardization and market-driven skills. They also imply that time can be controlled by space, wherein spatially discrete data sets are standardized, codified and commodified at "faster speed" and "decreasing cost," – criteria that are primarily products of rationalistic Western thought. The restructuring of space using GIS also implies a view of the efficient coordination of action over time, where people and departments coordinate with each other, since these discrete data sets will typically be the responsibility of different groups of people.

Through the above discussion, the authors have tried to emphasize that the assumptions of objectivity, spatial thinking and rationality which GIS embody, represent quite fundamental conceptions of the world based on which some of the post-industrial societies of the West are socially structured. Sensitivity to these different and broad cultural assumptions of the nature of life is important in developing interpretations of the nature of social activities in a context, because they help in understanding metaphors of the kind which Pepper (1942) calls root metaphors. These metaphors are not something which may be explicit and stated, but are unconsciously drawn upon by people, as a means of seeing the world, and also to govern their everyday functioning down to the most mundane details (Bird-David, 1990).

The argument thus being made by the authors with respect to indigenization is that, for GIS technology to be successfully adapted to a particular developing country context, the various people concerned with its adaptation would need to address these more fundamental assumptions inscribed in GIS at two inter-connected levels: how can existing social systems be transformed to accommodate this new technology and the associated methods it embodies; and, how can the nature of the technology in design and application be readapted and reinvented to reflect the values and belief systems in the recipient society?

These are rather complex issues to address, involving long-term and intensive measures because social change is so difficult to bring about. Through the course of this study, the authors have tried to identify and discuss various mechanisms at both the institutional and social levels by which these adaptations and modifications can be attempted, and what are the underlying challenges in doing so. For example, an implication was made with respect to the transfer of GIS – a key vehicle for the dissemination of GIS and related know-how – is for planners in developing countries to examine alternative sources of knowledge; sources that are closer to them spatially as well as culturally, as compared to uncritically trying to adopt models for GIS design and development that originate from North America or Europe.

An implication in this respect for Asian countries such as Viet Nam and Cambodia, could be to examine the paths of development that China or India have adopted, and see how these models could be adapted within their specific contexts. For example, China has demonstrated the effectiveness of applying raster-based data sets to environmental problems, and shown how cost-effective and suitable they are compared to the vector-based systems that are typically used in Western models. Also, India has developed its own GIS packages, which may be inferior to Arc/Info in terms of available functionality, but probably more reflective of the functionality required for, say, district administration; and much cheaper in comparison.

In making these suggestions of alternative sources, there is of course the danger of being seen as promoting a binary opposition involving the "developing" and "developed" countries. However, that is not the intention of the authors, because they are not implying that a Chinese GIS water-quality model is superior to a Dutch system, or the Indian GRAMS GIS developed by the Department of Science and Technology is better than Arc/Info. Instead, their aim is to highlight the need for planners to be sensitive to the social and cultural dimensions inherent in adapting the technology, and thus encourage them to look for sources of knowledge that are more reflective of their local situation, where the technology and systems have been created and used by people who share relatively similar social experiences as themselves. In some cases, there may not even be the need to look at another country, because the sources of knowledge may be found quite easily internally. For example, the Ministry of Industries in India could benefit greatly in its GIS development efforts by learning from the experiences the Ministry of Environment and Forests, situated in the same city, has had vis-à-vis GIS. For this reason, the authors have stressed the critical need for communication and coordination, both through institutional measures, such as establishing a national geomatics policy for data sharing, and by social efforts of creating and promoting informal user groups.

However, bringing about transformations of the kind referred to above is an extremely complex task, since institutions and society are bound up in issues of history and traditions which are difficult to dislodge. We are not dealing here with relatively simple issues such as increasing levels of user participation or training methods, but with deep-seated cultural and social issues. The latter include the existence or not of a map culture, and cultural attitudes to job responsibilities, such as scientists not viewing implementation as part of their role. These issues thus bring us to the next point for discussion: is indigenization possible at all? which, at a more fundamental level concerns the issue of the "appropriateness" of GIS to developing countries.

7.3 Is indigenization possible?

At one level, we can adopt the perspective of the training programme participant referred to earlier, and state that indigenization of GIS to developing country contexts is impossible to achieve in practice. Using this argument, GIS can thus be dismissed as a rather "inappropriate" technology because of the more macro-level complexities involved in bridging the gap between the "developing" and "developed" worlds. There is, of course, some degree of validity in that argument if we evaluate it within the context of the experiences that developing countries have had with GIS to-date, and the extremely deep-rooted and difficult-to-change institutional and social structures within which attempts are being made to operationalize this technology. However, such an argument is deterministic in nature, and tends to ignore the fact that social change has always been an aspect of our history and, in current times, that the processes of social transformations are greatly accelerated due to the processes of globalization and increased privatization. Another source of change, which the view of GIS as an "inappropriate" technology tends to ignore, is that arising out of "unintended consequences," whereby changed properties of higher level systems can emerge due to other events taking place in the social system (Harre, 1981). This implies that changes taking place in other parts of the social system, for example through the media or larger educational processes, can influence significantly how GIS is used in government.

