2007

Environmental Information Systems and Community-Based Resource Management in Ghana: An Investigation of Institutional Policy and Implementation in Context

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Your file Votre référence
ISBN: 978-0-494-38000-0
Our file Notre référence
ISBN: 978-0-494-38000-0

ENVIRONMENTAL INFORMATION SYSTEMS AND COMMUNITY-BASED RESOURCE MANAGEMENT IN GHANA: AN INVESTIGATION OF INSTITUTIONAL POLICY AND IMPLEMENTATION CONTEXT

By

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A thesis submitted to the Faculty of Graduate Studies

in Partial Fulfillment of the

Requirements for the degree of Doctor of Philosophy in Geography

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ABSTRACT

This study employed a case-study approach and cross-case analysis to investigate the impact of Environmental Information Systems (EIS) and Local Knowledge Systems (LKS) on agro-forestry management and biodiversity conservation. Questionnaire-based interviews with service providers, resource managers and focus group discussions with farmers associated with the United Nations Capacity 21, the Netherlands Tropenbos International (TBI) and the United Nations Project on People Land Management and Conservation (UNPLEC), projects yielded in-depth information on agro-forestry practices in southern Ghana. The findings of the survey revealed that computer-based information systems have been used to identify areas of resource degradation. This has served as a sanitization tool to organize and intensify tree-planting exercises and agro-forestry management activities in the affected areas.

Evaluation of individual cases and cross-case analysis of EIS projects in Ghana showed parallels and divergences in the modus operandi of EIS implementation at national and district levels. The Capacity 21 project initiated the District Environmental Resource Information System (DERIS). The project procured datasets (eg. satellite images, software, computers and printers) in 8 pilot districts including Sekyere West and Assin Fosu Districts and offered training and skill development programmes under the auspices of the Centre for Environmental Remote Sensing and Geographic Information Services (CERSGIS) to equip focal district planning officers to use tools and datasets to analyze the state of the environment and the extent of resource degradation as well as other development-related activities. This fostered cooperation between the national coordinator of the project, district planners and local farmers to organize regular tree-

planting exercises and workshops on alternative livelihood activities which have helped to lessen pressure on the environment to some extent. This approach exhibits a greater degree of top-down planning and implementation.

The field survey revealed that PLEC used computer-based information systems during the earlier stages of the project to demarcate demonstration sites and capture spatio-temporal variations in agro-ecological conditions. However, during the subsequent phases, the PLEC project relied heavily and predominantly on local agro-ecological knowledge from a diverse group of farmers to assess resource conditions, and promoted the use of various traditional and exotic agro-forestry and agro-diversity management techniques in the Manya Krobo and Suhum Kraboa Coaltar Districts. The PLEC approach was more bottom-up in its philosophy and practice by allowing natural and social scientists to learn from farmers, and the scientists in turn offered technical advice which enabled farmers to improve their local farming techniques and maximize their farm productivity, while at the same time enhancing the capacity of the biophysical environment to support conventional and alternative livelihood activities continually. The Tropenbos International (TBI) project exhibits elements of both top-down and bottom-up implementation approaches. It recognizes the significant role of tailor-made information (computer-based systems and socio-economic studies mainly from the Forest Services Commission and the University of Ghana, respectively) and skill in forest management. The TBI GORTMAN project streamlined the capacity for information collection in the Goaso and Offinso districts.

The findings revealed that farmers associated with the three projects apply various knowledge systems and techniques in agroforestry management. These include, mixed cultivation of domestic, economic and medicinal trees as well as food crops. Reasons such as windbreak, construction materials, medicine, food, fuelwood and nutrient enhancement were cited by farmers for practicing agroforestry. Common food crops found on farms include cocoyam, okro, maize, plantain and yams, among others. These crops are the mainstay of family food and income sources. Other livelihood activities include beekeeping, snail rearing and grasscutter raising and livestock breeding. The diversities of agroforestry practices have engendered decades of farm management practices and resource conservation measures. Another challenge of agroforestry management which is common to all the three projects is that farmers are victims of indiscriminate felling of trees on their farms by timber companies which destroys their crops.

Farmers repeatedly cited logistical (tools, seedlings etc) challenges and financial constraints as factors that hamper effective application of knowledge systems in agroforestry management. This is a dominant problem that PLEC and TBI farmers face. Capacity 21 farmers benefited initially from logistical supplies but it was short-lived.

In view of these problems, the study recommended measures for improving environmental information systems and local knowledge systems applications in agroforestry management and agrodiversity conservation in southern Ghana.

ACKNOWLEDGEMENT

I extend my gratitude to the International Development Research Centre (IDRC) for offering me doctoral research award, which enabled me partly finance the field expenses. The comments from the IDRC reviewers were valuable for a successful completion of the field survey.

I wish to extend my appreciation to all those who contributed in one way or the other towards a successful completion of this research and report. I specifically thank my advisor, Dr. Scott Slocombe for his invaluable support and directions. I am grateful for the important assistance of my committee members; Dr. Bob Sharpe, Dr. Isaac Luginaah and Dr. Kevin Hanna whose knowledge and expertise helped shape this study and report.

I am grateful for the assistance from Professors Paul Yankson and Edwin Gyasi, University of Ghana for their advice, faithful commitment and constant support during the field study. I extend my regards to Mrs. Kinful Aryee (Faculty of Education, University of Western Ontario), Mr. Clement Tuonuru (Department of Geography, University of Ghana), Mr. Eric Adomako (Assin Fosu District Assembly), Ms Anneke Wieman and Mr. Kwame Okae (Information Centre, Tropenbos International) and Mr. Ofosu (Ministry of Environment, Science and Technology).

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ACRONYMS

ADRA	Adventist Development and Relief Agency
BOP	Balance of Payment
CBRM	Community-Based Resource Management
CEC	Community Environmental Committees
CERSGIS	Centre for Environmental Remote Sensing and Geographic Information Science
CIDA	Canadian International Development Agency
CRMU	Collaborative Resource Management Unit
CSIR	Centre for Scientific and Industrial Research
DA	District Assembly
DACF	District Assembly Common Fund
DCEMC	District Community Environmental Management Committees
DERMIS	District Environmental Resource Information Systems
DPC	District Planning Committees
DPCU	District Planning Coordinating Units
DERIS	District Environmental Resource Information System
EBK	Ethno Botanical Knowledge
EIS	Environmental Information Systems
EISD	Environmental Information Systems Development
EPA	Environmental Protection Agency
ESICOME	Expanded Sanitary Inspection Compliance and Environment
FAO	Food and Agriculture Organization
FC	Forestry Commission
FEWS	Famine Early Warning System
FR	Forest Reserve
FSC	Forest Services Commission
FSD	Forest Services Division
GAPVOD	Ghana Association of Voluntary Organizations in Development (GAPVOD)
G-CAG	Ghana-Country-at-A-Glance
GDP	Gross Domestic Product
GEF	Global Environment Facility

GERMP	Ghana Environmental Resource Management Project
GIS	Geographic Information Systems
GPS	Geographic Positioning System
GRATIS	Ghana Regional Appropriate Technology Industrial Service
HSD	Hydrological Services Department
IAC	International Advisory Committee
ICBD	Integrated Community-based Development Programme
ICT	Information and Communication Technologies
IFAD	International Fund for Agricultural Development
IIED	International Institute for Environment and Development
IIGSEO	International Institute of Geo-Information Science and Earth Observatory
IK	Indigenous Knowledge
IKE	Information and Knowledge-based Economies
IKS	Indigenous Knowledge Systems
ISSER	Statistical, Social and Economic Research
ITK	Indigenous Technical Knowledge
ITTU	Intermediate Technology Transfer Unit
IWRMI	International Water Resource Management Institute
KNITC	Knowledge Network Information and Technology Centre
KNRMP	Kumasi Natural Resource Management Project
KNUST	Kwamen Nkrumah University of Science and Technology
LIIS	Local-level Integrated Information System
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MEST	Ministry of Environment, Science and Technology, Ghana
MOFA	Ministry of Food and Agriculture, Ghana
NACIA	National Committee for Implementation of Agenda 21, Ghana
NADMO	National Disaster Management Organization, Ghana
NAFGIM	National Framework for Geo-spatial Information Management, Ghana
NAP	National Action Plan, Ghana

NAS	National Academy of Sciences, USA
NEA	National Environmental Agency, Ghana
NEAP	National Environmental Action Plan, Ghana
NRC	National Research Council
NIFP	Non Timber Forest Product
NTIA	National Telecommunication and Information Administration
OFR	Off-Forest Reserve
OOC	Object-Oriented Classification
PPGIS	Public Participation Geographic Information System
RCC	Regional Coordinating Council
RESPRO	Renewable Energy Services Project
RMSC	Resource Management Support Centre
RNRI	Kumasi Renewable Natural Resource Institute
RPK	Rural People's Knowledge
RSAU	Remote Sensing Applications Unit
SHD	Sustainable Human Development
SLA	Sustainable Livelihood Approach
SRI	Soil Research Institute
TBI	Tropenbos International
TEK	Traditional Environmental Knowledge
TOF	Trees-Off-Forest
TK	Traditional Knowledge
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNITAR	United Nations Institute for Training Research
UNPLEC	United Nations Project on People Land Management and Environmental Conservation
UNU	United Nations University
USAID	United States Agency for International Development
WAPLEC	West Africa Project on People Land Management and Environmental Conservation
WCED	World Commission on Environment and Development

WRI	World Resources Institute

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Introduction

A major challenge in developing countries is to increase and secure food production for a growing population while, at the same time, conserving natural diversity of crops, livestock, plants and other life forms in-situ (Gyasi, 2002). Striking a balance between food security and environmental sustainability requires adequate data and information on natural resources and the extent of human impacts on them. The need for improved and relevant information on the environment in turn is a prerequisite to manage natural resources towards helping to achieve sustainable development (Prevost and Gilruth 1997). Folloux (1989) argues that sub-Saharan Africa is probably the region of the world in greatest need of frequently updated information, particularly on renewable resources, due to its extremely fast changes in population, land tenure, land use and renewable resources compared to other continents. Yet, it cannot afford such information. Hence, tailor-made, people-centred and cost-effective information systems supplemented by local knowledge systems have been espoused by experts and community-based resource managers as necessary conditions for addressing the recurring environmental problems in developing countries.

In Ghana, natural resources are under continuous threat of degradation due to population growth, overexploitation, smaller farm lands, shorter fallow periods, excessive logging, charcoal production and land-use changes (TBI, 2005). A critical issue of resource management is the incessant forest degradation and loss of biodiversity associated with unsustainable harvesting in the high forest and savanna, and inappropriate farming practices. Hence, the survival of indigenous varieties of important food crops and an increasing number of medicinal plant species are being threatened. The aim of improving information use in agriculture is to reduce poverty by increasing productivity in food crops and conserving the biophysical environment. These problems are compounded by adverse social, political, and economic developments. Efforts to address these environmental problems have led to the emergence of donor-funded environmental initiatives some of which operate independently or in collaboration with the Government of Ghana. The United Nations Project on People Land Management and Conservation (UNPLEC), the United Nation's Development Programme/Ghana Capacity 21 Project, and the Netherlands Tropenbos (Tropical Forest) International (TBI) are examples of such projects. The operational objective of the TBI is to provide knowledge, information, methods and techniques relevant to policy formulation and forest management. The project focuses on institution building, training and community participation (TBI, 2001). Similarly, the UNDP\Ghana Capacity 21 Programme has a District Environmental Resource Management Information Systems (DERMIS) that provides datasets, information and services for resource management at the district level (Saaka, 2001). In the case of the PLEC, farmers use indigenous knowledge, local initiatives and new information to manage their land (Gyasi, 2004). A common feature of these projects is the integration of Environmental Information Systems (EIS) and Traditional or Indigenous Knowledge Systems (IKS) for agro-forestry management and biodiversity conservation.

Unfortunately, Ghana has been riddled with environmental projects which are donor-funded, supply-driven, expert-oriented, top-down and ad-hoc in nature. The technical burden involved in such projects inhibits the use of the data by non-specialists (farmers and resource managers) unfamiliar with the intricacies of environmental information systems. In addition, contemporary environmental management trends have relegated traditional systems of environmental protection and sustainable development to the background (UNDP, 2001).

The opportunity for using EIS and LKS in natural resource management at the community-level reveals the benefits and problems of adding spatial and ecological details to decision making as they are developed for indigenous natural resource management (Walker and Young, 1997). A number of issues currently underpin the sustainable application of EIS and local knowledge systems in community-based natural resource management in southern Ghana. These issues serve as opportunities or pose serious challenges to the implementation process. A World Bank (2002) study of natural resource management in Ghana indicated that while undertaking resource management projects, researchers have to realize that environment, economy, politics, and social factors are all interrelated (as in systems thinking) and all have to be taken into account when working towards practical meaningful environmental management. Due to this there are uncertainties in the implementation of UNDP/Ghana Capacity 21, PLEC and TBI projects in an unpredictable environment which involves major biophysical irregularities, political instability and economic fluctuations which will affect the use of EIS for sustainable agro-forestry management. Unsatisfactory understanding of the intricacies of socio-economic conditions, local culture and informal institutions can pose serious challenges to the application of environmental information systems.

1.2 Research problem and questions

Thus, key research questions of this study are; (1) Does EIS application enhance access to data/knowledge and participation of district planners, resource managers and farmers in agro-forestry management? (2) Does EIS application promote sustainable agro-forestry management in southern Ghana? Emerging from these two questions are relevant sub-questions which relate to the EIS component of the UNDP/Ghana Capacity 21, PLEC and TBI projects in local communities in Ghana and the role of alternative knowledge system in promoting agroforestry management at the grassroot level. Rural communities are marginally integrated into the entire resource management initiatives. One major misgiving about the application of EIS to natural resource management is unequal access to spatial information tools. A related issue to this problem is awareness of the existence of data, information and knowledge systems and how they can be used to enhance agroforestry management and biodiversity conservation. Awareness of the existence of information alone does not necessarily guarantee timely access to accurate, reliable and relevant information, especially in marginalized rural societies which are far removed from information society.

Another problem is whether the existing environmental information system designed by experts is compatible with users' needs, skills and tasks. There are concerns about whether or not EIS application in biodiversity conservation and agroforestry management are ecologically and socially appropriate for the intended community user groups. In a study of information systems application in Bali, Indonesia, Subaryono (1996) asserts that sometimes GIS users are "successful acquirers" of GIS but this does not necessarily mean they are "successful users" of GIS. This assertion is not an isolated case because unique local conditions can create circumstances that enhance or inhibit progress in the implementation of EIS projects within communities in Ghana.

At the biophysical level, an important problem which must be explored is how EIS application promotes agro-forestry management. This stems from the fact that some environmental initiatives and EIS-based projects prove to be less sustainable in developing countries, or completely unsustainable. Enthusiasts of environmental sustainability often grapple with the problem of whether EIS use can actually improve upon the integrity, function, species diversity and intrinsic value of land, soil and vegetation resources. Further, what level of resources and logistics will be required to accomplish this goal? Environmental initiatives such as UNDP/Ghana Capacity 21, PLEC and TBI in Southern Ghana, as with many other environmental initiatives, are currently predominantly or exclusively donor-driven. The question often posed is to what extent does ad-hoc donor funding guarantee continuity of EIS application in natural resource management? The study unearths the financial principles and mechanisms formulated and implemented to ensure continuous application of EIS in agroforestry resource management.

Preliminary field survey in Ghana revealed that information systems application in agroforestry management vary from one level to the other depending on the methods of operation and available logistics. Hence, sophisticated EIS are employed at the national level by data providers, namely Forestry Services Commission (TBI), Centre for Environmental Remote Sensing and Geographic Information Services (CERSGIS) under the auspices of Capacity 21 and minimal application under the PLEC project. The second tier of EIS application is the district level. This is undertaken by planning officers at the

District Assemblies. Most of the planning officers have been trained by either CERSGIS or TBI Forest Services Commission. These two levels have institutional frameworks and protocols for data collection, skill acquisition and knowledge and information dissemination. Hence, the type of information systems usually applied at the national and district levels are sophisticated than those at the local level where there is low literacy rate among farmers and minimal exposure to computers. At this level, community-based knowledge system has been the most predominant knowledge systems used for agro-forestry management. The focus group discussions component of the survey captured the nature, processes and progress made in applying local knowledge systems into agro-forestry management and biodiversity conservation. Local knowledge systems are context-specific, shared and transmitted across generations. The research question evolved to accommodate local knowledge systems at the community level. Failure to incorporate local knowledge systems into the assessment of knowledge system would have created a huge gap in the study of end user part of information system application.

Within the context of this study, agro-forestry refers to the intentional mix of agriculture and forestry on the same land management unit. It has been defined as phases in the development of a productive agro-ecosystem for increased social, economic and environmental benefits (Leakey, 1996). Its technologies include multipurpose tree species and tree crop and/or livestock mixtures. Agro-forestry helps farmers to produce food, wood fuel and/or construction materials and generate income from the sale of agro-forestry products, while protecting and improving their ecosystem. Biodiversity conservation focuses on the variety and variability of biological life considered in terms of its hierarchical composition at genetic, species, and ecosystem levels (Grimble and Laidlaw, 2002).

1.3 Objectives of this Research

The study examines effectiveness, efficiency and sustainability of EIS application in agro-forestry management and biodiversity conservation by employing multiple case study, interviews and group discussions. Guided by a conceptual framework I developed out of the Systems Theory and Political Ecology literature as well as the iterative process of EIS integration into CBRM, this research analyzes a range of situations where EIS have been used to address community-based agro-forestry management problems. This study addressed the following objectives;

Objective 1: To analyze a range of situations where EIS have been used to address community-based agro-forestry management problems and examine their effectiveness and effciency.

Objective 2: To evaluate the impact of workshops, training and skill development programmes on EIS application in agro-forestry conservation at the district level.

Objective 3: To assess how economics and institutional procedures affect EIS and LKS access and use for agro-forestry management in Ghana.

Objective 4: To determine the sustainability of EIS and LKS programmes and how it can meet the changing needs of resource managers and local people.

Past assessments of EIS applications in resource management in Ghana have been done with a national and regional outlook and virtual neglect of individual users at the community level who are at the helm of natural resource mangement. The more proactive approach adopted in this research is to focus on the end users of EIS and also to explore the role of alternatives, such as LKS in agroforestry management. This research was timely, and evaluated the impact of workshops, training and skill development programmes on EIS applications in agro-forestry conservation at the district level. This has helped to adopt a more holistic and pragmatic assessment of the interplay of socio-economic, institutional and political factors which impinge on EIS use in agro-forestry or agrodiversity management.

1.4 Contribution of the Thesis

This report will guide current and future efforts to develop long-term sustainable EIS and LKS applications in agro-diversity conservation, in which human, technical and financial resources are wisely and efficiently used to ultimately improve the environment. In addition, this document provides mechanisms for exchange and spread of knowledge of best practices of EIS application in agro-forestry management and agro-diversity conservation and suggests possible ways of enhancing efficiency and effectiveness.

The findings of this study will bridge the gap in the literature by providing a set of policy and institutional guidelines and indicators relevant for EIS and LKS application in agro-forestry management at the grassroots level. These indicators will serve as yardsticks for measuring sustainability of EIS application. Armed with these indicators and guidelines, environmental managers can forecast and devise practical solutions to the institutional and policy problems that arise during the design and implementation processes. The problems of EIS implementation may not be related to institutions alone, but to the socio-cultural milieu within which it is used. I am optimistic that the findings of this study will serve as a ground-breaking step in modifying and re-shaping EIS to suit local agro-diversity and agro-forestry conservation needs. It will also provide mechanisms for integrating pubic opinions and community values and aspirations into the development and implementation phase of EIS. Finally, this dissertation highlights best practices in EIS application and serves as a model for applications in other developing countries with similar resource management needs, environmental conditions and technological capacities.