India provides an interesting example to examine how social change can come about despite the deep-rooted social and institutional systems that exist in that country. For example, Indian government systems display strong inertial properties. However, as noted in the previous chapter, external pressures from globalization trends and environmental concerns are influencing Indian government policy. Occurring simultaneously, and often in inter-connected ways, there are a number of internal processes that are taking place as a result of the ongoing GIS projects, which in themselves act as a source of learning on how indigenization can take place and provide an impetus for larger-level change. From the micro-level situation of the GIS project, processes of "aggregation" (Knorr-Cetina, 1981) can take place through both formal and informal means to help provide linkages with the more macro-level processes of the state or national government. The development and expansion of such linkages help to create a wider network of people who see their interests to be aligned with those of the technology. In India, for example, the District Information Officers (DIOs) of a state meet once a month, and during these meetings individual district-level experiences are shared. Thus, knowledge about, for example, the MoEF projects which are taking place in a particular district, can be shared with districts not directly involved with the projects. Also, the DIOs within a state are periodically called to the state capital for meetings and training programmes, during which results from district projects can be communicated to the state authorities.

The link between the districts, state and the central government is often provided by the scientists and bureaucrats, who are periodically transferred to other positions in different geographical locations. State-, regional- or national-level meetings take place under different initiatives, and enable the intermingling of different levels of the hierarchy.

Contributing significantly to the expansion of these linkages is the large influx of international experts, and through their ideas and work methods, a strong impetus for change is provided. An example of such an event was the training programme on GIS for water applications in Viet Nam referred to earlier, where more than thirty government employees from different departments in the South-East Asian region were lectured about the potential prospects and problems associated with GIS technology. These experts will carry back some of these experiences to their workplaces, and it may be that in some cases the seed which is sown as a result of the training will develop into fully grown projects. The use of technologies such as the internet can also help to stimulate these processes of development. For example, some of the trainees from the Viet Nam programme continue to communicate with one of the authors of this study, and this communication may help to reinforce some of the earlier ideas through processes of debate and discussion over the electronic media.

In addition to the transformations taking place through these more visible "aggregation mechanisms," changes take place by virtue of the "unintended consequences" of other events taking place in the social system, as mentioned earlier. Harre (1981) compares the concept of unintended consequences in social systems to the idea of emergent properties manifested in biological systems. The implication of these ideas to our analysis of the indigenization problem is that the impact of GIS on the social structure should not be looked on in isolation, but in conjunction with other developments taking place in developing countries, such as the influences of globalization and the media on people's lives. For example, a significant number of children in India are growing up routinely watching American television programmes. Such exposure is bound to provide an impetus for larger-scale change in social attitudes and values. Debates on the merits of such changes are ongoing in Indian society, and this by itself is a reflection of the transformations that are taking place. Also, with the increasing incidence of travel, familiarity with the use of maps and map-producing technologies such as GIS may be increased. The use of technologies like the internet are also adding new dimensions to the kinds of people with whom they can interact, and the availability of information.

In the above discussion, the authors have sought to identify and discuss various sources which can induce processes of social change in developing country societies, sources which are often not as visible or explicit compared to specific efforts taking place in the context of particular projects. So, while in a particular project it may appear as if no change has taken place as a result of the introduction of technology, there may be other processes of change set into motion because those involved in the project are members of larger and inter-connected social systems; then, there are always some individuals who are present that are more pro-active, who try to induce change with almost a missionary zeal. Thus, while some changes around GIS projects may be controllable and predictable, many others are beyond the domain of control, since they stem from much larger forces, and yet others come about as a result of random, apparently unconnected occurrences. Social systems change much more slowly than technical ones, and thus transformations often begin to be visible much later than the completion of specific projects.

7.4 Concluding remarks

In conclusion, two issues are relevant with respect to the issue of indigenization: feasibility and appropriateness. The authors' view on the subject of the feasibility of the indigenization task is that while it is extremely complex and likely to be long-drawn out, requiring intensive efforts from various relevant groups at multiple inter-connected levels, it should not be viewed as wholly implausible. Of course, this raises the important question of how long it will take for this stage of effective adaptation to come about, and more importantly, can developing countries afford the time and money on this exercise?

In commenting on the issue of appropriateness, the authors believe that, while GIS is indeed an extremely useful tool, there is the need for developing country planners to adopt a critical attitude grounded in healthy scepticism towards the technology and its potential relevance for their own domain problems. When we look at a GIS-generated map, we tend to think that we know what it shows, what it says, and what it means. This sense of knowing about our space is extremely seductive, and is key to the persuasive power behind GIS. It is precisely this persuasive power that makes GIS so useful, and also so dangerous. It is important to look at GIS only as a tool which provides one way to visualize, represent and analyze a spatial problem. The solution to a particular environmental problem often lies not in the particular GIS model, but elsewhere, sometimes at a much higher level, within the policy formulation and implementation domains. Once a GIS system has been set up, it can potentially be used to support decision making in a variety of important domains. But the key challenge lies in setting up relevant systems, and then providing incentives to planners to actually use its outputs to guide their management processes.

One needs to be critical about the kind of outputs that GIS produces, and how accurately they represent the phenomenon under study. There are many instances of the same phenomenon being represented very differently because of variations in the methods used for building that representation. For example, Pelkey (1997) describes how the Forest Survey of India and the National Remote Sensing Agency, two premier scientific institutions in India, came up with very differing estimates of the extent of loss in forest cover during the same time period. Pelkey and Ali trace these differences to the variations in the satellite reflectance data, depending upon the time of the year when it was collected. In December, it is far greener than in August, and data collected in December can be classified in certain ways using GIS so as to reflect higher forest cover than in August. The planner who is using GIS thus needs to be aware of such nuances, and will have to develop counter-checks to verify the validity of the GIS-outputs. Otherwise, as Pelkey points out, "different stories are told by the same data; different management options are required; and different futures would unfold. An overestimate of the amount of forest would likely lead to myopic harvest policies. Conversely drastic underestimates could rob a developing economy of desperately needed resources. Faulty analyses lead to faulty policies even when conscientiously applied."

This raises the crucial issue of human resources, and the need to develop skills that are extremely hybrid in nature: sensitivity to the local context; an expert understanding of the domain-area problem; literacy with computers and GIS; and, most importantly, an ability to influence the policy making processes. While GIS can help us in modelling a problem, it has to be developed around a sound understanding of the phenomenon, and an appreciation of the ground-level situation. Pelkey (1997) comments on this issue of relevance: "The only way to really know which image is the best is to increase the amount of ground truthed data. That is, to go on location and check it out. GIS combined with satellite data can be an extremely powerful tool. But, contrary to popular practice: it requires more field research, not less; it requires more field researchers, not fewer; and finally, it requires greater scepticism in the apparent truth of the result. Unfortunately, more and more funding is being allocated to GIS workstations, scanners, satellite data, and digitzers without a matching increase in expenditures on field data. In fact, it appears that the increases in equipment expenditures are at the expense of field research. It is critical that funding agencies resist the current trend to transform the entire natural science community into amateur cartographers. Otherwise, the legacy we leave our children may be extensive archives of pretty maps of where things used to be."

The effective use of GIS technologies in developing countries presents great opportunities but also significant challenges, and throws up issues which cannot be addressed solely at the level of the individual project. It requires intensive efforts at all levels by international agencies, national governments, scientific institutions, universities, user departments, NGOs and individual researchers. Each group is relevant and has a role to play in the important domain of environmental management, in which we believe that GIS technology can indeed play a key role in improving the practice of information use.

REFERENCES

Ahmad, Z.A., "GIS Project Management for Large Projects," in **Proceedings of NALIS '94, Symposium and Exposition**, Kuala Lumpur, Malaysia, Paper TS3.1 1-9, (1994).

Al-Ankary, K.M., "An Incremental Approach for Establishing a Geographical Information System in a Developing Country: Saudi Arabia," **International Journal of Geographical Information Systems**, 5 (1991), 85-95.

Anderson, S., "ALIS Development Approach – Comparing Malaysia and Sweden," in *Proceedings of NALIS '94, Symposium and Exposition*, Kuala Lumpur, Malaysia, Paper TS2.2, (1994), 1-10.

Angus-Leppan, P., "The Thailand Land Titling Project: First Steps in a Parcel Based GIS," *International Journal of Geographical Information Systems*, 3 (1989), 59-68.

Asian Development Bank, "Remote Sensing and Geographic Information System for Natural Resource Management," Asian Development Bank, ADB Environment Paper No. 9, (1992).

Aureli, A., Han, Q., Missten, R. and Rose, J.B., "The Role of GIS in Natural Resource Management and Sustainable Development," *Proceedings of the Second Seminar on GIS and Developing Countries*, Utrecht, The Netherlands, (June 1993).

Bamberger, W.J., "Lessons in Organizing and Implementing a Production GIS," *AM/FM Navigating the Future Conference XIV Proceedings*, (1991), 167-173.

Barthel, K.M., "Evaluating the Reliability of Geographical Information Systems for Environmental Assessments in Data Poor Regions," *URISA 1991 Annual Conference Proceedings*, Urban and Regional Information Systems Association, Washington, D.C., Vol. 10 (1991).

Bird-David, N., "The Giving Environment: Another Perspective of the Economic System of Gatherers-Hunters," **Current Anthropology**, Vol. 31, 2 (1990), 189-196.

Brooks, H. "Science and Sustainability," *Selected Papers on IIASA's 20th Anniversary*, (1992), 29-60, Vienna: Novagraphic.

Campari, I., "Cultural Differences in GIS: A Basic Approach," *Proceedings of the Fourth European Conference and Exhibition on Geographical Information Systems*, Genoa, Italy, (29 March-1April 1993).

Campbell, H., "Theoretical Perspectives on the Diffusion of GIS Technologies," in I. Masser, H. Campbell and M. Craglia (Eds.), *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, Taylor and Francis, London, UK, (1996), 23-45.

_____, "The Organizational Implications for Geographic Information Systems for Local Government," EGIS '90, First European Conference on Geographical Information Systems, (1990), 145-157.

_____., and Masser, I., AGIS in Local Government: Some Findings From Great Britain," **International Journal of Geographical Information Systems**, 8 (1992), 309-325.

Cane, S., "Implementation of GIS in a Large Authority," EGIS '90, First European Conference on Geographical Information Systems, (1990), 158-166.

Chakraborty, S.K., *Human Response in Organization: Towards an Indian Ethos*, A.K. Chaterjee, Calcutta, India, (1985).

Chandra,V., Arif, M., Reddy, G.B., and Sainath, R., "NICNET-based Natural Resources Informatics for Sustainable Development at Grass-root Level," seminar presented at a National GIS Workshop, Ministry of Environment and Forests, New Delhi, India, (28-29 July 1995).