This study explores new ways of integrating environmental information with local knowledge systems for community-based agro-forestry management. This will enhance the benefits of combining local ecological knowledge with information systems and address the mis-match between the skill requirements inherent in EIS and the skill of local people. It will help to provide tailor-made information and knowledge systems which can easily be used by illiterate farmers, community leaders and resource managers. It will make it easier for people to afford EIS and other knowledge systems in natural resource management. It also provides means of crafting EIS to meet the skills and other needs of local people to use them effectively, and explores ways of re-crafting EIS to meet the user needs and skills of locally-based resource managers.

1.5 Organization of the Dissertation

This dissertation is organized into six chapters. Chapter 1 provides general background and outlines the problems that stimulated the field study. The rationale for this research and the expected application of the findings are also presented in this chapter.

Chapter 2 discusses the theoretical approaches that informed and shaped this study. It highlights issues of sustainable environmental management, systems theory and political ecology of EIS and LKS application in agro-forestry management. Indigenous knowledge is also discussed as an integral part of the continuum of information systems and as a foundation for community-based resource management. The literature review addresses various contextual and implementation issues that determine the success or failure of EIS and LKS projects and compares different methods of evaluating the sustainability of local land use management systems.

The research techniques and design are presented in Chapter 3. In addition, I present the rationale for the project selection and criteria used to demarcate the respective project communities which were earmarked for the survey. There is also a comparison of the different methods of evaluating EIS applications in natural resource management in developing countries and illustration of an integrated and context-specific framework for assessing the efficiency and sustainability of EIS and LKS application in rural resource management. Finally, various approaches for compiling, coding, and analysis of the survey responses are stated in this section.

Chapter 4 offers an overview of Ghana's political, economic, social, agricultural and current environmental situations. It traces the evolution of Environmental Information in Ghana with reference to the UNDP/Ghana Capacity 21, PLEC and TBI projects. It explains the emergence of Local Knowledge Systems, the dynamics of their inter-generational acquisition and accumulation and mechanisms for their application in community-based natural resource management. The various approaches for community-based natural resource management in Ghana are also discussed in the light of EIS and IKS applications. The underlying human resource and socio-economic conditions of community development with special reference to population, socio-economic, and institutional policy are examined.

Chapter 5 discusses the findings of the field survey. It describes and classifies the various EIS and IKS used under the UNDP/Ghana Capacity 21, PLEC and TBI projects in their respective districts. District-level EIS used in agro-forestry management and village-level conservation techniques and customary practices are discussed. In the context of a systems approach, this chapter examines the institutional policies, political, socio-economic and human resource development and contextual issues of EIS implementation in natural resource management. Chapter 5 also provides a synthesis of the research findings. It offers cross-case comparison and analysis of the UNDP/Ghana Capacity 21, PLEC and TBI EIS projects vis-à-vis agro-forestry management to determine their relative effectiveness and efficiency. The chapter also presents best practices, improvisations, failures and coping mechanisms.

Chapter 6 summarizes the research findings, draws conclusions and provides recommendations and leads for future research in order to improve the use of EIS and IKS in natural resource management.

CHAPTER TWO: THEORETICAL UNDERPINNINGS AND THE CONTEXT OF EIS IMPLEMENTATION

2.1 Introduction

This study is informed by systems theory and sustainable resource management. By bringing forward concepts and arguments from different theoretical traditions, this study provides an "interpretational repertoire", against which the experiences from the field are examined. This process will in turn shape the theoretical concepts. The dominant ideas and concepts of systems thinking and sustainable natural resource management guide interpretation and analysis of the survey data and secondary materials derived from the field activities. In addition, the literature overview brings to the fore the institutional policies and implementation issues which characterize EIS application in community-based natural resource management.

2.2 Community-based Resource Management

Community can be defined by physical proximity to others and the sharing of common experiences and perspectives (Weiner et al., 2001). The word is synonymous with neighbourhood, village or town. Crehan (1997) argues that community can be treated as a single entity with a single set of interests. However, in reality, the term can be complicated (Est and Person, 2001). One has to reckon with realities such as local power dynamics, differences in access to resources between men and women, several ethnic groups, age groups and individuals. The fact that ideals of community differ from reality has important practical implications for resource management in general (Est and Person, 2001). Community-based resource management is a process by which the people themselves are given the opportunity and/responsibility to manage their own resources, define their needs, goals and aspirations and to make decisions affecting their well-being" (Fellizar, 1993:141). This implies that people have access to and control over their natural resources and they have knowledge, expertise and logistics to sustainably manage these resources. Community development approaches emphasize local knowledge systems, local initiative, capacity-building, ownership, participation, education and action (Caldwell, 1999). Drijver and Sajise (1993) synthesize the most important principles of community-based resource management which are: linking the environment with development; cultural appropriateness; incentives; conservation; and sustainable use of natural resources; local participation; people-centred approach; and decentralized control and decision making (Manchur, 1999)

Bryant (1995) posits that community ranges from networks of social interactions and shared interests either associated with particular geographic spaces or independent of specific geographic spaces. Given the perceived limitations of top-down, centralized management of natural resources, there have been increasing calls for the devolution of authority from national to local communities where responsibilities for resource management will trickle down from distant-centred professionals to those directly impacted by resource management decisions (Bradshaw, 2003). Thus, analysis must start from "the bottom at the level of these communities and then be pursued at other levels, up to national high-level planners and decision makers" (Folloux, 1989:16). Resource planners agree that community-developed solutions are feasible because they tend to be reasonable, realistic and sustainable (Weiner et al., 2001).

Other proponents of community-based resource management argue that situating decision-making closer to the place of resource use and subjecting decision-makers to the repercussions of their decisions create potential for more flexible and prudent resource management (Bradshaw, 2003). The District Assembly concept of the International Monitoring Fund is a case in point of community-based resource management in Sub-Saharan Africa. Fox (1992) notes that community resource management programmes operate on the premise that resources are managed best when the people affected by decisions participate in the design and implementation of these decisions. However, finding common ground between government technical experts and local users of EIS is difficult due to power relations and differential access to information. Knowledge-based empowerment occurs when the decentralization of resource management gives not just responsibilities, but also access to information and the requisite resources to local communities (Kull, 2002).

Information systems assist communities in identifying environmental problems and making informed management decisions. Citizens and local people embrace increased access to information and seek the capacity to use that information to address their high-priority environmental problems more effectively and participate in decisions that will affect environmental conditions in their communities (Sawicki and Craig, 1996). Community participation facilitates information and knowledge flow among resource centres, district assemblies, local authorities and individuals. A formidable obstacle to the realization of the potential of EIS for grassroots resource management is the improper administrative mechanisms for implementing information exchange and EIS use in local communities. This raises a number of critical issues about the sustainability of EIS application in community-based natural resources management.

Community-based resource management is based on the traditional belief that bio-resources and people's livelihood systems are intricately interrelated and opportunities for intervention for development purposes must start from good understanding of different people's access to and use and management of these resources (Grimble and Laidlaw 2002). Community-based conservation (CBC) is based on an improved understanding of the linkages and mutual dependence between conservation and local people, and the need for people to participate in conservation activities. It is the decisions and actions of local people that commonly bring about bio-resource loss and the approach sees working with them, and getting them on management's side, as being of key importance for conservation. The development of community-based initiatives runs alongside the rationality of poor rural people and growing recognition of the depth and value of indigenous knowledge (Grimble and Laidlaw 2002).

The reasons for the loss of biodiversity are complex and locally specific but frequently relate to the processes of habitat conversion and agricultural intensification brought about by demographic and market-driven pressures (Pagiola and Kellenberg, 1997). The immediate land managers in the developing world are commonly the many millions of farmers, livestock keepers, forest dwellers and other sets of rural people, both men and women, whose livelihoods are closely dependent upon the availability and productivity of biological and other natural resources (Grimble and Laidlaw, 2002). Some livelihoods are closely bound up with conservation and the sustained use of wild

Box 2 The Value of Bioresources to Local People

Though many bio-resources do not enter markets or provide financial income, they contribute significantly to many people's nutrition and livelihoods. They are particularly important in times of hardship and in marginal areas, especially for the very poor, women and children. The International Institute for Environment and Development IIED document "The Hidden Harvest" (1992) identifies some examples:

- wild foods from common property are estimated to contribute some 20% of the nutrition of the poor in the dry season in parts of India,
- in 1973, the Berti tribe in Sudan survived a famine in large part by collecting wild grass seeds,
- unmarried and divorced women in Usambara in Tanzania support themselves by collection and selling wild leaves and berries,
- some 41% of the Karimojong population in Uganda subsisted largely off wild foods in a famine in 1980.

The following uncultivated products are of value:

- wild foods such as fruit, berries, nuts, fungi, bush-meat and insects such as grasshoppers,
- housing construction and roofing materials, such as poles and grasses
- raw materials (eg. rattan, raffia, needs) for manufacture of furniture, tools & ropes
- traditional herbal medicines,
- clothing and bedding (e.g. back cloth and kapok)
- fuel of cooking and heating (e.g. firewood and charcoal),
- animal feed, fodder and litter.

In agriculture bioresources provide:

- inputs such as manure, compost and mulch
- crop and livestock varieties, cultivars and land races (including wild relatives)
- wild and domesticated pollinators and associated products (honey and wax)
- soil organisms that contribute to soil fertility and nutrient recycling
- predators of important pests that damage cultivated crops
- coppiced poles and other products
- livestock feed and forage

More generally, bioresources provide:

- protection against the adverse effects of climatic variability and extremes
- resilience and maintenance of a healthy agro-ecosystem
- new potential crops and livestock types
- genetic material for breeding improved yields and pest/disease/drought resistance
- culturally and spiritually preferred environments for human habitat and leisure

Source: Grimble and Laidlaw, 2002

resources while others are driven by market opportunities and investment in conversion of natural systems to productive agriculture.

Biological resources, their management and people's livelihood systems are thus complex and intricately inter-connected. The opportunities for intervention designed for the purpose of rural development must start from a knowledge and understanding of what these resources contribute to different sets of people, the economic incentives and institutional factors governing process and the costs and benefit of change.

2.3 Sustainable Resource Management

Life on Earth has evolved into a unique, complex and beautiful phenomenon, in which there is both change and stability. The stability results from interlocking checks and balances, in which every species plays its role with little or no awareness of the true complexity of the biological, ecological and physical dynamics that constitute the system of which it is part. The rate and scale of human impact on the global ecology is such that it is now necessary to think about these system dynamics and whether it is possible that our species could engineer its own decline or even demise. This is the challenge of sustainability.

Changes in global ecology indicate that we need to become more aware of the consequences of our actions and to start to manage our affairs more consciously than has been the case in the past. This may mean that it will be necessary to evolve new political and economic structures and decision-making mechanisms in order to respond to these emerging global demands. Long before the concept of sustainability became a buzz phrase of development among ecologists, economists, development planners and other experts in the 1980s, a prominent Ghanaian chief, the late Nana Sir Ofori Atta, is reputed to have expressed the concept of sustainability with respect to land in the following words;

> "I conceive that land belongs to a vast family of whom many are dead, a few are living, and countless hosts are still unborn" (Benneh 1995:1).

Most of the principles of sustainability are enshrined in this saying, which embodies the basic African philosophy of land management (Benneh, 1995). And by implication, the biophysical environment must be used in such a way as to satisfy the needs of the present generation without depriving future generations of their source of sustenance (WCED, 1987). Sustainability can be defined as the ability to last, endure or continue indefinitely (Benneh, 1997). Hence, recent development paradigms call for a shift from destructive exploitation and consumption of natural resources that threatens human survival to more environmentally-sensitive development approaches that guarantee continued existence of resources for human needs. At the root of this concept is the fact that the environment does pose a limit for development and economic activity and a balance must be struck between environmental constraints and development activity. Thus, the idea of sustainability has economic, social, as well as environmental or ecological dimensions, all of which interrelate synergistically (Benneh, 1997). Gerster and Zimmermann (2003) argue that sustainability is not a static but a dynamic concept of institutional functionality over time as a result of changes in institutional, staffing and financial concerns. The authors identified three components of these changes. Institutional sustainability where ownership of the process by local people is the basis for an institution to become sustainable through capacity building. Usually, sustainability is in danger where the programme is not an answer to the needs of local people and the information content is not adapted to the needs of the partners.

Sustainable human resources is a challenge where there is always a constant dilemma between training key personnel on one hand and keeping staff on another. High turnover of staff may pose problems for institutions (especially in the form of a brain drain) or may have positive effects in the forms of cooperation. Financial sustainability may differ for non-profit organizations and commercial institutions. Usually, donors face challenges in several and sometimes contradictory ways that can only be mastered by tailor-made individual solutions in the form of regularity of financial support and in-built money generating mechanisms.

Hence, the impact of a particular initiative on the community concerned, and ultimately the sustainability of the natural resources, may vary considerably for different situational contexts and at different levels. A system-based evaluation framework recognizes the multiple levels and nested nature of natural resource management policy, namely: issue characterization, policy formulation and intent, program logic, on-the-ground implementation, and the fundamental importance of context (Bellamy et al 2001). Sustainability in the context of EIS application in natural resource management requires long term planning, management and resource allocation. In addition, system design and some EIS need to be developed over long-term financial plans and strategies, interoperable and retrievable environmental data (Toledano 1997; Prevost and Gilruth, 1997). The problem of sustainability of EIS projects is compounded by the fact that initiatives in developing countries usually depend on short-term donor funds. As proposed by Toledano (1997), long-term feasibility requires a phased approach in which “clear objectives and a funding strategy are articulated with each phase”. Also, sustainability requires the use of an evolutionary development approach where existing institutions are strengthened with a gradual process of growth that allows for adaptation and learning. Falloux (1989) recommends that an exhaustive needs assessment is conducted particularly at the local community level to better understand land information needs.

After decades of experience in developing the sustainability aphorism, forming sustainability principles and detailing sustainable practices, the concept continues to evoke criticisms due to its ambiguity, vagueness and operational shortcomings (Worster, 1995; Mitchell, 1997). Irrespective of these criticisms, numerous efforts under the umbrella of sustainable development examine social, economic and ecological dimensions of the human-environment relationship. Thus, sustainability also connotes the institutional, human resource and financial capacity to ensure continuity of the resource management routines especially in the case of conservation, perpetual use and protection of natural resources.

Sustainable agroforestry management takes a holistic approach and uses tailor-made information systems, local knowledge and locally available resources, thus making technologies more economical for poorer farmers. Consequently, this approach is more ecologically sound because it recognizes and integrates local farmer knowledge instead of sidelining and radically transforming local ecosystems (Altieri and Yurjevic, 1995). Objective knowledge, traditional systems, and some of the inputs developed by modern agricultural institutions can be combined to improve significantly both traditional and modern ecosystems (Norgaard, 1984). Appropriate management and information technology has been stressed for realistically meeting the goals of sustainability to improve the quality of lives. Sustainability has been suggested as a changing process as what is sustainable at one time may not be in another and what is sustainable at one place may not be sustainable in another (Flora, 1992).

An off-shoot of sustainable development is the *sustainable livelihoods approach* (SLA). It is a way of thinking about poverty elimination and the needs of the poor that rests on core principles stressing people-centred, responsive and multi-level approaches to development. Like other sustainable development concepts, the SLA has multiple interpretations but is essentially a holistic and systems-based approach to development that incorporates the key ideas of participation, wise-use of natural resources and economic stability. The SLA thus aims to meet the development needs and aspirations of the poor in a socially and environmentally sensitive way (Scoones, 1998; Ashley and Carmey, 1999).

Sustainable agriculture systems are characterized by strong farmer participation and a thorough understanding of local dynamics, problems and opportunities and only farmers have an intimate knowledge of these including the development of site-specific solutions-for which the formal research and extension system lacks the capacity; replacing external agro-chemical inputs with a stronger management role by farmers of their resources –thus strengthening farmers capacities to do this;
maintenance of sustainable systems in vulnerable environments under ever-changing economic conditions- constantly monitored by the people directly involved, the farmers.

Despite these original agricultural roots, there are clear indications that it is of practical relevance in other rural technology development initiatives (Guijt and

Veldhuizen, 1998). A strategy of improving the situation, including improvement in species diversity, is to encourage sustainable techniques. In West Africa, there are indigenous farming systems of proven sustainability and others which exhibit strong characteristics of sustainability and which therefore could serve as prototypes for even more environmentally sustainable systems of farming (Benneh, 1997). West Africa abounds in examples of maintained, improved, and degraded environments.

The concept of *Sustainable rural livelihoods* (SRL) relates to a wide set of issues and is increasingly central to the debate about rural development, poverty reduction and environmental management (Scoones, 1998). It was first put forward in the report of an Advisory Panel of the World Commission on Environment and Development (Chambers and Conway, 1992). In calling for a new analysis, the commission proposed sustainable livelihood security as an integrating concept and made it central to its report. The definition of SRL is:

> "Livelihood is defined as adequate stocks and flows of food and cash to meet basic needs. Security refers to secure ownership of or access to resources and income-generating activities, including reserves and asserts to offset risk, ease shocks and meet contingencies. Sustainable refers to the maintenance or enhancement of resource productivity on a long-term basis. A household may be enabled to gain sustainable livelihood security in many ways-through ownership of land, livestock or trees; rights to grazing, fishing, hunting, gathering through stable employment with adequate remuneration or through varied repertoire of activities" (WCED, 1987 in Chambers and Conway, 1992: 32).

Thus, the idea of SRL emerged as an approach to maintaining or enhancing resource productivity, securing ownership of and access to assets, resources and income earning activities as well as ensuring ownership of adequate stocks and flows of food and cash to meet basic needs. Clearly, food security is an important component of this framework.

The definition of sustainable livelihoods has undergone modifications since it was first introduced. For example, in modifying the WCED Panel definition, Chambers and Conway (1992) put forward the following working definition of sustainable livelihoods;

> "A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets and provide sustainable livelihood opportunities for the next generation and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term" (Chambers and Conway, 1992:7).

Drawing on Chambers and Conway (1992), Scoones (1998) also defines sustainable livelihoods as a livelihood which comprises the capabilities, assets (including both material and social resources) and activities required for a means of living.

Sustainability is a key quality of sustainable livelihoods. Sustainability implies a successful and on-going adaptation to changed environmental and socio-economic conditions. Sustainability implies a system that has the capacity to withstand short term environmental, demographic or social shocks such as drought. It is the ability of the livelihood system to deal with and recover from shocks and stresses and also the ability of the livelihood system and the natural resources on which it depends to maintain or enhance productivity over time. A livelihood is sustainable if it can cope with, recover from and adapt to stresses and shocks, maintain and enhance its capabilities and assets, and enhance opportunities for the next generation (Roe, 1998).

From the above definitions, three fundamental attributes of a livelihood can be identified, namely: the possession of human capabilities (such as education, skills, health, psychological orientation etc.), access to tangible and intangible assets (such as land, forest, etc.), and the existence of economic activities. Out of the tangible and intangible assets people construct and contrive a living, using physical labour, skills, knowledge and creativity. Cooperazione (2005) identified three key principles of SL:

1. Putting people at the centre of development and involving them at all stages, from design, to implementation and the assessment of process,
2. Identifying in a holistic manner the opportunities and constraints for poor people to improve their situation, and
3. Recognizing that poor people have diverse livelihood strategies and expectations based on a range of different activities. These will evolve over time, so support must also move on and be dynamic.

However, sustainability of rural livelihoods is being affected by pressures on the agricultural land base, leading to progressive fragmentation of farm holdings and overuse of arable land. The ability of farm households to achieve food self-sufficiency and livelihood security from their land has declined considerably. Rural populations are increasingly becoming reliant on natural resources for their livelihoods and uncultivated forest lands have come under extreme pressure for food, fodder, fibre, fuel wood, building materials, chewing sticks and other materials. Cooperazione (2005) indicates that challenges to sustainable livelihoods include policy support, developing suitable credit schemes for various beneficiaries, developing producer markets, land and tree rights, conservative attitudes of some rural communities, and effective networks. Adopting an SL approach builds on the strength of poor people, so increasing the opportunities open to them.

Environmental problems can be more effectively solved if educational programmes are done continuously and are consistently backed by physical demonstrations of projects by the communities (UNDP, 2000). Attitudes of communities can be changed for the better if programmes of the sort are carried out frequently. Unfortunately, in some cases, management practices have proven to be unsustainable because of harmful effects on the soils, flora, fauna, micro-climatic conditions, hydrological cycle etc. Biophysical sustainability must therefore mean the sustainability of the biosphere minus humanity. Likewise, sustainable development should mean both sustainability of the biophysical medium or environment and sustainability of human development, with the latter sustaining the former (Rao, 2000). Agenda 21 emphasizes the importance of rethinking the 'blueprint' approach to REM in favour of one that involves people's participation and accommodates indigenous knowledge and local values and interests (United Nations, 1992).

2.4 Systems Theory and EIS Application

Systems Theory has been used to examine a variety of problems in ecology and natural resource management. Systems thinking emphasize connectedness, context and feedback. Systems are composed of interrelated components such that the properties of both the system and its components are changed if the system is disassembled in any way (Ashmos and Huber 1987). Applying systems thinking approaches means taking something apart in order to understand it and then putting it into the context of a larger whole. Kay and Foster (1999) concur that system thinking examines how the whole is made of processes and structures which define it and these processes and structures are studied in terms of inputs and outputs, changes and interconnections between the components which make up the system. It connotes the ways of organizing our thinking about the complex socio-ecological reality within which we live. Complex socio-ecological systems can be understood only from multiple and non-equivalent perspectives. The different layers (household, community, and region) evolve within a variety of ecological and socio-economic contexts and constraints (Allen & Star 1982).

In some cases, the different hierarchies or levels call for a cross-scale interaction of key variables that explain the complexity and multi-dimensionality of the issues. O'Neill *et al.* (1986) argue that to properly understand hierarchies it is necessary to identify different process rates, arguing that the structure imposed by differences in rates is sufficient to decompose a complex system into organizational levels and into discrete components within each level. Gore (2000) notes that systems can be further divided on the basis of rates into subsystems or 'holons', that is wholes with a boundary or surface which while being composed of parts, are themselves parts of larger wholes. Such holons can be interpreted as a special case of the relationship between processes of different rates. Within a holon, there is a high frequency of interaction between components while these components interact with components of other holons (Gore, 2000).

The systems approach can be viewed as a process of conceptualization and evaluation and provides a perspective from which to evaluate current natural resource management problems (Grant, 1998). Two simple but powerful principles form the core of the systems message: (1) systems are composed of interrelated parts; (2) system function is related to system structure. It allows for the presentation of ideas concerning systems relationships and dynamics (Bellamy et al, 2001). The approach is an important unifying theme in natural resource management. It seeks to identify general causal relationships that allow representation of all relevant system dynamics in the simplest manner. Unfortunately, existing systems frameworks for evaluating the impact of EIS on natural resource management are fragmented due to the inability to reconcile the different domain parts into a coherent evaluative framework (Bellamy et al, 2001). This gap in systems thinking with regards to EIS and LKS application in natural resource management can be dealt with through a synthesis of all the major components of knowledge application. This demonstrates how a holistic systems approach helps to consider the interplay of multiple factors, namely political, institutional, financial, social, and ecological issues of EIS application in natural resource management.

The holistic view of systems approaches helps to bridge both the biophysical and socio-economic dimensions in land use system. In the context of sustainable development, views of agricultural systems based on the concept of agro-ecosystems have to turn into a more social constructs approach which focuses on knowledge of rural communities to address ill-structured resource management problems (Toledo, 1997; Roling and Wagemakers, 1998). A systems approach gives better insight into sustainable EIS application in natural resource management as change in one aspect necessarily affects others (Sodogo, 2002). It also helps to combine information systems and knowledge of local people about land degradation and management together with biophysical, socio-economic and cultural factors to assess land degradation and biodiversity loss and prescribe effective management measures. EIS and LKS applications in natural resource management in Ghana exist in nested hierarchies. They are comprised of smaller systems while at the same time being part of a larger whole. The different levels evolve within a variety of institutional, ecological, and socio-economic contexts and constraints.

2.5 Environmental Information Systems and Local Knowledge Systems

Environmental Information Systems (EIS) or a variant thereof denotes a computer and satellite system (GPS, GIS and Remote Sensing), statistical and qualitative (Interviews and Participatory Rural Appraisal) methods, together with operational policies and procedures that allow data to be collected, stored, updated, displayed, managed and used for decision making and resource management (Costanza, et al., 1996; Gilruth and Prevost, 1999; Gavin and Gyamfi-Aidoo, 2000). Such a definition is based on assumptions of a fairly predictable environment within which GIS are to be used. It recognizes the behavioural and institutional aspects that are increasingly determining the success or failure of EIS implementation in land use management (Karikari et. al., 2005). Carter (1989) defined GIS as an institutional entity reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time. This definition is more appropriate in a developing country context. This definition is not only generic but it also includes an organizational dimension that affects GIS adoption and a financial dimension that is crucial in developing countries (Karikari, et al. 2005).

In a much larger number of cases, environmental information must be linked with economic information, social information, cultural information, biophysical information, base map information etc. for its full benefit and potential to be realized (EIS Africa, 2002). Such information can be in written, visual, aural, electronic or other form. EIS helps to bring together and analyze different types of data and information (environmental, demographic, quantitative and qualitative) that apply to different spatial units and to quantify complex multi-dimensional concepts (Constanza, 1996). Hence, aspects of spatial information technologies are viewed as objective compared to indigenous knowledge systems which tend to be subjective in application yet able to capture complex social realities of community-based natural resource management.

A key feature of EIS application in natural resource management is the possible connection between organizations at different levels (national, regional, and local levels) inherent in systems thinking. In addition, EIS facilitate understanding of complex environmental problems and issues in rural communities and assist decision makers in choosing particular course(s) of action(s), among competing alternatives. Policies and efficient mechanisms for data access are as important as the availability of the data themselves and their application. EIS includes resources, strategies and procedures together with data management tools that ensure access to environmentally-relevant data and information (Gavin and Gyamfi-Aidoo, 2000). Information is useful if it improves our knowledge and understanding of environmental problems in rural areas and facilitates effective decision making. Prevost and Gilruth (1997) note the importance of end-user demand by stating, "perhaps most important in designing information systems is to have a sound understanding of the decision making process in community-based natural resource management and how this process generates need for information" (p3).

Community-based knowledge systems describe the knowledge, practices and beliefs of indigenous people around the world. Blaikie, et al. (1996) broadly define local knowledge as knowledge which is held collectively by a local population, informed by people's socio-cultural tradition which structures how they explain the world, view events and anticipates the future. Such local knowledge includes intergenerational knowledge that is handed down from one group to another new or modified knowledge which is created or developed locally through processes of experimentation or innovation, and also knowledge which has been developed elsewhere, adapted or transformed and incorporated into local way of life. Variations range from "Indigenous knowledge" (IK), "Local Knowledge" (LK), "Traditional Knowledge" (TK) to "Rural People's Knowledge" (RPK). Each of these terms has created considerable debate as a result of discrepancies with their numerous interpretations. Chambers defines Indigenous Knowledge (IK) as:

> "..Knowledge located in the people and only rarely written down…[it] refers to the whole system of knowledge, including concepts, beliefs and perceptions, the stock of knowledge and the process whereby it is acquired, stored, and transmitted" (1983:83).

Subsets of the general field of indigenous knowledge include: Indigenous Technical Knowledge (ITK), Traditional Environmental Knowledge (TEK), Ethno-botanical Knowledge (EBK) (Manchur, 1997). Tengberg and Stocking (1996) provided a typology of the constructions of local knowledge (Table 2.1). LKS is often contrasted with what is generally referred to as "scientific explanation". LKS is better defined in terms of skills and experiences than as a set of identifiable facts or principles. For Ingold and Kurthila (1999), local traditional knowledge is "generated in the practice of locality" (26). Such knowledge consists of skills "re-grown in each generation through training and experiences in the performance of particular tasks (Ingold, 2005) rather than being a stock of knowledge of an unchanging cultural heritage passed down intact from one generation to the next. Intergenerational knowledge is that knowledge which is handed down from one group to another--new or modified knowledge which has been developed elsewhere, adapted or transformed and incorporated into local ways of life (Tengberg and Stocking, 1999). Hence, traditional ecological knowledge is a cumulative body of

Table 2.1 Knowledge-in-action-- a typology of construction of Local Knowledge

Knowledge appropriated	LK has financial value- people as 'local gatekeepers'
Knowledge ventriloquised	LK, a language to transmit modern ideas
Knowledge esteemed	LK, as a study of culture; an entry to understanding local beliefs, attitudes and practices
Knowledge negotiated	LK as the means for participation and mutual problem solving
Knowledge as empowerment	LK as the means for local people to exercise their own skills and take control of their own affairs

Source: Tengberg and Stocking 1996.

knowledge, practices, and beliefs about the relationships of living beings, including humans, to one another and to the environment (Gadgil et al. 1993). This body of knowledge evolves by adaptive processes and is handed down through generations by cultural transmission. This definition recognizes that ecological knowledge used in local resource management can also be generated by and reside in communities that lack historical and cultural continuity. Local ecological knowledge is a blend of knowledge generated locally through practice and experience plus knowledge incorporated from other sources, such as scientific knowledge. Thus, LK is mainly the tacit judgment, wisdom and skills of local people based on their sense and experience to judiciously act in the right place at the right time. Second, LK is always being created and transformed from tacit to explicit (and vice versa) through interactions among local peoples and between local peoples and outsiders (World Bank, 2004).

The hallmark of indigenous knowledge creation and innovation is that it is usually collective and for social good. Although IK is readily shared among members of a community (in so far as these IK practices are a part of the daily life of the community), it is generally shared to a lesser degree across communities. Further, as IK is predominantly tacit or embedded in practices and experiences, it is most commonly exchanged through personal communication and demonstration: from master to apprentice, from parents to children, from neighbor to neighbor, from priest to parish. Recording tacit knowledge, and transferring and disseminating it is therefore, a challenge (World Bank, 1998).

Traditional knowledge reflects local conditions including popular values. It can be assumed to offer a sounder basis for developing more locally adaptive resource management initiatives in line with grassroots and bottom-up development paradigm (Gyasi, 2004). Buabeng (2004) identifies two forms of traditional knowledge; (1) technical knowledge and (2) non-technical knowledge. Technical knowledge refers to that knowledge which incorporates skills and is manifested in production and socio-cultural systems such as arts and music. Non-technical knowledge refers to value systems, beliefs, customs and rules of behaviour (Buabeng, 2004). Hountondji (1997) has described traditional technical knowledge research as ethno-technology and within the realm of science as ethno-science which is defined as the study of a corpus of knowledge, information and know-how handed from generation to generation.

Traditional technical knowledge seen in this vein can be said to be complementary to technical knowledge (Chambers, 1998, Mammo, 1999, Haveerkort, van't Hooft, and Hiemstra, 2003). Scientific inquiry, whether in the form of soil and plant surveys or remote sensing, positioning systems and geographic information systems has been very effective in generating information and knowledge by reducing complex problems into smaller and smaller pieces. While this strategy has allowed information technology to accumulate vast amounts of knowledge about many things, it does not address the difficulty of organizing and synthesizing such a body of knowledge and applying it to real-world problems (Schank, 1996). The ecological and environmental sciences are somewhat of an exception to the lack of holism in scientific investigation but still, large collections of static knowledge do little to answer questions about the dynamic world that contains many complex biophysical and socio-economic systems each with many interacting components. For example, agro-forestry and biodiversity conservation require the application of knowledge from many different fields, such as soil science, silviculture, economics, botany, geography, ethno-botany and indigenous knowledge.

Soyez (2002) argues that there is lay knowledge as well as expert knowledge and a person may be an expert in a field, especially indigenous knowledge systems, which professional experts ignore. Schank (1996) concurs that certain individuals possess knowledge in terms of mental models and are referred to as "experts". Experts perform better than non-experts because they have large amounts of "compiled", domain-specific knowledge stored in long-term memory and they have become skilled at using that knowledge to solve specific environmental resource management problems (Schank, 1996). This problem notwithstanding, there have been attempts at combining expert and non-expert knowledge.

Attempts at integrating environmental management regimes and local knowledge systems are increasingly apparent in Senegal where local histories of ecological succession are incorporated into fire and plantation planning (Lykke, 2000), or in Lebanon where local knowledge of mountainous terrain has been incorporated into land use mapping to develop otherwise unavailable data that facilitate democratic participation in planning (Zurayk et. al., 2001). As individuals, we already live within a social system of social behaviour. Learning what our perceptions may involves not knowledge of different viewpoints so much as experiencing the interaction of these viewpoints in a continuous and collective field of activity wherein significant relations are exposed. The familiar is the vast stock of social knowledge, that everyone has access to and hence may share as existing knowledge (Merwe, 2002). Consequently, depending on context, there is no clear answer as to which type of knowledge is more important. Further, knowledge is not a true reflection of reality but is socially constructed and influenced by, for example, power, interests or self referential processes (Soyez, 2002). Both views neglect LK's provisional nature--its subjective, bodily and tacit aspects; and its context--particularly, the place and timing for LK creation and transformation.

Further analysis revealed that LK is created and transformed by the creative activities of local people through a spiral process, the process of informal transformation of tacit LK of one person to create a new tacit LK or upgrade an old one of another person through "shared experiences (World Bank, 2004). This intuitional judgment of local experts is developed from their relevant proficiency and skills, gained through lifelong day-to-day interaction and experience accumulated from similar experience of peers and previous generations, and is based on their unique mental models and schemata built on local culture and religious beliefs, but not on scientific theory or reasoning. It became apparent that only a small portion of LK can be shared as explicit information in a numerical sense, and that such explicit knowledge is only the "tip of the iceberg" of LK held by informed local people. While conventional science is based on facts and employs systematic approaches to establish universal laws about phenomena and cause and effect relationships and is transmitted through retrieval systems, journal publications etc.

Traditional knowledge is the knowledge which has been acquired over the years through experience and passed on from generation through oral tradition and by practice.

The features described above suggest that indigenous knowledge is an integral part of the development process of local communities. According to the 1998/99 World Development Report, knowledge, not capital, is the key to sustainable social and economic development. Building on local knowledge, the basic component of any country's knowledge system, is the first step to mobilize such capital but they will have the most success if they help developing countries adapt knowledge to local conditions (World Bank, 1998). Sharing knowledge with the poor is most effective when we also solicit knowledge from them about their needs and circumstances. Among the key determinants of client satisfaction is knowledge of local institutions and local practices. However, many IK systems are currently at risk of extinction because of rapidly changing natural environments and economic, political, and cultural changes on a global scale. Practices can vanish, as they become inappropriate for new challenges or because they adapt too slowly. Moreover, many local practices may also disappear because of the intrusion of foreign technologies or development concepts that promise short-term gains or solutions to problems without being capable of sustaining them. Local practices require fewer material resources than imported technologies, allowing the former to weather the vicissitudes of local shortages and material constraints. Moreover, as IK is predominantly tacit or embedded in practices and experiences, it is most commonly exchanged through personal communication and demonstration: from master to apprentice, from parents to children, from neighbor to neighbor, from priest to parish. Recording tacit knowledge, and transferring and disseminating it is, therefore, a challenge

(World Bank, 1998). The next typical step is to validate IK in terms of its significance and relevance (to solving one or several specific problems), reliability (not being an incidental occurrence), functionality (how well does it work), effectiveness and transferability.

Ecological communities provide energy, materials and information required for human societies to sustain themselves. The societal system depends on the flow of energy, materials and information from the ecological system to support its processes and structures. These flows along with the biophysical environment provided by the ecological systems are the context for societal systems (Gore, 2000). The context constrains the possible societal processes and structures in a specific location. Societal systems can also influence ecological systems (for example: cutting trees down in a woodlot, filling in wetlands and all the human landscape). Such actions, of course, alter the flows from the ecological systems to the societal systems and thus create a feedback structure on the landscape (Gore, 2000).

The feedback loop has more steps and accordingly is more indirect. By changing the context of the ecological system, the societal system affects the ecological processes and, in turn, the ecological system. The societal system affects the ecological processes and this in turn affects the ecological structure and ultimately the societal system's own context. Scientific or rational modern knowledge has become the most effective legitimizer for the homogenization of the world and the erosion of its cultural and ecological richness. Modern Western knowledge is posing as universal and as inherently superior to local and diverse knowledge. Further, the modern Cartesian knowledge system being inherently fragmenting and having inbuilt obsolescence, creates alienation of wisdom from technology and dispenses with the former. In its preoccupation with quantitative analysis it further distorts reality and disregards aesthetic values, experimental learning and intuitive insights (Wignaraja, 1991). Modern knowledge systems exclude the vulnerable and create in their wake the process of moving them further from marginalization to dispensability. This irrational process has become unacceptable economically, politically and culturally. Local knowledge is responsive to socio-cultural realities. A holistic approach is essential to understanding reality. This means that single discipline analysis which flows from the Western knowledge system is insufficient. A few factors singled out from a rich social reality become very abstract (Wignaraja, 1991).

2.6 Political Ecology of EIS and IKS Applications

Political ecology aims to integrate both political and economic inquiry with ecology in the sense that clear connection is being sought between what happens at the political level which relates to the economics of natural resources and how it affects the use and therefore ecological functioning of resources (Blaikie and Brookfield 1987: Greenberg and Park, 1994). Thus, political ecology recognizes the role of power, politics and how this influences environmental and resource appropriation. Political ecology has evolved into a disciplinary conjunction that questions the foundations of society-environment relationships. Peluso's (1983) political economic analysis of the environment incorporates some discussions of the actions of the resource users and their linkages to the broader processes that structure the social and physical environment in which they act (Lye 2000).

The second feature of political ecology is the importance of identifying power relations. Central to the political ecology argument is the acknowledgement of different agents and social groups who have different resources, interests or access to resources and are mutually connected through a range of social, political and economic relationships. The literature on spatial information systems and society raises a number of issues concerning politics and power relations, sometimes with grave consequences for local people. The dominant public outcry is that information produced by computer-based systems reinforces both existing practices and power structures creating a phenomenon which has come to be known as the digital divide and in some cases less-technically oriented people and women are at the lower end of the divide. Hutchinson and Toledano (1993) suggest that any spatial technology for community empowerment requires that the technology be taken out of a conventional top-down and technocratic view of computing to a more human-centred, social and bottom-up approach. Mckenzie (2005) explores processes through which the relationship between political and ecological can be created and analyzed by connections between power resistance and power knowledge. People's experiential ecological knowledge and land use practices vary according to political and social positioning (eg. class, gender, age and marital status) and this approach allows for investigation of complex social relations in access to and use of information for natural resource management.

The cultural ecology of environmental knowledge, starting in Kropotkin's time and advancing into the environmental geography of the 1960s established a record on the accuracy and practicality of local ecological practices, especially amongst traditional people practicing subsistence production. This tradition continues into the present with empirical work revealing the strength and efficacy of traditional ecological knowledge on multiple levels, including immediate empirical knowledge and taxonomies of plants, animals, and soils, practical knowledge of functional relationships and processes, like ecological succession, social knowledge of traditional rules, institutions and systems of management and conceptual systems, worldviews and more abstract beliefs that order experience and interpretation of environment (Berkes, 1999).