Chen, S., "Geographical Data Handling and GIS in China," **International Journal of Geographical Information Systems**, 1, 3 (1987), 219-228.

Chrisman, N.R., "Design of Geographic Information Systems Based on Social and Cultural Goals," **Photogrammetric Engineering and Remote Sensing**, 53, 10 (1987), 1367-1370.

Craig, W.J., "Comment," **URISA Journal**, 3, 1 (1991), 57.

Crosswell, P.L., "Obstacles to GIS Implementation and Guidelines to Increase the Opportunities for Success," **URISA Journal**, 3, 1 (1991), 43-56.

De Reincourt, A., *The Soul of India*, Harper and Brothers, New York, NY, (1960).

Deboeck, G. and Kinsey, B., "Managing Information for Rural Development, Lessons from East Africa," World Bank Staff Working Papers, (1985), Number 379.

Eyre, L.A., "JAMGIS, The First Jamaican Government Comprehensive Multi-data Geographical Information System: Achievement and Problems," **International Journal of Geographical Information Systems**, 3 (1989), 363-371.

Fletcher, P.T., Bretschneider, S.I., and Marchand, D.A., *Managing Information Technology: Transforming County Governments in 1990s*, Center for Science and Technology, School of Information Studies, Syracuse University, Syracuse, NY, (1992).

Frank, A.U., Egenhofer, M.I., and Kuhn, W., "A perspective on GIS in the Nineties," **Photogrammetric Engineering and Remote Sensing**, 57 (1991), 1431-1436.

Frawley, W.J., Piatetsky-Shapiro, G. and Mathews, C.J., "Knowledge Discovery in Databases: An Overview," **Al Magazine**, (Fall, 1992), 57-70.

Fox, J.M., "Spatial Information for Resource Management in Asia: A Review of Institutional Issues," **International Journal of Geographical Information Systems**, 5 (1991), 59-72.

Garg, P.K. and Parikh, I.J., "Managers and Corporate Cultures: The Case of Indian Organizations," **Management International Review**, 26, 3 (1988), 50-66.

GIS World Inc., *1991/92 International GIS Source Book*, Fort Collins, CO, (1991).

Gecolea, R.H., "Information Systems for Rural Development," Information Systems for Government and Business – Trends, Issues, Challenges, *Proceedings of the International Seminar on the Information Systems Challenge for Government and Business*, Kawasaki City, Japan, (July 1987).

Goodchild, M.F., "Geographic Information Systems and Geographic Research," in J. Pickles (Ed.), *Ground Truth: The Social Implication of Geographic Information Systems*, The Guilford Press, NY, (1995), 31-51.

Gregory, D. and Urry, J., *Social Structures and Spatial Structures*, St. Martins Press, New York, NY, (1985).

Government of India (GOI), *Computerisation of Rural Development Information – A Manual*, Government of India, Ministry of Agriculture, Department of Rural Development, New Delhi, India, (1987).

Haldane, J.B.S., *Science and Indian Culture*, New Age Publishers, Calcutta, India, (1965).

Harley, J.B., "Deconstructing the Map," in T.J. Barnes and J.S. Duncan (Eds.), *Writing Worlds*, Routledge, London, UK, (1992), 231-247.

Harre, R., "Philosophical Aspects of the Micro-Macro Problem," in K. Knorr-Cetina and A.V. Cicourel (Eds.), *Advances in Social Theory and Methodology: Towards an Integration of Micro- and Macro Sociologies*, Routledge and Kegan Paul, London, UK, (1981), 139-160.

Harvey, D., *The Condition of Postmodernity*, Basil Blackwell, Oxford, UK, (1989).

Harris, M., Weiner. D., Warner, T.A., and Levin, R., "Pursuing Social Goals Through Participatory Geographic Information Systems," in J. Pickles (Ed.), *Ground Truth: The Social Implications of Geographic*

Information Systems, The Guilford Press, New York, NY, (1995), 196-222.

Hastings, K., "Current Environmental Issues – Part Two," **GIS Asia Pacific**, (February 1996), 27-29.

Hastings, P., *New Solutions for Sustainable Development – Linking Policies with Action*, Thailand Environment Institute, Annual Conference (1994), 29 July, Bangkok.

Hastings, P.J., "GIS in Sustainable Highland Development: Experiences from the TA- HASD Project," in J.S. Edrain and K. Tin-Seong (Eds.), *Sustainable Natural Resource Management and Spatial Planning in Developing Countries*, United Nations Centre for Regional Development, (1993), 99-140.

Hastings, D.A. and Clark, D.M., "GIS in Africa: Problems, Challenges, and Opportunities for Cooperation," **International Journal of Geographical Information Systems**, 5, 1 (1991), 29-39.

Healey R.G., "Database Management Systems," in, D. Maguire, M. Goodchild, and D. Rhind (Eds.), *Geographic Information Systems: Principles and Applications*, Longman, (1991), 251-267.

Heeks, R., *India's Software Industry*, Sage, New Delhi, India, (1996).

Hutchinson, C.F. and Toledano, J., "Guidelines for Demonstrating Geographical Information Systems Based on Participatory Development," **International Journal of Geographical Information Systems**, 7, 5 (1993), 453-461.

Huxhold, W.E., "The GIS Profession: Title, Pay, Qualifications," **Geo Info Systems**, 12 (22 March 1991).