Whether or not traditional forms of environmental knowledge are exceptionally different or superior to laboratory knowledge or that of experts is a matter of debate. Certainly, the failures of many imposed environmental management solutions around the world, ranging from failed crop introductions to disastrous property regime changes, highlight the appropriateness of environmental knowledge developed locally (Brokensha et al., 1980). New England fishers show a sensitive and well-developed spatial conception of fish biology including explicitly mapped knowledge of breeding grounds, fish migrations and other dynamic characteristics of the undersea environment (McKenzie, 2005). This is better vis-à-vis the aspatial conceptions of scientific bioeconomics most commonly used in official management. Indeed, where local knowledge of biodiversity has been shown to be well developed, the most serious concern is not its efficacy but rather whether local people will receive control over the due compensation for that knowledge when it is appropriated by plant growers and pharmaceutical companies (Brush and Stabinsky, 1996).

This kind of knowledge can be adjudicated by incorporating local ways of knowing into a flexible but rigorous scientific framework which will distill myths from realities and produce better, more emancipatory knowledge (Batterbury et al. 1997; Sullivan, 2000). The constructions of nature by officials and locals can sometimes be well integrated. Regrettably, officials and scientific managers continue to dismiss local people's environmental knowledge as political, not objective and poorly informed. Hence, the difference between formal and informal knowledge systems remains a source of conflict. While constructivist accounts in political ecology can and must acknowledge the interested and contextual character of local knowledge, they must also explain the structured biases built into official knowledge systems which are used by experts to secure employment, control resources and justify extraction (Robbins 2000).

Some studies (Peluso, 1995; Kitchin and Frendchuh, 2000) provide methodological opportunities to explore how political ecology plays out in information application in environmental management. Some of these methods emerged from "cognitive mapping" which encourages people to map their surroundings (Kitchin and Frendchuh, 2000). Counter mapping, the most politically explicit form of geomatics has as its aim to "appropriate the state's techniques and manner of representation to bolster the legitimacy of 'customary' claim to resources" (Peluso, 1995:384). The challenges in this methodological area are many. Paper and pencil mapping is foreign to many extremely knowledgeable local or traditional people, who may be far more comfortable in the oral communication of environment with sticks, and rocks laid out on the ground (Robbins, 2004). In contrast, the "formal" cartographies arranged by professional mapmakers following standardized guidelines may not reflect the environmental geographies in the heads of individuals or institutions that produced these maps. In spite of this, some of the obvious constructions of the environment which impinge on the political control of the environment are embedded in the stories of environmental change and memories of past ecologies that people hold (Robbins, 2004). Such narratives are usually rooted in collective agreement and tacit consensus reached within communities—whether these are peasant villages, planning offices or GIS labs—such that stories of change provide a window onto collective priorities and group memory.

2.7 Evolution, Prospects and Challenges of EIS Application in Africa

African countries are going through a familiar phase that many countries have gone through in their GIS development whereby different sectors are engaged in GIS activities without coordination. Technological developments in the field of remote sensing from the early 1970s to the early 1980s led to the evolution of environmental information management. These developments, such as the launch of remote sensing satellites (LANDSAT, SPOT, etc.) provided large amounts of environmental data that could have been used for analysis and management (Paradzayi and Ruther, 2002). There was a small but growing community of geographic data providers, processors, analysts, trainers, technicians, advocates, data and information users (decision makers). It is not uncommon to find different agencies collecting the same data at the same time or different times (NAS, 2001). A few enthusiastic individuals championed the establishment of environmental information systems at the departmental levels of various institutions concerned with environmental management. The majority of EIS-related activities during this decade were exploratory and experimental in nature and confined to specific sectors with few if any linkages between sector efforts (Paradzayi and Ruther, 2002). Most of the environmental information systems were created to support donor-funded (UNEP, UNDP, FAO, etc.) natural resource management projects and were as a result supply-driven and data-oriented (Paradzayi and Ruther, 2002).

During the 1980s, more and more institutions became aware of the need to establish EIS due to increased pressure on natural resources from rising population levels as well as natural disasters such as floods and drought. This period saw a phenomenal growth in the number of actors involved in EIS construction. Duplication of data and resources during this stage was inevitable due to the legacy of sectoral environmental management policies which delegated different sector ministries to manage the same environmental information. Also, there was the proliferation of incompatible hardware and software configurations in implementing agencies. The lack of project coordination also resulted in the adoption of different database development standards (Paradzayi and Ruther, 2002). As a result of the cross-sectoral nature of EIS development, the late-1980s saw the formation of National Environmental Action Plan (NEAP) processes in the late 1980s which emphasized the need for shared solutions and integrated data products.

The 1992 UN Conference on Environment and Development in Rio de Janeiro called for the establishment of information systems that could improve access to information. Chapter 40 of Agenda 21, "Information for decision making" stresses the need for more different types of data to be collected at all scales to track the status and trends of the Earth's ecosystems, natural resources, pollution, and socio-economic variables (NAS 2005). Chapter 40 concludes that "the gap in the availability, quality, coherence, standardization and accessibility of data between the developed and the developing world has been increasing, seriously impairing the capacities of countries to make informed decisions concerning environment and development" (Dernbach, 2002).

Needs-driven approaches and open data-sharing environments are common among effective applications of geographic information. The needs-driven approach of community-based resource management programmes has built credibility with field users and has led to a strong feeling of ownership by rural people and field support staff and this fostered a culture of sensitivity to community needs among technical institutions that are partners to the programmes. It also generated trust and a common vision among partners, communities, governments and donors (NRC, 2005). However, a systematic needs-driven approach faces numerous challenges in practice. For instance, it is difficult to articulate exactly what the day-to-day information needs are. Few understand the concept of GIS and the relationships between structured databases and environmental action programmes (World Bank, 1992).

A major continent-wide activity is the African Famine Early Warning System Network (FEWS) which was initiated by the US Agency for International Development (USAID) in 1980. This activity uses satellite imagery to provide estimates of the amount and vigor of vegetation across Africa. The World Bank has been funding EIS projects for sub-saharan Africa since the early 1990s to promote the implementation of effective environmental information systems. Countries such as Uganda, Zambia, Tanzania, Gambia and Eritrea launched various initiatives to set up frameworks aimed at institutional and technical constraints to EIS development. The aim was to construct a versatile and inter-operable geographic database directed towards decision makers and similar persons. The FEWS net is the principal support of food security information-based approach to preparedness and planning in Sub-Saharan Africa which aims at finding solutions to food security problems in Africa (NAS, 2005). The primary vehicle for this support has been an initiative known as Environmental Information Systems (EIS) for Sub-Saharan Africa. The objective of this programme is to conceptualize and help to implement operational EIS. The project is funded on the premise that better environmental information management will assist resource users, planners and decision

Box 1 The Kiepersol (South Africa) Project

Kiepersol is a locality in the Mpumalanga Province of South Africa. It exhibits significant social and ecological variation and has a long history of contested resources and forced removals. The demand for land and agrarian reform is high. The initial phase of a GIS project involved 'capturing' local knowledge through the production of mental maps and the integration of that knowledge with traditional spatial information within a GIS. The mental maps were produced from a series of participatory workshops involving residents of the former KaNgwane 'homeland'. The integration of 'local' with 'expert' knowledge raised four broad sets of issues:

1. *The historical geography of forced removals*: Using data obtained from oral histories, aerial photography, and satellite imagery, Weiner et al. (1995) recorded the historical geography of forced removals and information on past farming systems. Together these data provide complementary images of changing local geographies and an understanding of contemporary natural resource struggles and land restitution demands.
2. *Defining agro-ecological potentials*: Overlays of official land type data and local knowledge about soils indicate conflicting representations of land potential. These discordant understandings are a product of scale, the multiple meanings of agro-ecological potential and differing farming systems. They were able to make maps of the areas from these differing perspectives that could help groups understand each other better.
3. *The politics of land, water, and biomass access:* The Kiepersol participatory GIS demonstrates that proximity should not be confused with access. For example, differential access to river water and changes in the boundary of the Kruger National Park were identified as significant issues, which the traditional GIS obscured.
4. *Developing policies for socially appropriate land use:* The GIS incorporates community ideas about spatial transformation and supports a more democratic land use planning process.

By overlaying numerous individuals' or groups' mental maps of local resource conditions, differing perceptions of the importance of varying access rights to resources can be identified.

Source: Weiner et al., 1995

makers to move towards improved resource management regimes in developing countries. However, conspicuously missing in some of these studies is how EIS is being applied in natural resource management at the local level. Harries et al. (1995) explored the potential for incorporating local knowledge within an alternative GIS production in pursuit of a participatory land reform project in Kiepersol locality of South Africa (Box 1). In this study, conventional GIS coverage of districts is combined with local knowledge comprising mental mapping exercises and intensive interviewing. This information was used to understand the perspectives of people's needs, and the politics of access to natural resources. This is instrumental in land reform programmes and produces beneficial land use plans.

EIS applications in natural resource management in Africa are not without problems. Human-induced errors may be introduced during the data collection, input, storage and manipulation processes. There remain barriers to effective use of geographic information in Africa including: technical limitations of accessibility to data such as inadequate telecommunications infrastructure, limited bandwidth and low internet connectivity; administrative challenges of accessibility to data, including lack of (1) familiarity on the part of government officials with requests for information, (2) efficient protocols for requesting government data, (3) common data standards to promote sharing, and (4) issues of copyright and distribution; inability to afford needed data and lack of availability of hard currency and foreign exchange in many countries, educational and organizational limitations on access to data and technology including poorly trained workforce and limited private sector demand to spur developments of geographic information and tools. Another problem is that available data often are not of sufficiently high spatial or temporal resolution to be useful for decision-support at the local level. Especially in rural areas where the bulk of the population still lives, the minimum spatial resolution of value to agricultural extension workers and rural development specialists is small farms. The problem is confounded by the fact that data available to date rarely reach the rural and urban decision-makers at the local level dealing with the day-to-day realities of sustainable development (NAS, 2005).

In addition to the challenges of data availability, many decision-makers in developing countries have no experience with GIS and other spatial decision-support tools, and thus do not appreciate their potential for using geographic information. Decision support in the area of land cover will be one of the most fruitful application areas of geographic data and tools in Africa. This is because the livelihoods of a majority of Africans depend on agriculture and natural resources and there are many pressing problems within these areas. Addressing these problems requires better data and better ways of analyzing the relationship between human activities and changes in the land surface.

Hall et al. (1997) cite capacity as a major problem militating against GIS implementation in Burkina Faso and Mali. Installation of GIS technology is often driven by the desire to demonstrate the software rather than use it to address pressing resource management needs (Falloux, 1989; Hutchison and Toledano, 1993). The effective use of geographic information to implement Agenda 21 will require sustained investment in human resources development, building public and private organizations and improving societal capabilities for generating and using new knowledge (NAS, 2005). Capacity development needs to the addressed at three levels:

1. Human or individual –this involves enabling individuals to embark on continuous process of learning –building on existing knowledge and skills and extending these in new directions as fresh opportunities appear.

2. Organizational or institutional –This involves strengthening and improving existing institutions as well as the design of new ones where they do not exist. There is also the need for interactions between different organizations.

3. Societal—this involves capacities in the society as a whole or a transformation for development. This is linked to the national system of governance since without such opportunities people will find that their skills rapidly erode or become obsolete (NAS, 2005).

If they find no opportunities locally, trained people will join the brain drain and take their skills overseas. Characteristically, trainees were selected from government ministries and taken to a national or regional center, or to an institute of higher learning outside Africa, and then returned to work on a specific project. In Swaziland and Lesotho, for example, personnel who have been trained over the years have carried out projects on reforestation and soil erosion respectively and in both countries skills in EIS application are strong in government departments but are only emerging at the national universities. While this approach to capacity building contributed greatly to the increase of skills in EIS in sub-Saharan Africa, it had a number of defects. Firstly, it lacked the multiplicative effect associated with training trainers and educators who may then multiply their skills by educating or training others.

Developing geospatial capacity in Africa is part of the larger challenge of building scientific and technical capacity and a trained workforce, which in turn depends on primary, secondary and post-secondary education and continuous on-the-job training in relevant sectors (NAS, 2005). Provost and Gilruth (1997) observe that various EIS efforts have focused on ad hoc projects. Provost and Gilruth emphasized the need for countries to develop a core national environmental data infrastructure: A major problem is that most EIS initiatives have a short-term impact on environmental management without contributing to building the data infrastructure and architecture necessary for opening the door to applications, and the availability of core datasets is an absolute prerequisite to EIS implementation. Prevost and Gilruth defined EIS as an institutional and technical response needed to improve the role and benefits of information in environmental management.

"The central message here is that environmental information when organized in a systematic manner helps to support decision making which is an essential building block for sustainable development" (p. 7). Prevost and Gilruth however do not provide specifics on how environmental data should be linked to decision making processes and not that "the use of EIS for decision support is in its infancy".

2.8 Context of EIS Implementation

Analyzing the context of project implementation requires that the analyst agree on a basic element of implementation. For instance, two widely accepted variables of implementation analysis are; (1) The content of the policy and project and (2) its context (Hamblay, 1999). While there are divergences of opinion on the weight given to each variable, both interact to define policy or project implementation (Found 1991). Both Najam (1995) and Grindle (1980, 1996) concur that two key aspects affect the success of implementation: (1) the influence of power relations and, related to this, (2) the issue of popular participation in policy and project implementation. Thus, implementation is seen as "a political calculus of interests and groups competing for scarce resources, the response of implementing officials and the actions of political elites".

The second point of divergence among implementation analysts is over popular participation in policy and project implementation. Recently, implementation analysts have found that stakeholder involvement in the implementation process and the role of the target group in defining and reaching policy goals are positive factors for success (Found 1997). As Najam (1995:13) elaborates, the "top-down" vs. "bottom-up" debate in implementation has tended to divide, not unite, implementation theorists. Rabinovitz (1978) once argued that "an open and complex decision-making process that functions at many levels is always in danger of eroding consensus and distorting its initial priorities.

Hamblay et al. (1999) observe that implementation analysis is being applied to more complex issues, typically encompassing subjects that lie well outside its origins. Found (1991), Najim (1995) and Brinkerhoff (1996a) see the study of implementation as relevant to the analysis of global environmental problems. Analysts investigating the implementation of sustainable development policies or projects may need to address their content and context beyond the immediate generation or across the geographic area, on which they are focused. The next section explains the two main dimensions of implementation analysis for EIS/GIS.

2.8.1 Institutional Policies and Capacity Building

The adoption and diffusion of GIS in any organization or community is a complex process and the circumstances within developing countries are usually significantly more difficult than in the developed world. It is therefore pertinent to address various dimensions of GIS adoption including organizational context, institutional capacity, the development of a model, and the design of pilot projects (Karikari and Stillwell, 2004).

Institutions are social structures, including policy and authority systems and routines of ingrained habits and patterns of behaviour. Institutions can also be used to refer to the process and outcome of regulations, maintenance and diffusion of social rules, norms and meanings (Scott, 1995). Erik de Man (2000) views institutions as a rather stable cluster of norms and normative behaviours that develops around a basic social need. Kyem (2001) concurs that institutions are the collective patterns of our thinking, feeling and acting. It is pertinent to emphasize that not all societies share the same institutions since institutions are shaped by their particular historical, cultural contexts and therefore vary in time and space. This is characteristic of the institutional set-up of resource management in developing countries. Cashman (1992) suggests that the acceptance of new agro-forestry technologies by farmers in West Africa can be explained by the compatibility of new technologies with the indigenous and prevailing norms and values of agro-forestry. Another aspect of institutions is common identity and behavioural patterns, often involving trust relations, which are crucial to social transactions that embed or internalize institutions in society (Zucker, 1988; Ciborra, 1993; Furlong, 1996; Tolbert and Zucker, 1996). Studies by Rocheleau (1991), den Biggelaar (1995) and Edmunds (1997) are relevant insofar as they illuminate how groups of farmers generate a system of knowledge with specific language and repeated behaviour to support certain indigenous agro-forestry practices and biodiversity conservation.

Scott (1995) submits that regulations and norms are only part of what constitutes institutions because individual and shared human experience creates meanings for the institutions in people's lives and livelihoods. In agro-forestry, a wider view of institutions is useful for examining why some EIS applications in resource management activities succeed while others fail. Some institutional and organizational studies view institutions as a process and the product of a process, through which social meaning and experience are generated and reproduced. Institutionalization of EIS is an on-going process within a group, community or society whereby concrete and recurrent applications of these technologies would gain a normative impact on the common definition of problems (Erik de Man, 2000). The question regarding assumed institutionalization of EIS is how to address common group or societal challenges, especially with regard to spatial problems (Erik de Man, 2000). These spatial problems vary from environmental degradation to biodiversity loss. Hence, a range of EIS which vary from highly sophisticated computer-based systems to local knowledge systems in different formats are applied for community-based natural resource management.

It is important to note that legitimacy and empowerment are not simple keys to successful community-based resource management but instead complex, dynamic elements constantly being re-negotiated (Kull, 2002). An alternative viewpoint of institutionalization as a process and not an "end state" will help to identify conditions and factors for EIS use, especially in community-based agro-forestry management and agro-diversity conservation. Institutional rules can facilitate or constrain EIS application in natural resource management. Apart from the institutional procedures, other issues of EIS application are the issues of human resource and skill development initiatives.

The effective use of EIS is predicated on data management capacity that includes staff mastery of hardware, software and database management elements (including use of database management software) and practice integrating data in a variety of formats and from a variety of sources (Department of Environment, 1987, Campbell, 1993; Budic, 1994). Knowing how to use data, once assembled, to create useful and meaningful information is key for effective use of the technology (Budic, 1994; Sawicki and Craig, 1996). Clearly, one of the barriers to using information or data is simply a lack of awareness of the existence of the information (Meredith, 1997). A number of potential users of EIS and policy makers do not know where the data exist and how to access them.

In other studies (eg. NTIA, 1996), it was discovered that rapid turnover of staff in participating agencies and the frequent changes in technology necessitated that training be integrated on a continual basis in to their projects. Prevost and Gildruth (1997) provided some guidelines for long-term training; they note the need to develop a "critical mass of people and qualified staff". In view of this, EIS training programmes must take the form of ongoing refresher courses with hands-on or regular on-the-job practice. Building proficiency in GIS requires significant investment of time to learn the software and to build GIS databases and also requires practice on a regular basis (Kellogg, 1999). Research suggests that the presence of a GIS-specialized staff person, for instance, with the time for improving skills and developing databases has been a key feature of successful use of GIS in municipal and county planning agencies, especially in the developed world (Budic, 1994).

Western-style education in EIS must be re-crafted and re-applied to the conditions in developing countries and then placed into the situation-specific contexts of individual nations (Hall, 1999). Karikari and Stillwell (2004) call for the need for governments to place emphasis on the development of indigenous expertise and participatory approaches in GIS project design and implementation which will allow local users to assume ownership of GIS projects (Eason, 1988; Campbell and Masser 1995). In addition, staff need to know and understand what GIS means and the functions it performs because staff perceptions of the nature and utility of geo-technology are likely to differ. Studies show that human resource issues such as the availability of trained staff through education, training, and continuous professional development and adequate financial resources from within, and to a lesser extent from without, are major factors that will determine the successful take-off and sustainability of GIS as a need to involve users in the design process itself (Karikari et al., 2003a). This is true for even the well-established and best-funded facilities. Training issues include data preparation, human resource planning, cost of technology, project management and an understanding of the EIS implementation philosophy. Another issue is that the educational process must not be distinct but embedded within the human resource component and infrastructural strengthening of developing countries. Pubic Participation GIS (PPGIS) researchers have investigated the resources necessary for GIS adoption (Ramasubraminian, 1995; Sieber 1997, Barndt 1998). Lack of resources may begin with insufficient funding to purchase equipment, lack of vendors to sell or train purchasers on the equipment, no skilled staff to maintain the system and an absence of peripherals like printers, telephone, modems, electricity, and adequate bandwidth.

2.8.2 Socio-Economic Context of EIS Application

Another issue for the implementation of EIS is the entrenched belief systems pervasive of indigenous communities. A study of local community participation in forest management in southern Ghana revealed that some belief systems were attached to resources that became objects for mapping (streams, timber etc). Experts were therefore compelled to contend with values and beliefs using a technology that draws its strength from analysis of empirical facts (Kyem, 2002). Modeling some of these beliefs in an EIS and providing accurate interpretation of such customs is a major problem for EIS experts who undertake projects in unfamiliar communities (Kyem, 2002). In view of this, Sieber (2002) cautions organizations that GIS or EIS implementation encompasses far more than purchasing and installation of hardware and software. The top-down approach pursued in the implementation of EIS projects in developing countries could result in applications that promote an elitist agenda but do little in support of grassroots participation (Kyem, 2001). Hence, Laituri (2002) observes that the use of GIS and other information systems must be constructed with equity in mind for all societal groups and methods need to be developed that allow access and empower such groups through appropriate training and education. The human resource development and social issues are relevant for the evaluation framework.

Effective implementation of EIS in developing countries therefore depends on a number of factors. The quality of human resources, the predominant kinship groupings, customs, and tenure arrangements can either enhance or impede progress in the implementation of EIS. Kyem (2001) draws a contrast between ethnic groups in Ghana during the implementation of Public Participation Geographic Information Systems (PPGIS) for the Kofiase Forest Management. However, working through clans resuscitated buried claims to land currently occupied by forest reserves (Kyem, 2001). In other cases of EIS implementation, designers and technical experts do not properly study and examine the unique local conditions and circumstances within which EIS projects are implemented. In addition, the level of literacy of community members plays a significant role in the implementation of GIS projects. There was a general lack of interest in tree planting among 21% of respondents (Nsiah-Gyabaah, 1994). The long-term cycle for trees weakened the interest of elderly people, mostly those above the mean age. Although young farmers expressed interests and were generally disposed to tree planting, the lack of ready markets and investment capital acted as a disincentive to participation in agro-forestry practices.

Rocheleau (1995) presents a gender perspective of knowledge acquisition and use in natural resource management. The author shows the degree to which women and men in Kathama, Machakos District, Kenya have distinct environmental knowledge, and how "a feminization of rural environment" with the increasing rate of male migration to urban centres, but also how in times of drought, poor women rely not just on their deep agricultural knowledge but also their political and social skills in obtaining access to resources, private plots or public lands controlled by men. A key finding of Rocheleau's research is that women's rights of access and control of land frequently are not commensurate with their responsibilities for agricultural production or ecological sustainability. In research carried out in Murang'a, McKenzie (2005) suggests that sustainable management of soil was bound up not only with the level of wealth or poverty of the household but also with how successfully women (with primary and exclusive responsibility for agricultural production) were able to secure rights to land and labour.

According to Prevost and Gilruth (1997), short term funding has resulted in piecemeal ad hoc EIS efforts: Most donor-funded managers are sector specific, cover limited areas and have relatively short-term span. The critical problem is that (1) short-term funding does not always match long-term development and (2) donors often specify the approaches that should be taken which may not meet local needs and values (Nkwae and Nichols, 2002). Clearly, the EIS community is confronted with the dilemma of how to set an economic price to encourage its production, while maintaining a low price to encourage its widespread use (EIS-Africa, 2002). Johnson (1996) used a case study approach to examine the legal and practical issues of GIS data dissemination in US local government agencies and identified two main approaches—open access and cost recovery. In the three open access cases studied, copies of GIS data were provided at costs of media or charges for staff time and computer time. The potential revenue from sales of geographic information are a primary argument for a cost recovery policy while the loss of those potential benefits is often cited as the greatest weakness of open access policy (Johnson, 1996). However, in some cases, EIS agencies use contracts to restrict secondary uses. Johnson (1996) finds that cost recovery at the local government level is either not achieved at all or is only achieved to a minimal extent. In the US, the Federal Government provides information at little or no cost and without restricting licensing conditions for its supply. The US Government is convinced that there is much greater economic benefit gained by making spatial data freely available than by charging for it (Klinkenberg, 2003).

In Canada, the Crown maintains the copyright on all federally and provincially produced spatial data and collects royalties on the data it sells to resellers (Klinkenberg, 2003). The crown copyright was introduced to ensure that government documents were not reproduced inaccurately and that in the 1800s, a few private companies could not unreasonably profit from the reproduction of ordinance survey maps. Unfortunately, the

Crown copyright does not apply to municipally produced data in Canada (Evangelatos, 1999). In addition, crown copyright has simply become a mechanism to create an artificial rarity value for mapping data with the aim of covering the agency's costs (Barr, 1998a).

However, in the UK, the government policy for the Ordinance Survey is explicitly designed to recover full cost. In 1997, the UK had a total cost-recovery rate of 80% for the Ordinance Survey. A number of other European national mapping authorities (Norway, Sweden, etc.) have a cost recovery rate of 30-40% (EIS-Africa, 2002). A review of the state of EIS development in Africa by the World Resource Institute (WRI) / United States Aid for International Development (USAID) Information Working Group in 1999 revealed that some of the EIS institutions mandated to produce data on environmental and natural resources have been transformed into commercial entities losing the democratic values which engendered funding for such projects. In Burkina Faso, the World Bank's EIS support has proved disappointing because the Survey Department is more interested in using the new equipment to sell its services to the private sector than honouring its contracts with other government agencies (WRI/USAID, 1999). In spite of the Bank's readiness to pay for 1,000 copies of the database on CD-ROM to be distributed free by the National Environmental Agency (NEA), the offer was not taken up because the NEA prefers to sell the data, not to cover marketing and maintenance costs (which is the usual justification), but rather to supplement salaries (WRI/USAID, 1999).

The context-specific issues such as institutional policies, capacity buildling, economic policies and costs, interests, attitudes and customs of the people are complex, interrelated and mutually reinforcing. Investigating the role of these factors in community-based agroforestry management or biodiversity conservation requires both systematic and rigorous survey techniques that will generate statistically quantifiable information on one hand and a participatory survey approach that can capture subjective aspects, such as peceptions of individuals associated with these proejects. This will help to understand the progress of EIS and LKS implementation in natural resourcement. The following section provides an overview of the survey methods; research design and instruments employed to elicit information from the EIS service providers, resource managers, and farmers from the communities within which these projects were implemented.

CHAPTER 3: RESEARCH DESIGN AND METHODS

3.1 Introduction

The objective of this study was to examine the policy, institutional and implementation issues of EIS application in community-based natural resource management. The methodological approach employed in this investigation highlights the criteria used for selecting the projects and the corresponding districts which were demarcated for the case studies. The conceptual framework for this study illustrates the hierarchical nature of EIS implementation and the extent of interactions in terms of knowledge flow and collaborative initiatives among the EIS service providers, district planning officers/resource managers and farmers within the communities. No complex socio-ecological system can be captured using a single model or method, as no single perception is able to provide a comprehensive or adequate view of reality.

Hence, a variety of forms of inquiry, multiple sources of evidence and dialogue with persons representing different worldviews were appropriate. Questionnaire-based interviews were used to elicit information from EIS service providers and resource managers about their knowledge in and experience with EIS and IKS application in natural resource management. In addition, focus group discussions were conducted in six districts to allow farmers from different agro-ecological zones to voice their views on the success or otherwise of EIS implementation and to share their ecological knowledge on agro-forestry practices. In addition, informal interactions and focus group discussions brought multiple perspectives on the importance of EIS and indigenous technical knowledge which were accepted as valuable sources for making the project sustainable. Data on agroecosystem dynamics, natural resources use and spatial information systems are completed with in-depth focus-group discussions and community-level participatory methods. The methods were complementary in their ability to contribute to and verify the results.

3.2 Rationale for Project Selection and Site Demarcation

The nature of natural resource management projects in Ghana varies considerably depending on the objective of the donor-funded project, individual community problems, and the location and needs of the communities. These projects include forest management, coastal erosion defense, mangrove management, tourism, minerals, forestry, land use planning, water and sanitation, feeder roads, export processing, public health, wildlife and fisheries. Some of these projects have an information systems component and local knowledge-based systems. It became necessary to select several case study projects on the basis of a set of criteria;

1. Application of EIS and LKS to agroforestry and biodiversity management,
2. Duration of the Project (5 years and over),
3. Evidence of community participation,
4. Consideration of gender-sensitive activities.

These criteria were used to identify the projects which have an agroforestry and biodiversity management component and have been on-going long enough for significant impact to be felt on the environment. Projects that endorse grassroots participation in natural resource management facilitate in-depth understanding of the local dynamics of EIS application at the end-user stage where the impact of resource management decisions is greatly experienced. Also, the gender criterion was intended to assess how female and male roles influence access to and use of EIS. The EIS projects which met these criteria were the (1) Netherlands Tropenbos, (2) The UNU/PLEC, (3) and UNDP/Ghana Capacity 21 Projects. The greatest challenge in using these criteria was providing an operational definition of "resource management". This is because some of the major projects such as the UNDP/Ghana Capacity 21 are characterized by comprehensive activities which include, among other things, human settlement planning, sanitation, energy-saving activities and other community development projects. Another issue is the different time frames of the projects. Hence, projects which were chosen are of different duration and at various stages of implementation. The projects are implemented in various districts across major agro-ecological zones in Ghana. For a fair representation of all the districts in which EIS is implemented, 6 districts were selected, two districts from each of the project sites. Some of the project demonstration sites traverse major agro-ecological zones, namely Forest Transition and Semi-deciduous Forest. For a fuller representation of the Ghana-wide EIS application in natural resource management, additional sub-criteria were incorporated into the selection criteria; (1) Location of the Districts within two major Agro-ecological zones of Ghana, (2) Accessibility of the districts (especially by car or motorbike), and (3) Evidence of community participation through workshops and demonstration activities.

3.3 Multiple Case Study Approach

The research objectives were addressed with a multiple case study approach by examining EIS projects in varying agro-ecological zones. A defining characteristic of this approach is description (understanding component parts) and exploration (understanding how component parts fit together) (Benbasat, et al., 1987; Denzin and Lincoln, 1994;

Miles and Huberman, 1994). Two aspects of a multiple case study approach were employed—'Within-case Study' examination of the *modus operandi* of each project and 'Cross-case Study' examination of different projects. The 'Within-Case Study' analysis provides in-depth study of individual agro-forestry management projects in Goaso, Offinso, Assin North, Manya Krobo, Sekyere West and Suhum Kraboa Coaltar districts (Figure 1.1). Humblay (1999) praised single or individual case study approaches because they increase the flexibility and strength of analysis by investigating multiple sources of information (a process referred to as triangulation). Case studies are valuable methods of inquiry and they are appropriate research approaches for investigating indigenous knowledge systems. This method provides in-depth understanding of social setting and yields context-specific knowledge about agro-forestry conservation practices which emerged and evolved through generations as a result centuries of social practices that have been modified, adapted and accepted by the communities.

The first case study is the Project on People, Land Management and Environmental Change which was initiated in 1993 by the United Nation's University (UNU/ PLEC). In March 1998, the UNU/ PLEC became a Global Environment Facility (GEF)-funded project. PLEC/UNU is executed by UNU through a network of locally-based clusters. The second case study is Tropenbos International (TBI) which pursues the application of knowledge, methods and techniques through assembling, integrating and translating results of research into customized information for land-use planners, policy makers and forest managers (Tropenbos International, 2001). The third case study is the UNEP\Ghana Capacity 21 Programme which recognizes the need for detailed knowledge of environmental conditions and the risks posed by forest degradation and resource

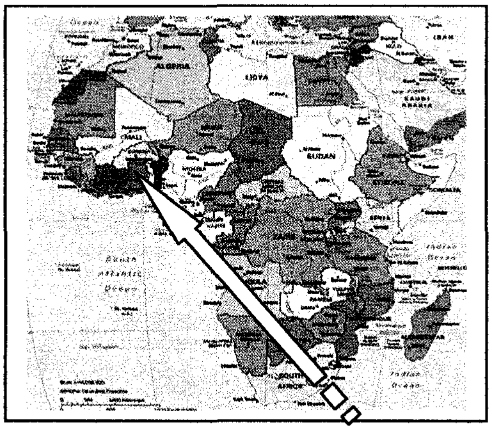
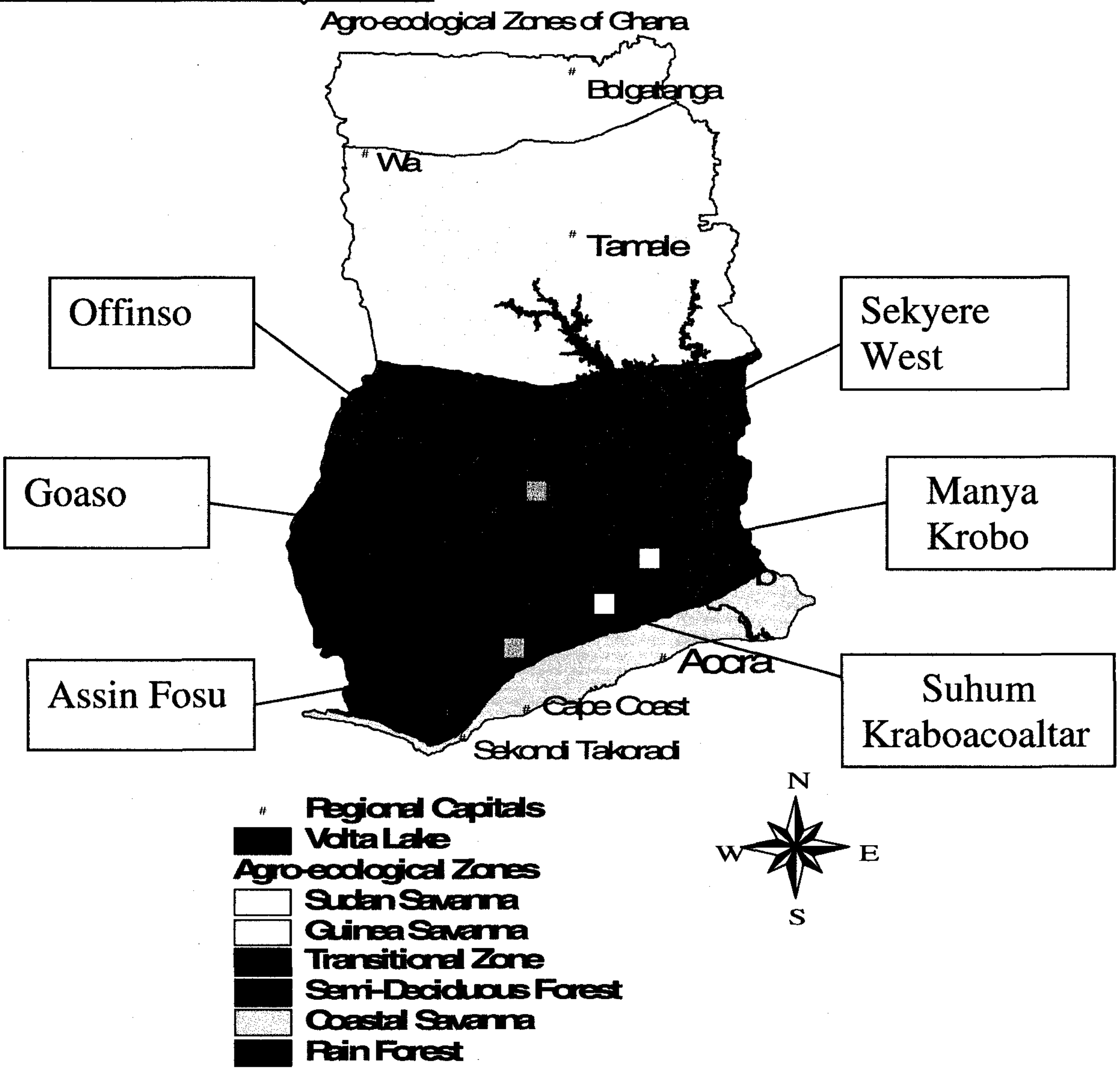


Figure 1.1: Distribution of Districts and Corresponding Survey Areas



depletion at the Assin and Sekyere West district assemblies, among others. At the district level, the main concern is to identify the environmental management and technology development efforts, by detecting capacity constraints in these broad areas and then proposing capacity-building actions for decision-making processes at various levels (Saaka, 2001).

A case study approach helped to explore in-depth issues of EIS implementation and the dynamics of change over time by bringing together rich evidence from documents and interviews (Hamblay, 1999). The Cross-Case analysis of the different projects helped to compare the cases of EIS implementation in order to identify similarities and differences among them. They brought to the fore success, improvisations, failures and coping mechanisms. The case study and cross-case analysis approaches are pre-requisites for addressing issues of 'why' and 'how' EIS initiatives have worked (or not) (Yin, 1994; 2003). Hammersley (1992) suggests that case studies and ethnography research are the two most widely used qualitative research traditions.

Benbasat et al. (1987) identify three strengths in case study approaches, (1) the researcher can study information systems in their natural setting, learn about the state of art and generate theories from practice, (2) the method allows the researcher to understand the nature and complexity of the processes taking place, and (3) provides valuable context-dependent insights into new topics emerging in a rapidly changing information systems field. However, the multiple case studies are not without challenges. One of the key challenges of using a case study approach is the equivocal evidence or biased views which tend to influence the direction of the findings and conclusions (Yun, 1994). In order to overcome this problem, data was obtained from different categories of

EIS users. In addition, a case study using a mix of survey methodologies allows for the collection of data from a wide variety of backgrounds in training, interest-level, understanding and social occupation (Arksey and Knight, 1999). By combining quantitative and qualitative methods to understand necessary and sufficient conditions respectively, researchers can deliberately engage in an iterative process of building complex theme pictures around research questions (Ducan, 2004). Another criticism levelled against the case study approach is that it has given rise to negative stereotypes; lack of rigour, an insufficient basis for scientific generalization and the production of massive, unreadable documents. You cannot generalize from a single case and social science is about generalization (Flyvbjerg, 2004).

After in-depth review of other research methodological works, Flyvbjerg (2004) identified five misunderstandings and oversimplications about case study research;

1. General, theoretical (context-independent) knowledge is more valuable than concrete, practical (context dependent) knowledge.
2. One cannot generalize on the basis of an individual case; therefore, the case study cannot contribute to scientific development.
3. The case study is not useful for generating hypotheses, that is, in the first stage of a total research process, while other methods are more suitable for hypotheses testing and theory-building.
4. The case study contains a bias towards verification, that is, a tendency to confirm the researcher's preconceived notions.
5. It is often difficult to summarize and develop general propositions and theories on the basis of specific case studies (p. 421).

On the other hand, it is clear that in order to understand a complex issue like EIS and LKS application in agroforestry and agro-diversity conservation, in-depth case-study research is necessary because more discoveries have arisen from intense observation than from statistics applied to large groups. Although a single case study allows for detailed examination of a single example but can arouse criticism, this study investigated three case studies of EIS projects and cross-case comparison. Thus, case study research often reveals a rich detail of information that goes beyond traditional aggregated quantitative studies and highlights the critical contingencies that exist among the variables (Bozeman and Klein 1998). As Yin (1994) noted, case-study research objects are complex social situations with a large number of variables which cannot be controlled and cannot even be perceived and recognized in all their dimensions. The paradigmatic difference is that case studies do not rely on a controlled environment. They follow the research philosophy of analysing an existing, real-life situation in all its complexity, exploring it as close to the people concerned as possible, describing the situation in as much detail as possible, and finally explaining the findings in a clear and comprehensible way (Kyburz-Graber 2004). Hence, Horsburgh (2003) suggests that qualitative case studies receive maximum recognition citing potential elements of the framework, researcher reflexivity, the research context, the selection of participants and interpretation of their accounts, the acknowledgement of 'lay' knowledge and researcher flexibility. According to Firestone (1993), qualitative research is best for understanding the processes that go on in a situation and the beliefs and perceptions of those in it.