"Informatics, Putting a Computer Tab on Natural Resources," **NIC Newsletter**, (1993).

Indian Society for Geomatics, Newsletter, November (1993), 2-3.

Jain, H.C., "Is There a Coherent Resource Management System in India?," **International Journal of Public Sector Management**, 4, 3 (1991), 435-450.

Jain, R.B. and Dwivedi, O.P., "Administrative Culture and Bureaucratic Values in India," **Indian Journal of Public Administration**, 36, 3 (1990), 435-450.

Jelinski, D.E., Goodchild, M. F. and Steyart, L.T., "Multiple Roles for GIS in Global Change Research: Towards a Research Agenda in Ecosystem to Global Scales," in S.G. Stafford , J.W. Brunt and W.K. Michener (Eds.), *Environmental Information Management and Analysis – Ecosystem to Global Scales*, Taylor and Francis, London, UK, (1994), 3-20.

Jianbang, H., "A Review of the Development of GIS in China Over the Last Decade," in *Geographic Model and Geographic Information System in China (summary)*, presented by Chinese geographers on the Thirteenth Session, Regional Conference on Asian Pacific Countries, (1990), 30-31, IGU, Regional Study and Exploitation Journal Press, Beijing, PRC.

Kakar, S., *A Psychoanalytic Study of Childhood and Society in India*, Oxford University Press, New Delhi, India, (1978).

Kasturirangan, K., "Sustainable Development and the Role of Geomatics," Vision 2000 Seminar, Indian Society for Geomatics and National Informatics Centre, New Delhi, India, (1994).

Khalil, R., "GI-Technology in Developing Countries: Challenges to be Faced," **GIM International Journal of Geomatics**, (June 1996), 28-29.

Kling, R., "Defining the Boundaries of Computing Across Complex Organizations" in R.J. Boland and R.A. Hirschheim (Eds.), *Critical Issues in Information Systems Research*, Wiley, Chichester, UK, (1987), 307-323.

Knorr-Cetina, K., "Introduction" in K. Knorr-Cetina and A.V. Cicourel (Eds.), *Advances in Social theory and Methodology: Towards an Integration of Micro- and Macro Sociologies*, Routledge and Kegan Paul, London, UK, (1981), 1-48.

Kumar, U. and Singh, K.K., "The Interpersonal Construct of the Indian Manager: A Determinant of Organizational Behaviour," **Indian Journal of Psychology**, 51 (1976), 275-290.

Kottak, C.P., "Putting People First – Sociological Variables in Rural Development," in M. Cernea (Ed.), *World Bank*, Washington D.C., (1991), 431-464.

Lahiri, M., "The Bihar GIS Project in India," in J.S. Edrain and K. Tin-Seong (Eds.), *Sustainable Natural Resource Management and Spatial Planning in Developing Countries*, United Nations Centre for Regional Development, (1993), 171-192.

Latour, B., *Science in Action: How to Follow Engineers and Scientists Through Society*, Harvard University Press, Cambridge, MA, (1987).

Lauer, D.T., Estes, J.E., Jensen, J.R. and Greenless, D.D., "Institutional Issues Affecting the Integration and Use of Remotely Sensed Data and Geographic Information Systems," **Photogrammetric Engineering and Remote Sensing**, 57, 6 (1991), 647-654.

Lee, S., "Geographic Information Systems and Organizational Transformation," AASHTO Geographic Information Systems for Transportation Symposium, Orlando, FL, (1991).

Levinson, A.G., "Institutional Issues in GIS Implementation," Working Paper, A.G. Levinson Consulting Inc., USA, (1989).

Lind, P., *Computerization in Developing Countries: Model and Reality*, Routledge, London, UK, (1991).

Madon, S., "Information Systems for Decentralised Rural Development Planning: Experiences from Indian and Malaysia," Working Paper, London School of Economics, London, UK, (1996).

Madon, S., "Introducing Administrative Reform Through the Application of Computer-based Information Systems: A Case Study of India," **Public Administration and Development**, 13 (1993), 37-48.

Madon, S., "Computer-based Information Systems for Development Planning: Managing Human Resources," **European Journal of Information Systems**, 2 (1993a), 49-55.

Madon, S. and Sahay, S., "Managing Natural Resources Using GIS: Experiences in India," **Information and Management**, Vol. 32 (1997), 45-53.

Madon, S. and Sahay, S., "Geographic Information Systems for Development Planning in India: Challenges and Opportunities," **Information Studies**, Vol. 2, 1 (January 1996), 3-24.

Maguire, D.J., Goodchild, M.F., and Rhind, D.W., "Geographical Information Systems," **London Scientific and Technical**, Vol. 1 (1991).

MAMPU, *An Annual Report on Computerization in the Malaysian Public Sector*, MAMPU, Malaysia, (1994).

Marble, D.F. and Wilcox, D.L., "Measure Twice – Cut Once: A Successful Approach to GIS Design and Implementation," **Proceedings of the Eleventh Annual ESRI User Conference**, Vol. 2, (1991), 585-597.

Marshall, E., "Bringing NASA Down to Earth," **Science**, 244 (16 June 1989), 1248, 51.

Masser, I., Campbell, H. and Craglia, M. (Eds.), *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Europe*, Taylor and Francis, London, UK, (1996)

Matheison, G., *Practical Issues in Developing an Urban LIS. GIS in Thailand: Strengthening User Networks*. A report compiled by the Thailand Development Research Institute, (1992), 1-9.