3.4 Documentary Data Collection

The first phase of this research involved extensive literature review of issues of EIS and LKS applications in community-based natural resource management. Secondary data collection also continued in the field and was done along side field tours. The Ghana Ministry of Environment, Science and Technology library provided useful quarterly annual reports on the UNDP/Ghana Capacity 21. Many of these reports relate to progress in the implementation of environmental initiatives at the designated districts. Also, technical reports on various natural resource management initiatives and EIS applications were obtained from the World Bank Information Centre e-library and databank in Accra and the Ghana Environmental Protection Agency (EPA; 1998, 1999; 2000; and 2001).

The online libraries of Balme, Institute of Statistical, Social and Economic Research (ISSER), African Studies, International Water Resource Management Institute (IWRMI), World Food and Agriculture Organization (FAO), Soil Research Institute (SRI), Kumasi Renewable Natural Resource Institute (RNRI), Centre for Scientific and Industrial Research (CSIR) provided database information, published and unpublished reports, socio-economic and household indicators for Ghana, policy document agreements and studies of Indigenous Knowledge Systems application in Natural Resource Management. Yin (1994) observes that documentary information is likely to be also relevant to every case study topic. Archival records—often in computerized form are also relevant. The documentary data include survey data, maps and charts of the project demonstration sites.

In addition, PLEC books, reports, news and reviews were obtained from the head office of PLEC at the Department of Geography, University of Ghana. Workshop and conference proceedings were obtained from the Tropenbos office at Fumesua, Kumasi. Some of these documents include newsletters on sustainable agroforestry, forest conservation, executive reports on EIS project implementation, workshops on tree planting exercises and skill development programmes. In the case of Capacity 21, annual progress reports, district assemblies communiques, memoranda of understanding and policy documents were acquired from the districts. In addition, workshops and training manuals were obtained from UNDP offices in the Ghana Ministry of Environment Science and Technology (MEST). This background information made it possible to review the state of environmental resource management programmes in Ghana and helped to identify the potential study sites and survey respondents.

3.5 Reconnaissance Studies and Pilot Survey

During the second phase of the field work, I undertook an exploratory and reconnaissance tour of the various EIS project districts, demonstration sites and resource centres at the district level in Assin Fosu and Sekyere West (Capacity 21 project), Manya Krobo and Suhum Kraboa Coaltar districts (PLEC project) and Asunafo Goaso and Offinso districts (TBI project) between February 12 and Febuary 25, 2005. This was geared towards gathering first hand information on the progress of work in EIS application and also to assess the rural conditions within which the research would be conducted. With the assistance of the field coordinator of the PLEC cluster in southern Ghana, district assemblymen in Sekesua (Manya Krobo District), expert farmers and district planners, I contacted the local farmers and established rapport for subsequent meetings. The meetings with the field coordinators and district planning officers of the projects were fruitful as I explained the rationale of the study to them and the assistance that they could offer. This set the stage for further contacts and meetings with resource managers and farmers who participated in the workshops and demonstration activities undertaken under each of the projects. In some cases, contacts, especially Amanase Whanabenya, the chairman of the PLEC farmers association, drew up a plan and informed the other farmers about my pending trip and subsequent focus group discussion. This made it easier to organize the farmers and arouse their enthusiasm about the relevance of the study.

In addition to establishing contacts, it became necessary to undertake preliminary assessment of the validity of the survey questions (Appendixes A, B and C). This research and survey methods were reviewed and approved by the Research Ethics Board of Wilfrid Laurier University and matters of rights and treatment of research subjects and confidentiality were taken into consideration during the entire field work in Ghana between 2005 and 2006. After consultation with key EIS service providers and resource managers in the project districts, copies of the questionnaires were submitted to 6 respondents. The feedback obtained from the respondents indicated that 75% of the responses related to the activities of the individuals involved. Other questions which had

Table 3.1 Breakdown of Total Survey Respondents

CATEGORY OF RESPONDENTS	UNDP/GHANA CAPACITY 21	UNITED NATIONS PLEC	NETHERLAND TROPENBOS	TOTAL RESPONDENTS
EIS service providers **(Interviews)**	8	8	8	**24**
District planning officers/resource Managers/ **(Interviews)**	4	4	4	**12**
local people farmers **(Group Discussions)**	46	41	53	**140**
TOTAL	**58**	**53**	**65**	**176**

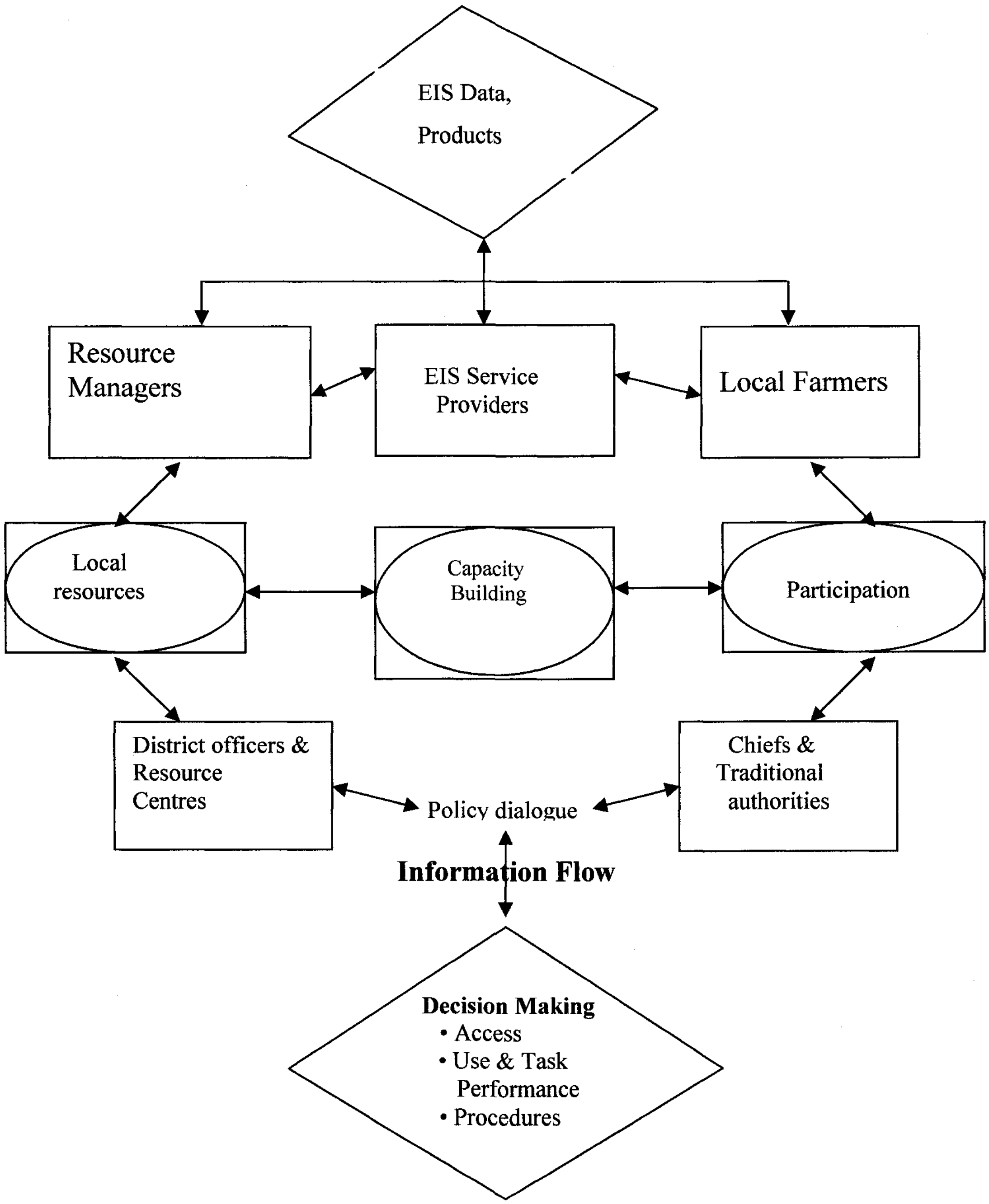
Source: Field Survey, 2005-2006

no relevance to the subject under investigation were either eliminated or modified. In the same vein, one of the villages was earmarked for a mock group discussion. The questions were translated into Akan (indigenous language) to make it easier for the farmers to participate in the group discussion. Contributions and feedback from the farmers were used to re-structure the themes for the group discussions.

3.6 Selecting the Survey Respondents and Survey Methods

The conceptual framework designed for this study involved working with three major groups of respondents: (1) service providers, (2) resource managers and (3) farmers (Figure 3.1). Agro-forestry has been in operation prior to the introduction of the PLEC, Capacity 21, and Tropenbos projects in Southern Ghana. Views from these respondents help to illuminate the projects' impact on farmers' and resource managers' adoption and perceptions of EIS and LKS use for agro-forestry management as well as differentiation between the traditional agro-ecological knowledge and environmental information systems. Overall, 8 service providers and 4 district planning officers were chosen from each of the project districts based on their specialized knowledge about EIS application in the districts and their availability for the interviews (Table 3.1). The study also helped to compare and contrast the benefits that farmers and resource managers associated with these projects obtain relative to other individuals who are not associated with the project. Chambers et al. (1989) suggest that farmers innovate at least as a result of what they observe or experience at the local level. This is plausible, but there are social, economic and political obstacles that inhibit information acquisition and movement to and between service providers, resource managers and farmers (Humblay, 1999). These respondents provided their opinions about the impact of EIS application on agro-forestry management and the constraints hindering these practices.

Figure 3.2 Integrated Resource Management Process in Ghana



(Adapted from Bassole et al., 2001 and Sedogo and Groten, 2002)

3.7 Description of Interview Techniques and Focus Group Discussions

A snowball approach was used to obtain leads and contact addresses of field representatives from the national coordinators of EIS projects who were usually based in Accra except for working visits or field trips to designated project communities.

Semi-structured interview questions were developed from a combination of theoretical perspectives, trends observed from earlier interactions with respondents and trends discerned from the pilot survey. Purposive semi-structured interviews with EIS service providers and resource managers took between 40 minutes and 1 hour. At least 8 service providers and 4 resource managers/district planners were selected from each of the projects (Table 3.1). The semi-structured interviews allowed local and individual viewpoints to emerge freely. The responses helped to establish the content, currency, sufficiency, and relevance of EIS products in the light of the information needs, expectations and tasks of resource managers and decision makers. These individuals have working experience and possess in-depth knowledge of EIS and IKS application under the PLEC, Capacity 21 and Tropenbos projects. These respondents provided information on the state-of-the-art of EIS use in REM in the districts and communities. It also made it possible to unearth the technical and socio-economic factors that boost or hinder EIS applications at the grassroots level (Table 3.2). The interviews also brought out understanding of local knowledge, perspectives, and viewpoints about EIS and LKS application in natural resource management. It was an ethical consideration geared towards keeping the spirit of the community. You cannot turn away some members of the community where everyone knows everybody. This is a qualitative survey instrument and cannot be subjected to the rigours of systematic research.

Table 3.2 Distribution of Project Districts and Corresponding Survey Communities

EIS / IKS PROJECT	DISTRICT	AGRO-ECOLOGICAL ZONES	COMMUNITY VILLAGE	TOTAL PARTICIPANTS MALE/FEMALE	DURATION OF DISCUSSION HRS/MIN
UNITED NATIONS PLEC	Manya Krobo	Transition Zone	• Prekumase • Onsonson • Adwenso	**9** (7M & 2F) **6** (5M & 1F) **7** (6M & 1F)	1:16 1:30 2:00
	Suhum Kraboa Coaltar	Semi-Deciduous Forest	• Amanase • Whanabenya • Aboabo	**6** (4M & 2F) **7** (6M & 1F) **6** (4M & 2F)	1:30 1:15 1:00
UNDP/GHANA CAPACITY 21	Sekyere West	Transition Zone	• Nkwanta • Adidwan • Bomi	**6** (4M & 2F) **7** (6M & 1F) **11** (7M & 4F)	1:00 1:12 1:00
	Assin Fosu	Semi-Deciduous Forest	• Tuakwa • Asebu • Abura Dunkw	**9** (6M & 3F) **6** (1M & 5F) **7** (5M & 2F)	1:50 2:50 2:00
NETHERLAND TROPENBOS	Goaso	Semi-Deciduous Forest	• Kwadwo Ahenekrom • Nyankomago • Biaso	**7** (4M & 3F) 9 (7M & 2F) **13** (9M & 4F)	1:15 2:00 1:30
	Offinso	Transition Zone	• Konkon • Amoanim • Sarfo Krom	**6** (4M & 2F) **9** (9M & 0F) **9** (4M & 5F)	1:11 1:00 1:55
TOTAL (N)	**6**	**2**	**18**	**140**	**27:14**

Field Survey, 2005-2006

The questions were structured according to a set of themes covering the available products (data on soil and environmental conditions etc.); the quality and reliability of existing infrastructure; the cost and utility of EIS in agro-forestry management and biodiversity conservation; the existing policies (strengths and weaknesses), training programmes, workshops and refresher courses for EIS users and their impact on resource management initiatives.

The focus group members were randomly selected from 6 districts which cut across two major agro-ecological zones on the basis of their availability and consent to participate in the discussions. There were two districts for each project and each district traversed at least 1 agro-ecological zone, that is Semi-deciduous Forest or Transition Zone. Altogether, 6 districts were selected—Manya Krobo, Assin, Goaso, Sekyere West, Suhum Kraboa Coaltar and Offinso Districts (Table 3.2). Three communities or villages were systematically selected from each project district totaling 18 communities (Table 3.2). The average number of participants for the focus group discussions was 8 people/farmers with the largest recorded at Biaso in the Goaso district assembly because the chief linquist hit a gong to invite the whole village to participate in the group discussion. However, only 13 people took part in the actual discussion. The composition of the focus group members was not uniform across the three projects and corresponding districts (Table 3.2). It was an open forum and was intended to be flexible enough to provide equal opportunity for anybody (gender, class, age and socio-economic status). Different segments of people in the community have varied perceptions and interpreted a given situation from their own perspective and multiple views.

Using a checklist of relevant characteristics of EIS and LKS application in agro-forestry management, indicators of sustainable biodiversity conservation, and a recorder, group discussions were held within the selected communities. Due to time constraints and difficulties in mobilizing the farmers, it was found necessary to combine men and women. A number of females who are either farmers and/or traders were invited to participate in the focus group discussions, although the males outnumbered the females except in Asebu (Ghana/Capacity 21 Project) where there were 5 females against 1 male because the male counterparts were unavailable due to farm-related activities at the time of the group discussion. These discussions were held on non-farming days and market days when the farmers could easily be invited by the chief linguist, assemblymen or expert farmer leadership to participate in the group discussions. The themes for the group disussion were designed to offer farmers the flexibility to share their experiences and practical knowledge in EIS and LKS applications in agroforestry management as long as they wished. Consequently, the time spent during each group discussion ranged from 1 hour to 2 hours 50 minutes (Table 3.2).

Each focus group was made up of 6-13 individuals, mainly farmers and community leaders. A total of 140 farmers participated in the entire focus group discussions for the three projects. These individuals have practical experience in hands-on application of datasets, other information products and local knowledge such as plant grafting and agroforestry and biodiversity conservation. The discussion was suitable for obtaining first-hand information from semi-literate and illiterate respondents who sometimes collaborate to manage resources on common properties and communal lands. The hallmark of group discussions with a subject focus is the opportunity to use interactions to produce varied insights not otherwise easily accessible from interviews (Trotter and Schensul, 1998). Reactions to ideas and to each other by group members encouraged exploration of participants' feelings and experiences, illuminating the subject under discussion by understanding the cultural context, community conditions and the surrounding environment (Duncan, 2004). The discussion revealed farmer knowledge on the need for sustainable management of the farmlands, diversity of crops and conservation of biodiversity. This provides different perspectives on the practical situation-specific applications of EIS for resource management and the extent to which EIS use has enhanced decision-making processes in agroforestry management. The survey posed questions such as *what* EIS data and information are in use, *how* are they obtained, *what* technical supports are at the disposal of users. The process aspects of the survey complement this information with questions like *how* are EIS being used, *why* are they being used and *how* does EIS promote sustainable community-based agro-diversity management. The group discussions facilitated in-depth explanation of a number of issues which were raised in the qualitative structured interviews.

The interviews and group discussions were tape-recorded. The tapes provided more accurate renditions of interviews than any other method (Yin, 1984). Other advantages include the ability to rapidly and inexpensively accumulate large volumes of data; the production of easy-to-understand data in the words of respondents and the direct interaction with respondents by the researcher (Arksy and Knight, 1999). Krueger (1988) points out five advantages of focus group discussions: (1) The technique is a socially oriented research method capturing real-life data in a social environment; (2) It is flexible; (3) It has high face validity; (4) It has speedy results; (5) It is low cost. As Babbie (2001:294) notes, "…group dynamics frequently bring out aspects of the topic that would not have emerged from interviews with individuals". However, a limitation of the group discussion is that the interaction removes independence of responses and may constrain some individuals, especially female participants and may create difficulty in interpreting some of the open-ended responses (Arksey and Knight, 1999). Focus groups do not generally indicate consensus in attitudes of the group and they tend to indicate the nature and range of participants' views, rather than their strength (Robson, 2002).

In view of this, the interviews and group discussions were supplemented by documentary and archival materials most of which were obtained from the district assembly offices and other sources. This provided data on policy, human, social and institutional issues that influence EIS application at the community level.

3.8 Data Compilation and Analysis

The tape recordings (some of which were in local languages) from the 18 community-based focus group discussions were translated and transcribed by myself and the research assistant who was a final year student at Department of Geography, University of Ghana. The data was examined under the guidance of the key research questions. The responses were categorised into themes or clusters of meanings in order to understand patterns, relationships, sequences or differences in response on to the semi-structured questionnaires. The themes refer to settings, definitions, perspectives, events, processes, strategies, relationships and methods. The challenge of content analysis, not unlike many areas of qualitative analysis is that messages rarely have a single meaning and meanings are not necessarily shared. This kind of analysis is context-sensitive, meanings are specifically derived from the social and political context in which words and opinions are stated (Duncan, 2004). Reflexive examination of coding patterns is the only method of checking against this outcome. Transcription of focus group discussions allowed content analysis of the context-specific EIS and LKS applications.

The context of EIS project implementation involves identification and consideration of myriad ecological, economic, institutional, political and socio-cultural variables. Importantly, within a particular community established social networks and interactions, societal values, legal policy frameworks and historical influences shape human association with their natural resources and will continue to influence the associations and the pattern of behaviour in the future. As a consequence, the impact of a particular initiative on the community concerned, and ultimately the sustainability of the natural resources, may vary considerably for different situational contexts. The system-based evaluation framework recognizes the multiple levels and nested nature of natural resource management policy, namely: issue characterization, policy formulation and intent, on-ground implementation and the fundamental importance of context (social, economic, environmental, institutional and technological) on all of these aspects (Bellamy et al., 2001). The framework links both the intent and rationale of a natural resource management policy initiative to its implementation and performance 'on the ground'. It also provides the basis for synthesizing the multiple perspectives on the evaluation of the phenomenon of interest. The fundamental elements of this framework are discussed below.