Medyckyj-Scott, D. and Hearnshaw, H.M. (Eds.), *Human Factors in Geographical Information Systems*, Belhaven Press, London, UK, (1993).

Merchant, J.W. and Ripple, W.J., "Special Issue: Geographic Information Systems," **Photogrammetric Engineering and Remote Sensing**, (November 1996), 1243-1244.

Murthy, A.N.N., "Natural Resource Data Management System: A Case Study," **GIS Asia Pacific**, (February 1996), 30-32.

Nag, P., "A Proposed Base for a Geographical Information System in India," **International Journal of Geographical Information Systems**, 1 (1987), 181-187.

Naipaul, V., *An Area of Darkness*, Andre Deutsch, London, UK, (1964).

NALIS, Announcement of NALIS '94, Symposium and Exposition, Kuala Lumpur, Malaysia, (1994).

Nandi, A., *At the Edge of Psychology: Essays in Politics and Culture*, Oxford University Press, New Delhi, India, (1990).

Narayan, L.R.A., "Operationalization of Remote Sensing," in *Proceedings of the International Symposium Operationalization of Remote Sensing*, International Institute for Aerospace Survey and Earth Sciences, Enschede, (1993), 131-140.

Nakamura, H., *Ways of Thinking of the Eastern*, East and West Centre Press, Honolulu, HI, (1964).

National Wasteland Development Board (NWDB), Document, Planning Commission, Government of India, (1987).

Nijkamp, P. and De Jong, W., "Training Needs in Information Systems for Local and Regional Development and Planning," **Regional Development and Dialogue**, 8, 1 (1987), 72-119.

Obermeyer, N. J., "Bureaucratic Factors in the Adoption of GIS by Public Organizations," **Computer Environment and Urban Systems**, 14, 3 (1993).

Pelkey, N., "Fibs, Darned Fibs, and GIS in Environmental Monitoring: Histories of Forest Loss in Tamil Nadu." Chapter 7 in *Unraveling the Commons: A Comparison of Four Habitat Management Regimes in Southern India* (1 June 1997) 237 pages. Unpublished.

Pepper, S.C., *World Hypotheses, A Study in Evidence*, University of California Press, Berkeley and Los Angeles, CA, (1942).

Perquet, D.J. and Bacastow, T., "Organizational Issues in the Development of Geographical Information Systems: A Case Study of US Army Topographic Information Automation," **International Journal of Geographical Information Systems**, 5, 3 (1991), 303-319.

Phantumvanit, D. and Hastings, P., "Geographic Information Systems: A Review of Policy Issues Facing Thailand," Ninth Asian Conference on Remote Sensing, Bangkok, Thailand, (1988).

Pickles, I. (Ed.),"Representations in An Electronic Age: Geography, GIS, and Democracy," in *Ground Truth: The Social Implications of Geographical Information Systems*, Guilford Press, New York, NY, (1995), 1-30.

Radhakrishnan, S., *The Hindu View of Life*, Lotus, New Delhi, India, (1993).

Rais, J. and Suharto, P., "Land Resource Evaluation and Planning Project: A Geographic Information System Application for Regional Planning in Indonesia," **Regional Development Dialogue**, Vol. 11, 3 (Autumn 1990), 143-169.

Robey, D. and Newman, M., "Sequential Patterns in Information Systems Development: An Application of A Social Process Model," **ACM Transactions of Information Systems**, 14 (1996), 30-63.

Robey, D. and Sahay, S., "Transforming Work with Information Technology: Comparative Study of GIS in Local Government," special issue on IT and organizational work, **Information Systems Research**, Vol. 7, 1 (1996), 93-100..

Roe, G.V., "An Organizational Approach to Implementing GIS," **URISA Journal**, 3, 2 (1991), 81-84.

Roland, A., "The Self in India and America," in V. Kavlois (Ed.), *Designs of Selfhood*, Associated University Press, New Jersey, (1984).

Rondinelli, D.A. and Cheema, G.S. (Eds.), "Implementing Decentralisation Policies: An Introduction," in *Decentralisation and Development*, Sage Publications, (1983), 9-34.

Saha, A., "The Caste System in India and its Consequences," **International Journal of Sociology and Social Policy**, 13/3, 4 (1993), 1-76.

Saha, A., "Basic Human Nature in Indian Tradition and its Economic Consequences," **International Journal of Sociology and Public Policy**, 12/1, 2 (1992), 1-50.

Saha, A., "Traditional Indian Concept of Time and its Economic Consequences," **International Journal of Sociology and Social Policy**, 10, 7 (1990), 58-79.

Sahay, S., Personal interview with Vice Minister, Ministry for Industries, Hanoi, Viet Nam, (12 June 1997).

Sahay, S. and Robey, D., "Organizational Context, Social Interpretation, and the Implementation and Consequences of Geographic Information Systems," **Accounting Management and Information Technologies**, 6, 4, (1997), 255-282.b

Sahay, S. and Walsham, G., "Social Structure and Managerial Agency in India," **Organization Studies**, Vol. 18, 3, (1997), 415-444.

Sahay, S. and Walsham, G., "Implementation of GIS in India: Organizational Issues and Implications," **International Journal of Geographical Information Systems**, 10, 4 (1996), 385-404.

Samad, R.A., "Sabah Forest Management Information System," in *Proceedings of NALIS '94, Symposium and Exposition*, Kuala Lumpur, Malaysia, TS3.5 (1994), 1-27.

Sheshagiri, N., "Dovetailing Informatics and Geomatics as a Technology – Its Futuristic Development," Vision-2000 Seminar, organized by the Indian Society for Geomatics and NIC, New Delhi, India, (1994).

Sieber, R.E., Assess Employee GIS Perceptions Early – "A Simple, Radical and Cheap Approach to Addressing Management Issues," *Proceedings of the 1991 Urban and Regional Information System Association*, Vol. 2 (1991), 66-77.

Simmonett, O., "Geographic Information Systems for Environment and Development," **Geo-Processing Reihe**, (Geoprocessing Series), Geographisches Institut der Universität, Zurich, Switzerland, (1993).

Singh, J.P., "Managerial Culture and Work-related Values in India, Reply and Comment, **Organization Studies**, 11, 1 (1990), 75-106.

Sinha, D., "Basic Indian Values and Behaviour Dispositions in the Context of National Development," in D. Sinha and K.S.R. Kao (Eds.), *Social Values and Development*, Sage, New Delhi, India, (1988).

Sinha, J.B.P. and Sinha, D., "Role of Social Values in Indian Organizations," **Indian Journal of Psychology**, (1990), 705-714.

Sommers, R., "Organizational Change for Successful Implementation," *URISA 1989*, Annual Conference Proceedings, Urban and Regional Information Systems Association, (1989), 39-51.

Smith, R.S., "Resolving Discrepancies Between Records During Modernization of the Assessment Cadastre," *Proceedings of the Fifty-Fifth Conference on Assessment Administration*, (1989), 9-21.

Son, N.D., "Industrial Development in Viet Nam and the South-East Asia Region," report presented at a UNIDO Training Course on GIS Applications for Water Management, Hanoi, Viet Nam, (9-18 June 1997).

SPCM, "Decision Support Systems and Environmental Impact Assessment for Industrial Development," Scientific Planning and Coordination Meeting, International Centre for Science and High Technology, Final Report, Trieste, Italy, (October 1996).

Stafford, S.G., Brunt, J.W. and Michener, W.K., "Integration of Scientific Information Management and Environmental Research," in W.K. Michener, J.W. Brunt and S.G. Stafford (Eds.), *Environmental Information Management and Analysis – Ecosystem to Global Scales*, Taylor and Francis, London, UK, (1994), 3-20.

Swanson, E.B., *Information Systems Implementation*, Irwin, Homewood, IL, (1988).

Taylor, D.R.F., Preface, "GIS in Developing Nations," **International Journal of Geographical Information Systems**, 5, 3 (1991).

Taylor, D.R.F., "GIS and Developing Nations," in D.J. Maguire, M.F. Goodchild and D.W. Rhind (Eds.), *Geographical Information Systems*, Vol. 1, London Scientific and Technical, London, UK, (1991a).

Thailand Environment Institute, *An Action Plan to Implement GIS Technology in the Department of Mineral Resources*, Thailand Environment Institute, Bangkok, Thailand, (1994).

Thompson, B., "The Dazzling Benefits (and Hidden Costs) of Computerized Mapping," **Governing**, (December 1989), 40-45.

Unni, N.V.M., "Space and Forest Management in India," ITC Conference on the Operationalisation of Remote Sensing, Enschede, Netherlands (1993), 49-97.

Valluri, S.R., "CSIR and Technological Self-reliance," **Economic and Political Weekly**, (3 April 1993), 565-568.

Visvalingam, M., "GIS in Malaysia," Report, University of Hull, UK (1990), 55-56.

Walsham, G., *Interpreting Information Systems in Organizations*, Wiley, Chichester, UK, (1993).

Wunsch, J.S., "Institutional Analysis and Decentralisation: Developing an Analytical Framework for Effective Third World Administrative Reform," (1991).

Yaakup, A., Ibrahim, M. and Johar, F., "Incorporating GIS into Sustainable Urban and Regional Development: The Malaysian Case," Geoinformatics, Hong Kong, International Symposium on Remote Sensing, *Geographical Information Systems in Environmental Monitoring and Sustainable Development*, Vol. 2, (1995), 72-73.

Yapa, L.S., "Computer-aided Regional Planning: A Study in Rural Sri Lanka," **Environment and Planning B**, 15 (1989), 285-304.

Yeh, A.G., "The Development and Applications of Geographic Information Systems in the Developing Countries," **International Journal of Geographical Information Systems**, 5 (1991), 5-27.

Yuk Wah, T., "The Challenges and Returns of Establishing the Singapore Land Data Hub," in *Proceedings of NALIS '94, Symposium and Exposition*, Kaula Lampur, Malaysia, Paper TS2.5 (1994), 1-9.

Zin, M.A.M., "Towards Malaysian Geographic Information Standards," in Proceedings of NALIS '94, Symposium and Exposition, Kuala Lumpur, Malaysia, TS1.2 (1994), 1-20.

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

EMERGING TECHNOLOGY SERIES

(incorporating the Technology Trends Series and Industrial Technology Monitors)

If you would like to receive any of the following publications in future, please complete the list below and return to the address indicated. Please note that all publications are available in English only, and are free of charge to readers in developing countries; for readers in developed countries a handling fee of US$ 40 per annum is imposed for Genetic Engineering and Biotechnology; Information Technology and New and Advanced Materials.