3.9 Analytical Framework for Evaluating EIS use in Ghana

Several criteria were selected and developed against which the status, progress, effectiveness and efficiency of EIS projects can be measured. The system-based evaluation framework recognizes the multiple levels and nested nature of natural resource management policy and implementation, namely: issue characterization, policy formulation, program logic, and on the ground implementation and the fundamental importance of context (social, economic, environmental, institutional and technological) on all of these aspects. The evaluation criteria are fashioned out of systems thinking which reflects the interrelations and interacting nature of EIS applications among the various actors namely, farmers, resource managers and district planning officers at the

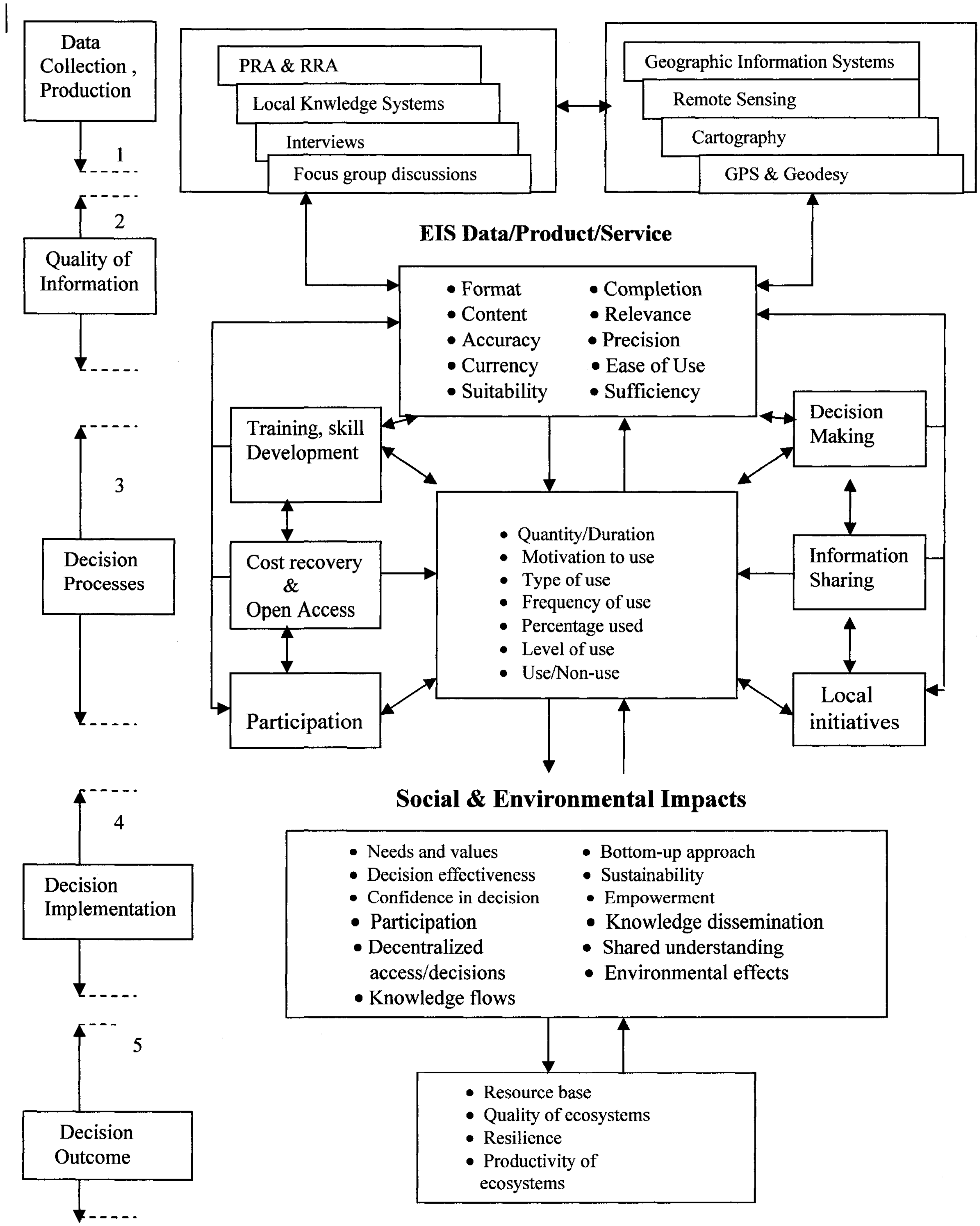
Table 3.3 Evaluative Frameworks for Analysis of Data

Indicators	Details
1. EIS Use and Credibility	• User friendliness • Accuracy of EIS products and services • Relevance to needs and tasks • Completion and sufficiency • Suitability • Limitation of EIS
2. Training, Skill Development and Technical Support	• Awareness of EIS availability • Existing training programmes • Skill development • Skill sharing (and common initiatives) • User satisfaction, individual effects • Societal/communal effects • Developing working relations among EIS users • Integration of Group into EIS projects • Institutional Power Issues
3. Decision-making effectiveness	• Acquisition of factual information • Access to data and information • Decision-making (explicitness and time) • Communication of information and information sharing • Changing needs and multiple task Performance • The emerging power relations
4. Economics	• Affordability of EIS • Cost recovery • Open Access

Adapted from DeLone and McLean (1992); Kyem, 1999; 2001; Tetteh et al., 1999; Subaryono, 1996, Allotey et al., 1999; Budic Nedovic, 1994; Gyasi 1998 and Gyamfi-Aidoo et al., 1999

different levels of implementation. The framework links both the intent and rationale of a natural resource management policy initiative to its implementation and performance 'on the ground'. It also provides the basis for synthesizing the multiple perspectives on the evaluation of the phenomenon of interest. The fundamental elements of this framework are discussed below.

Figure 3.3 Environmental Information System



Key themes are identified in Table 3.3 for grouping the research questions. The linkage between the key themes (such as credibility of EIS, skill development programmes and economics of EIS) is examined. Much needed narratives and clarifications are analysed on the basis of these themes. The analysis focuses on the effectiveness and efficiency of EIS use in community-based resource management in Ghana. Effectiveness is concerned with making use of quality information products to meet goals of individuals and groups, whereas efficiency refers to minimizing the "cost" of producing and acquiring information or the ratio of output to input (Nedovic-Budic 1999). A comprehensive review and typology of various measures of information system success, modified after DeLone and McLean (1992) and others, has been used as a framework of analysis (Table 3.3) where the authors identified six major categories of system success; system quality, information quality, information use, user satisfaction, individual effects and societal effects. This process is associated with EIS implementation in Ghana.

First, EIS data and quality assessment in Ghana will consider (1) visibility of uses and benefits, (2) availability of existing data, (3) ease of transferring data, (4) data accuracy, (5) ease of gathering results, (6) cost of datasets and services, (7) adapting GIS to meet communities specific goals or needs. In addition, level of product quality, efficiency and service delivery are contingent upon the needs, aspirations and objectives of resource managers and local users of EIS. Quality data and information may improve the process of decision-making due to the production of new information (Calkins and Obermeyer 1991). Aspects of the evaluation framework impinge on EIS application in natural resource management in Ghana (Figure 3.2).

Second, effective environmental policies and implementation of EIS in resource management in Ghana require adequately trained and well-informed data providers, resource managers and local people who understand the basic concept of a particular information system and how best to utilize it to meet their resource management needs. Studies (Allotey et al., 1999; Gyamfi-Aidoo et al., 1999; Kyem 2001) show the significance of technical skill and knowledge especially with regards to the functions, operation and maintenance of spatial information technologies. These human factors are very critical to the success of EIS application. EIS training programmes must take the form of ongoing refresher courses with hands-on or regular on-the-job practice and workshops on application of appropriate software (World Bank, 1998). Third, GIS and other information systems in Ghana must be constructed with equity in mind for all societal groups and methods need to be developed that allow access and empower such groups through institutional procedures and codes of practices (Laituri, 2002). There must be an institutional policy framework for open access and cost recovery (Johnson, 1996). The issue of cost of EIS acquisition and use in Ghana is crucial for evaluating the level of access and use of the technology.

The data collection process of EIS in figure 3.2 involves a series of field-based activities with the aid of scientific instruments (remote sensing) and social survey methods (interviews). This is supplemented by groundtruthing to enhance validation and cross-checking. The approach for data collection is contingent upon the information needs of the jurisdiction or agency that is conducting the project. Data collection also depends on the individual skills, cost outlay and the duration of the project. This reveals the relevance of behavioral and institutional factors in determining the success or otherwise of EIS projects (Karikari et al. 2005). A satisfactory data collection is one which fulfills the objective of the project and requires minimum skills and accomplished within the stipulated time. The cost of such data collection must be reasonable.

The quality of information can be ensured by monitoring and assessing the methods used for the data collection, removal of potential sources of errors in the field survey or data entry stage, (either by instruments or human causes). Cross-checking and other calibration methods are necessary to ensure that the data is of high quality in terms of content, precision, currency and suitability. High quality data will enhance understanding of environmental problems and ensure effectiveness of the decision support system.

The decision making process in resource management should be adaptive or iterative and inclusive. Decision making processes will incorporate local views and initiatives into the resource management decisions. The establishment of farmers associations, routine workshops and demonstration activities serve as useful forums for collating and synthesizing inputs from rank and file of the community and a vital way of networking and creating effective social systems which Gore (2000) elaborated. Such forums can serve as stages for cross-fertilization of ideas on the options appropriate for planning and resource decision making. Such processes should be adaptable to changing trends, resource situations and socio-economic expectations of communities. Best practices can be replicated in other communities whereas challenges or obstacles can be modified or reformed to improve the implementation strategies.

The implementation decisions should be all-inclusive, bottom-up and integrative. Decentralized decision making processes can remove the barriers of technocracy, strengthen local ingenuity and boost confidence in decisions at the local level. This can lessen the kind of power relations inherent in resources management processes which Blaikie and Brookfield (1987) and Greenberg and Park (1994) decried. Participatory processes require that experts learn from farmers and at the same time they should help farmers to modify their methods where necessary to accommodate unique local situations. Institutional capacity at the local level and appropriate mechanisms and protocols for information dissemination, knowledge exchange and logistical supplies among the different levels of institutions are vital processes for enhancing the decision outcomes and the group experience in resource management. Such approach, as noted by Karikari and Stillwell (2004), can enhance the development of models and design of projects.

Decision outcome is a reflection of the chain of processes which include the type or format of data used, the quality and suitability of the data, effectiveness of decision making and implementation context. The decision outcome is a compendium of comprehensive processes which result in improvement in the quality of the natural environment, increased awareness of sensitivity of the environment and preservation of productivity, resilience and complexity of the environment. A vital component of the decision outcome feedback loops (Figure 3.2) which can be achieved through constant monitoring of on-going project and evaluation to determine whether targets and timelines have been achieved. This will provide alternative options for revaluation sources of data, protocols for dissemination and suitability for the resource management objective. These processes are essential for analyzing the impact of information systems on natural resource management.

This analytical framework forms the basis of the quantitative and qualitative analysis. SPSS was used for standard descriptive analysis (Norusis and Marija 1998; Coakes, 2001). Responses to the questionnaire-based interviews were tabulated accordingly and ffrequency tables were generated from the responses based on the options provided for each of the questions (Appendixes A and B). The input data was used to produce bar graphs which show the trends in the responses. In the case of the focus group discussions, the questions designed for the deliberations were grouped thematically (Appendix C). The audio recordings of the conversatations, exchanges and views of farmers about their experiences with EIS and LKS application in natural resource management were transcribed verbatim for subsequent thematic analysis. The responses that relate to particular EIS issues were grouped under common themes and this helped to categorise and systematize the views from the respondents. The uncoded questions provided richer insights into EIS use and the advantages and problems associated with their use. The criteria for data analysis are based on the modified themes identified in EIS applications in Ghana (Table 3.3). The criteria also highlight the multiplicity of socio-political, economic and institutional, human and policy factors that influence EIS application in agro-forestry and agro-ecological districts which were earmarked for the interviews and focus group discussions. The criteria cover the key issues which are fundamental to determining the success or failure of EIS projects vis-à-vis the intended natural resource management objectives and targets. Social issues relevant to this study are whether there is gender-related differential access to EIS application in natural resource management. Hence, the assessment procedure I adopted is sensitive to gender issues.

3.10 Summary

There are past and on-going EIS and environmental projects in Ghana. Most of these environmental projects are characterized by the application of EIS, community participation and agro-forestry management, among others. This study employed a multiple case study approach to assess situations in which EIS have been applied under the PLEC, Capacity 21 and Tropenbos Projects. Three categories of respondents were involved in the interviews and focus group discussions—EIS service providers from national institutions, planning officers from the district level and individuals from the farming communities. Respondents engaged in the focus group discussions were selected from various communities within the 6 project districts in Southern Ghana. The survey methods helped to elicit views from respondents on their knowledge and experiences with EIS application for natural resource management. The responses were tape recorded and transcribed for subsequent content analysis. The study analyzes case by case strategies in the implementation of EIS and used cross-case analysis to compare and contrast the project-specific strategies in order to determine what worked, why and if not what improvisation or alternatives were employed. The analysis is guided by a set of themes fashioned out of the conceptual framework which reflect the various component parts of the implementation issues of EIS application in agro-forestry management. Trends in responses were analyzed using descriptive statistics and qualitative approaches which provide more in-depth explanations and information on the policy, institutional and environmental issues that enhance or inhibit EIS application at the community level.

Chapter 4: Case Studies of EIS and LKS Application in Resource Management in Ghana

4.1 Introduction

A central challenge facing development agencies is how to apply EIS and LKS to better accommodate ecological concerns in rural development projects and programmes, particularly simultaneously raising the living standards of poor rural people and promoting sustainable livelihoods (Grimble and Laidlaw, 2002). Another issue is inadequate understanding of the local culture, economics, environmental conditions and the lack of recognition accorded to the important contribution which local people, through participation and sharing of knowledge, make in the interpretation of needs and opportunities into natural resource management practices.

This chapter provides documentary evidence from published reports of EIS monitoring activities, memoranda of understanding, news letters, project databases, archival materials and state of the environment reports on the progress of EIS implementation. The documentary sources first highlight the biophysical and socio-economic background of Ghana and trace the origin and development of EIS projects and how their blueprints for action have been translated into local level initiatives. The section also describes and discusses the features and mechanisms for implementation of environmental initiatives in Ghana. It highlights the strategies employed under these projects for agro-forestry management or biodiversity conservation and analyzes case-by-case mechanisms for implementation of the projects; their successes and failures, and the coping mechanisms which to a great degree depend on the context in which the projects were designed and implemented.

4.2 Physical and Socio-economic Background of Ghana

Ghana covers an area of 238,539 square kilometers, including inland water bodies, and lies on the south central coast of West Africa between latitudes 4° N and 11° N and has a castline of 550 kilometres. The country spans five major ecological zones. The climate is tropical and humid with temperatures averaging between 21°C and 32°C (Allotey et. al., 1999). Almost the whole of Ghana lies below 500 m elevation and over half is under 150 metres. Despite the predominantly gentle slopes, forest degradation and removal of vegetation for agriculture mean that about 70% of the country is subject to moderate and severe erosion. The high forest zone covers roughly one third (8.2 million ha) of the land area and includes wet and moist evergreen and semi-deciduous forests. It has good soils and a bi-modal annual rainfall ranging between 1,300 mm and 2,100 mm (Ministry of Lands and Forestry, 1998). The predominant soils of the forest zone, known as Forest Oxysols and Ochrosols, are characterized by deep weathering, leaching of nutrients and acidity. Two characteristics common to most of the soils are low fertility and poor water holding capacity. Most of the country's economic activities (cocoa, oil palm, rubber, timber and mineral production) are concentrated in this zone. The savanna zone covers two thirds (16 million ha) of the national territory. The Northern section of the country has four types of vegetation: the derived savanna, the southern Guinea, the northern Guinea and the Sudan savanna. The soils are relatively poor and the main economic activities are in shifting annual crops (food crops, groundnut, cotton) and in livestock production (Ministry of Lands and Forestry, 1998). Agriculture is predominantly smallholder, traditional and rain-fed and still forms the pivot of the national economy. It employs 55% of the labour force and accounts for 35.2% of Gross

Domestic Product (GDP) in 2003 (Table 4.1). The Balance-of-Payment (BOP) position of the country is precarious because foreign exchange earnings from timber, cocoa and mineral exports are less than expenditures on imports. The country has an external debt of $7,962 million (Table 4.1).

Farming systems were developed over time as adaptations to the major agro-ecological zones in the country at a time when population was sparse and land abundant. Bush fallow is used to restore fertility and mixed cropping to minimize risks, and as well as widespread integration of forestry and livestock into farming systems for increased social, economic and environmental benefits (Leakey, 1996; Abagale et al., 2003). Agricultural performance helps to improve household incomes within rural communities. Other traditional methods of conservation include contoured stone lines, woody fallows, alley cropping, stone-faced terracing, retention of nitrogen fixing trees and compound farming.

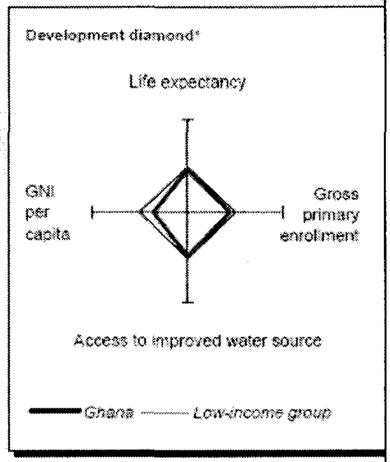
Ghana's population in mid-2003 was 20.4 million and was increasing at a rate of 2.6% per annum (Table 4.1). Nearly 67% live in rural communities where the majority of the people are poor. Population growth has influenced land use and increased conservation programmes. In addition, the household units act as a forum for obtaining first hand information on local people's views on resource managements issues, land fragmentation and reduced fallow period, now often no more than a year. The rate of population growth in rural communities and the attendant problems of overgrazing and increased agricultural activities continue to impact on land, water and forest resources of these communities.

Table 4.1: Ghana Country at a Glance Database

Ghana at a glance

9/15/04

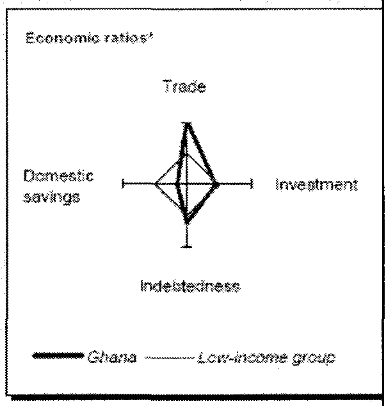
POVERTY and SOCIAL	Ghana	Sub-Saharan Africa	Low-income
2003			
Population, mid-year *(millions)*	20.4	703	2,310
GNI per capita *(Atlas method, US$)*	320	490	450
GNI *(Atlas method, US$ billions)*	6.5	347	1,038
Average annual growth, 1997-03			
Population *(%)*	2.6	2.3	1.9
Labor force *(%)*	2.2	2.4	2.3
Most recent estimate (latest year available, 1997-03)			
Poverty *(% of population below national poverty line)*	40	..	..
Urban population *(% of total population)*	45	36	30
Life expectancy at birth *(years)*	55	46	58
Infant mortality *(per 1,000 live births)*	60	103	82
Child malnutrition *(% of children under 5)*	25	..	44
Access to an improved water source *(% of population)*	73	58	75
Illiteracy *(% of population age 15+)*	26	35	39
Gross primary enrollment *(% of school-age population)*	81	87	92
Male	85	94	99
Female	78	80	85



KEY ECONOMIC RATIOS and LONG-TERM TRENDS

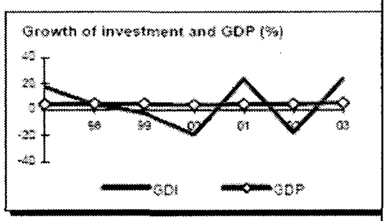
	1983	1993	2002	2003
GDP *(US$ billions)*	4.1	6.0	6.2	7.7
Gross domestic investment/GDP	3.7	22.2	22.3	19.4
Exports of goods and services/GDP	5.6	20.3	42.5	37.2
Gross domestic savings/GDP	3.3	6.0	10.3	5.6
Gross national savings/GDP	2.4	12.8	22.8	18.9
Current account balance/GDP	-6.1	-9.4	0.5	-0.5
Interest payments/GDP	1.1	1.4	1.2	1.4
Total debt/GDP	41.1	81.0	119.1	103.5
Total debt service/exports	30.4	24.6	7.3	23.1
Present value of debt/GDP	..	..	63.4	..
Present value of debt/exports	..	..	147.5	..