For new subscribers only

- ❑ GENETIC ENGINEERING AND BIOTECHNOLOGY (four issues per year)
- ❑ INFORMATION TECHNOLOGY (formerly Microelectronics) (four issues per year)
- ❑ NEW AND ADVANCED MATERIALS (formerly Advances in Materials (four issues per year)
- ❑ MARINE INDUSTRIAL TECHNOLOGY (two issues per year)
- ❑ HIGH-TECHNOLOGY SPIN-OFFS (two issues per year)

Special issues

- ❑ ADVANCED MATERIALS No.2 (New, Advanced and Improved Traditional Materials and Processes)
- ❑ ENVIRONMENTALLY SOUND MANAGEMENT OF BIOTECHNOLOGY (The Task Managers' Report on Chapter 16 of Agenda 21)
- ❑ FOOD PROCESSING TECHNOLOGIES FOR AFRICA
- ❑ THE USE OF GEOGRAPHICAL INFORMATION SYSTEMS IN DEVELOPING COUNTRIES: SOCIAL AND MANAGEMENT ISSUES

FAMILY NAME AND GIVEN NAMES	
TITLE OR POSITION	
ORGANIZATION OR COMPANY	
STREET AND/OR P.O. BOX NO.	
CITY AND COUNTRY	

Return to:

UNIDO, Industrial Information Section, P.O. Box 300, A1400 Vienna, Austria
Fax: (+43) 1-21131-6843

INVESTMENT AND TECHNOLOGY PARTNERSHIP INITIATIVE

Investment and technology play a vital role in the industrial growth of developing countries as well as in their gradual integration into the international economy. However, the changing national and international economic environments are prompting developing countries to take a fresh look at their efforts to secure and widen investment and technology flows.

While UNIDO is one of several institutions promoting investment to developing countries, it is the only one with a comprehensive background in industrial development and technology transfer. UNIDO can therefore be instrumental in linking investment promotion with technology upgrading and the enhancement of technological capabilities. UNIDO is in the position to provide a wide range of services to facilitate developing countries in gaining access to investment resources, technology and know-how, marketing and managerial skills, as well as in upgrading their domestic capabilities in these fields

EMERGING TECHNOLOGY SERIES

Technology is now at the core of competitive strategies of successful industrial firms. The new and rapidly evolving generic technologies, such as biotechnology, new materials and information technologies, offer many opportunities and challenges for broad competitive strategies. They engender entirely new products, services, markets and businesses. Their impact is trans-sectoral, radically improving the competitiveness of products, processes and services of firms in a large number of traditional industrial sub-sectors. New materials improve product specifications and lower production costs in engineering and chemical industries; biotechnologies save energy and raw materials in chemicals, pharmaceuticals and food processing, while the pervasive applications of information technologies allow companies in all industrial sectors to re-engineer critical processes, improve overall efficiency and raise productivity across functional areas. Monitoring and access to information is now a key to competitiveness.

Experience in newly industrialized countries shows that access to reliable technical information can be instrumental in allowing manufacturers to leap whole periods of technological development and adopt state-of-the-art systems directly – without needing to undertake a painful and costly development phase. Up-to-date economic information and analysis of global economic trends and the prevailing industrial situation in other countries is likewise indispensable – and the gateway to identifying industrial needs, opportunities, constraints and priorities of the country and region concerned. Monitoring technological advances and economic analysis provide the basis for the formulation and effective implementation of appropriate industrial programmes and projects by both public and private entities. For developing countries, with their limited resources and often greater susceptibility to the negative aspects of technology-led change, such activities are doubly important. Yet many developing countries still lack the critical elements for technology monitoring of emerging technologies and their implications for national development strategies. If they are to maximise the benefits and minimize the negative effects of technology on social and economic development, developing countries must manage technology in an appropriate manner – and monitoring is an essential element of that management process.

One of the objectives of UNIDO is to carry out a set of coherent activities at the national, regional and international levels, to help developing countries at different stages of development to acquire, apply, develop and manage technologies against a global background of technological change. Investment and technology play a vital role in the industrial growth of developing countries, as well as their gradual integration into the international economy. Although most developing countries now have liberal regimes for investment and technology transfer, this is not a sufficient condition for industrial growth. There is a need for a wide-ranging investment and technology approach that will not only attract and retain the inflows of investment and technology, but also make the optimum use of them for the domestic economy. UNIDO's wealth of experience in industrialization, combined with its worldwide network of contacts makes the Organization an ideal partner to assist developing countries in building up their investment and technology partnerships. The Organization is a focal point of industrial technology; it is a global source of industrial information; and it is an honest broker for industrial cooperation.

Through this new series of publications on emerging technologies in developing countries, which supercedes the ***Industrial Technology Monitors*** and the ***Technology Trends Series***, UNIDO plans to sensitize industry and governments to the need for and requirements of technology monitoring and assessment in the areas of new and emerging technologies. These technologies play a catalytic role in the development process of the new global pattern of rapid and accelerating technological change, sweeping trade liberalization, far-reaching deregulation of markets – including the privatization of state-owned enterprises and commercialization of R&D – and the globalization of international business.

Investment and Technology Promotion Division
November 1997