	1983-93	1993-03	2002	2003	2003-07
(average annual growth)					
GDP	5.0	4.3	4.5	5.2	4.9
GDP per capita	2.0	2.3	1.9	2.5	2.6
Exports of goods and services	9.9	7.1	-1.7	2.7	4.2

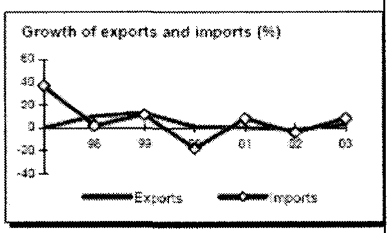


STRUCTURE of the ECONOMY

	1983	1993	2002	2003
(% of GDP)				
Agriculture	59.7	36.9	36.0	35.2
Industry	6.6	24.8	24.3	24.8
Manufacturing	3.9	9.4	9.0	8.4
Services	33.6	38.3	39.7	40.1
Private consumption	90.8	79.5	78.3	82.9
General government consumption	5.9	14.4	11.4	11.5
Imports of goods and services	6.0	36.4	54.5	50.9



	1983-93	1993-03	2002	2003
(average annual growth)				
Agriculture	2.3	4.0	4.1	4.6
Industry	6.6	4.6	6.3	0.7
Manufacturing	3.9	4.0	0.0	-1.4
Services	7.8	4.5	4.4	6.9
Private consumption	4.4	4.6	9.1	4.3
General government consumption	5.9	3.9	-4.4	7.2
Gross domestic investment	6.2	2.0	-17.6	24.1
Imports of goods and services	8.5	7.1	-4.4	7.7



Note: 2003 data are preliminary estimates.

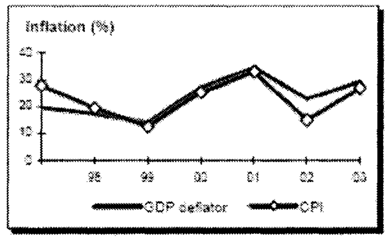
This table was produced from the Development Economics central database.

* The diamonds show four key indicators in the country (in bold) compared with its income-group average. If data are missing, the diamond will be incomplete.

Table 4.1: Ghana Country at a Glance Database Cont'd

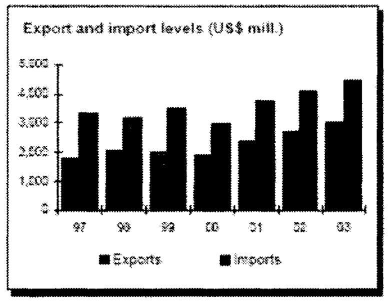
PRICES and GOVERNMENT FINANCE

	1983	1993	2002	2003
Domestic prices				
(% change)				
Consumer prices	122.9	25.0	14.8	26.9
Implicit GDP deflator	123.1	31.8	22.8	29.3
Government finance				
(% of GDP, includes current grants)				
Current revenue	5.5	23.5	20.2	24.3
Current budget balance	-1.9	5.5	0.2	4.1
Overall surplus/deficit	..	-5.6	-5.9	-4.5



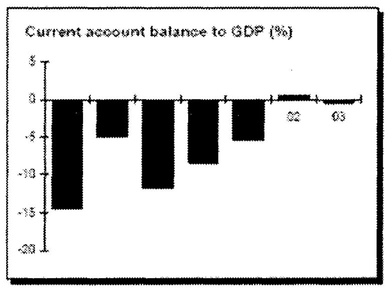
TRADE

	1983	1993	2002	2003
(US$ millions)				
Total exports (fob)	..	1,064	2,681	3,015
Cocoa	..	286	463	772
Timber	..	147	182	176
Manufactures	..	..	..	..
Total imports (cif)	..	1,888	4,099	4,469
Food	..	..	..	..
Fuel and energy	..	158	275	295
Capital goods	..	..	..	..
Export price index *(1995=100)*	94	76	81	88
Import price index *(1995=100)*	102	96	96	97
Terms of trade *(1995=100)*	92	79	85	90



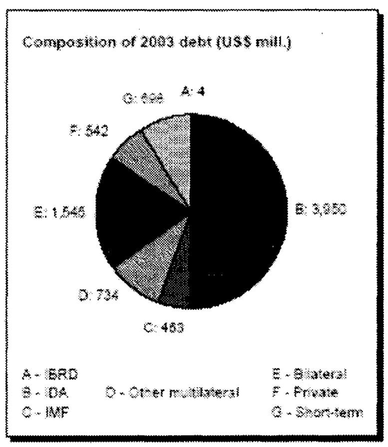
BALANCE of PAYMENTS

	1983	1993	2002	2003
(US$ millions)				
Exports of goods and services	477	1,208	2,613	2,856
Imports of goods and services	634	2,172	3,355	3,910
Resource balance	-157	-964	-742	-1,054
Net income	-90	-112	-129	-158
Net current transfers	-2	517	901	1,177
Current account balance	-248	-559	30	-35
Financing items (net)	-7	600	127	413
Changes in net reserves	256	-41	-157	-378
Memo:				
Reserves including gold *(US$ millions)*	..	..	631	811
Conversion rate *(DEC, local/US$)*	45.4	649.1	7,932.7	8,677.4



EXTERNAL DEBT and RESOURCE FLOWS

	1983	1993	2002	2003
(US$ millions)				
Total debt outstanding and disbursed	1,666	4,834	7,339	7,926
IBRD	128	77	5	4
IDA	141	1,838	3,471	3,950
Total debt service	145	303	193	670
IBRD	20	20	2	2
IDA	2	17	30	29
Composition of net resource flows				
Official grants	46	222	328	..
Official creditors	61	302	175	167
Private creditors	26	25	-23	-294
Foreign direct investment	2	125	50	..
Portfolio equity	0	0	0	..
World Bank program				
Commitments	72	269	0	166
Disbursements	23	205	99	198
Principal repayments	10	17	12	10
Net flows	13	189	88	188
Interest payments	12	20	20	21
Net transfers	2	169	67	167



The World Bank Group: This table was prepared by country unit staff; figures may differ from other World Bank published data. 9/15/04

Consequently, the resilience of the environment as traditional systems of sustainable resource use is being tasked to its breakdown point. This is reflected in shortened fallow periods, expansion into previously uncultivated areas and biodiversity loss. The effective management and control of environmental degradation therefore requires knowledge and information about the nature and extent of environmental problems and strategies that bring about fundamental changes in the socio-economic structure of society (Nsiah-Gyabaah, 1994). Environmental problems are very grave in rural areas due to a lack of basic facilities and budgetary constraints on the part of the government. The villages have also demonstrated little or no ability to undertake "self-help", "self-sufficient" or sustainable projects because the majority of the rural population is poor. Low rural household incomes and poverty affect not only the ecology by accelerating resource deterioration, but also affect the pre-disposition of parents to support their children's education (Nsiah-Gyabaah, 1994). The National Population and Housing Census in 2001 showed that 43.4% of those who are three years old or more have never been to school and 49.9% of the adult population of 15 years or more are totally illiterate. The national adult literacy average rate is 50%. The Canadian International Development Agency (CIDA)-sponsored programme in environmental management and literacy was initiated in 1992 to assist in organizing and implementing a continuing education, advanced forestry program for practicing foresters and to train community leaders and provide the technical support and facilities to sustain delivery of community-based environmental management and literacy. This and other literacy programmes reflect the relevance of embedding education and skill development programmes in community-based resource management programmes in rural localities.

4.3 Environmental Information Systems Development in Ghana

EIS application in Ghana follows from earlier attempts made by foreign donor agencies, sometimes in collaboration with the government of Ghana, to monitor and manage natural resources. Hence, several projects were initiated first in the 1980s, as an integral part of development programmes at various levels. Most of these projects were isolated and independent of each other. In some cases a wide range of scientists and practitioners, including earth systems scientists, land resource managers and urban planners as well as business persons seek information on the location, distribution, type, magnitude and currency of land use and land cover change (Stow, 1999).

Remote sensing products used in Ghana in 1981 were predominantly aerial photographs. They were used principally for traditional mapping and engineering applications. In a study of the fallowing and rotation patterns in the Accra-Winneba Plains, aerial photographs taken in 1962 and 1975 were used to map land use in the Plains and to determine the impact of traditional fallowing practices on soil and vegetation. Aerial photographs were also used to identify first-stage sampling sites in air pollution studies in the vicinity of Obuasi gold mine (Allotey and Gyamfi-Aidoo, 1989). The objective was to locate mine tailings from which samples could be collected in relation to the township. This project was undertaken by the European Office of the United Nations Institute for Training and Research (UNITAR) in collaboration with the United Nations Environment Programme (UNEP). In 1981, an Agricultural Development Project (ADP) was initiated in the Volta Region of Ghana, with funds provided by the World Bank, the International Fund for Agricultural Development (IFAD) and local funding by the government of Ghana. The project objectives included the improvement of general agricultural potential of the region with a view to increasing yields of local peasant farmers through adequate supply of inputs and the dissemination of modern farming methods (Tttriku and Anku, 1989).

Blankson (1989) also describes how vegetation surveys were used to delimit and classify existing plant associations on the floristic criteria into vegetation types. The vegetation survey provided a basis upon which to formulate management schemes for indigenous vegetation and agricultural land use for revegetation of areas which may be degraded due to agricultural misuse or mismanagement. Remotely sensed images and 1:25,000 or 1:50,000 aerial photographs with extensive field sampling and ground truthing helped to discover the structure of land cover, the relationships between vegetation cover and associated environmental factors such as soil type and climate. It also identified causes of land degradation (Blankson, 1989). The result of the survey was the production of a useful classification for better ecological understanding and utilization of vegetation as a resource on a sustained yield basis to prevent overexploitation of useful plants.

Several types of aerial cameras, meteorological and Landsat satellites have been useful for resource inventories and for monitoring environmental change but remote sensing applications and information systems technology are still in their infancy as guides to field investigation and as aids in resource planning in Ghana. These early projects were remarkable because they were supported by ground-truthed observation and local opinion which indicate that in some of the areas investigated, vegetation had undergone a change from wooded savannah to open grassland (Gyabaah, 1994). The implication is that degradation (biomass destruction) is positively related to population pressure and human misuse of the environment. It has been difficult to provide evidence of desertification and to quantitatively estimate degraded areas using Landsat imagery because of the limitations of the images used (poor spatial and temporal resolution).

By the mid-1990's, investment in EIS development in Ghana had taken off dramatically, although EIS-related activities were often small components of larger projects. A considerable portion of the investment in respect to EIS went into the provision of key environmental datasets, capacity building and institutional strengthening (EIS Africa, 2001). In Ghana, the Ghana Environmental Resource Management Project (GERMP) was designed to implement the National Environmental Action Plan (NEAP) and was approved by the government in 1991. Following the National Action Plan (NAP) in 1991, a series of workshops was held to identify information needs of producers and users to ensure the realization of the plan. The project involved five institutions undertaking mapping projects under the auspices of the Environmental Protection Agency (EPA). The Survey Department, The Remote Sensing Applications Unit, Ghana Statistical Services, the Soil Research Institute, and the Hydrological Services Department (HSD) are all institutions which were involved in this project. The workshops, which were attended by producers and users of EIS, led to development of the EIS component of the Ghana Environmental Resource Management Project which was aimed at the creation of core datasets for environmental planning (EIS Africa, 2001). The project was aimed at development of an effective system for the management of environmental resources in Ghana. It also involved components on the development of systems for the collection of information to monitor environmental quality, interpretation and presentation of topographic, land use, land ownership, land suitability and meteorological information (Karikari et al., 2003).

The data produced during this period was supply-driven and there was no specific analysis and application of the information for key resource management objectives. Similar workshops were held in 1995 which dealt with EIS database specifications which helped to set standards for database generation. During the 9th International Advisory Committee meeting (IAC) held in Cape Town, South Africa, in 1996, the World Bank proposed to undertake reviews of EIS implementation, and on the basis of the reviews developed a manual of "lessons and good practices". However, this was predominantly a national level activity which cut across various institutions in Ghana. The reviews did not reflect EIS application in natural resource management at the local level and in rural communities. After the consultants left following the end of the GERMP, the key problem was non-maintenance and minimal use of equipment. Karikari et al. (2003b) acknowledge the serious lack of indigenous expertise but suggest that effective GIS project design and implementation will only occur when indigenous people are fully involved. The approach to technology transfer needs to be strongly human-centred and driven much less by the technological prescriptions donors have frequently pursued (Toulmin and Quan, 2000). Yapa (1991) suggests that there is a need for the establishment of information systems involving strong and local public domain and argues that the term 'appropriate technology' is relevant only in terms of the technology being low-cost and professionally independent. This will take into consideration how EIS is being used for natural resource management and the benefits that accrue to communities in terms of environmental health and sustainable livelihoods.

In 1997, participants from the EIS community in Ghana attended a workshop on a "Geo-Spatial Information Framework for Ghana" (EIS Africa, 2001). During this workshop, participants discussed and recommended the establishment of a secretariat for a National Framework for Geo-spatial Information Management (NAFGIM) which was mandated to coordinate all EIS sector activities in the adoption of and conformity to compatible data exchange formats and promotes the use of GIS for decision-making in the country. Due to a lack of technical skill and infrastructure for EIS implementation, there was the need for the development of human resources, through short-term technical assistance and training focusing on technology transfer. Practical skills helped to improve operational activities and were implemented through arrangements between Ghanaian agencies and counterparts from the developed countries. This helped local agencies to develop conceptual and technical designs of the system. The networked EIS which was established ensured smooth data sharing.

However, much of the current effort in EIS development concerns the development of digital spatial databases (EIS Africa, 2001). Like many other countries, Ghana has several institutions and departments involved in data production, processing and analysis, each one often covering a specific sector (agriculture, water, soil, mapping etc.). About 70% of the organizations have no policy for data exchange and release to the public. Most of these organizations have different mandates and operational capacities and this has led to duplication of effort. Much of the information has been produced independently by institutions with the appropriate mandate. The differences in the standards are so extensive that data sets do not fit to each other. Consequently, users of data have to adjust the different datasets to each other before the data can be integrated (EPA, 1999).

In the absence of "interoperable" data sets, every new usage of the data implies having to pay the same large integration overhead cost. The Ghana-Country at a Glance (G-CAG) database is designed to solve this problem by harmonizing between data layers and features required to conduct environmental analysis. Nevertheless, there is less development at the local level. The G-CAG is a synoptic, inter-operable and user-friendly geographical database designed to assist in national-level environmental management and planning. The G-CAG is a logical extension of the Environmental Information System Development (EISD) component of the Ghana Environmental Resource Management Project (GERMP). The development of the G-CAG database was initiated by the EPA Ghana and the World Bank to meet their needs for data to facilitate environmental planning and decision making at the national level and to support sub-regional sustainable development initiatives (EPA, 1999).

Another issue with EIS implementation in Ghana was that a number of potential users of EIS (environmental planners and decision makers) do not know where the data exist and how to access them. This problem was compounded by the fact that data producers tend to cling to their information and are reluctant to release it even to other divisions of their own organization. Analysis results and secondary data produced are traditionally considered classified information and not released (Kyem, 2001). Kyem also points to inadequacies in the legal framework as a setback for information sharing. There is a lack of appropriate copyright laws dealing with digital data and other geographic datasets.

Another significant development in the area of EIS is the Kumasi Natural Resource Management Project (KNRMP) which was established at the Institute of Renewable Natural Resources (IRNR). The project emerged as a result of the need to identify gaps in the natural resources sector in Kumasi and its peri-urban districts. The gaps related to the availability and dissemination of information. The project was aimed at addressing critical issues of environmental conditions relating to water resource management that confront inhabitants of peri-urban Kumasi, Ghana's second largest city. Evidence shows that wholesale diffusion of geo-technology without considering the socio-economic and institutional background of each of Ghana's land resource agencies can be counter-productive (Karikari et al, 2004). It was realized that what was needed is not just the generation of information but, in addition, the storage, retrieval and accessibility of such information. The strategies developed to educate users on the Kumasi Information included the organization of workshops, seminars, and training sessions and the preparation of media products such as leaflets, manuals, and newsletters.

In the development of EIS in Ghana, the issue and possibility of sustainability of the structures has been recognized and discussed. The possibility of sustainability has been demonstrated by EIS institutions becoming self-supporting with respect to services normally provided by expatriate staff (EIS, Africa, 2001). What is worth noting is the participatory and progressive approach that has been used to address the main issues related to the design and implementation of EIS. This is aimed at avoiding duplication and creating inter-operable GIS system.

In addition, the World Bank in collaboration with the Government of Ghana, has developed an Integrated Community-Based Development programme (ICBD) which has created a GIS-related base map for its long-term monitoring and evaluation. The digital base map has been compiled by the Centre for Environmental Remote Sensing and Geographic Information Services (CERSGIS) based on the use of satellite images, GPS observations of community locations, existing but outdated topographic maps, local knowledge of the grass-roots level decision-makers and opinion leaders concerning distribution of communities and their vital attributes (Amamoo-Otchere, 2002). As part of efforts to improve agricultural policy and development in the Sub-region, the World Bank established a Knowledge Network Information and Technology Centre (KNITC) in 1996. This Centre builds specific dissemination databases and shapes local dissemination initiatives and best practices.

Several issues arise in the course of applying EIS for natural resource management in Ghana. Daudze et al., (1999) observed that the use of satellite imagery data (LANDSAT TM, LANDSAT MSS and SPOT) to accurately map individual agricultural fields in Ghana has proved to be difficult due to the small size of cropped fields. This is critical in tropical landscapes where the landscape within a kilometer square is characterized by a mosaic of different vegetation formations and fallow re-growths of different ages (Foody and Hill, 1996). Another problem is that cloud and haze are also limitations, and dry season images of the savanna landscape can be prone to obscurity by fire scars caused by annual bushfires (Duadze et al., 1999). In addition, data flows are most hindered by lack of sound communication between the supplier and the client. The client needs to ensure that the data is delivered on time, in correct format and meeting the quality demands. There are also problems in the data transfer process. Bureaucracy, commercialization of data and a lack of integration of data sources are some of the problems encountered in data production, exchange and use. During data production, organizations co-operate and interact with related organizations. Issues like distribution costs, copyright and data format become apparent (Allotey et al., 1999). A major threat of EIS implementation in Ghana is funding of the maintenance and operation of the EIS.

However, the issues that emerge during EIS implementation vary from one project locality to another. This means that contextual issues that may pose problems in one case study may not necessarily be an unsurmountable problem in another project. Again, the degree of EIS application and the level at which they are designed and used to a large extent will determine the success of the project. Hence, the following sections on the case studies of EIS implementation are intended to explore the underlying enabling factors or hindrances to EIS application in the Ghana Capacity 21, PLEC and TBI projects. This will bring to the fore the characteristics of these projects and the social settings in which they are implemented. Such background information is a necessary foundation for analysis of the findings of this field survey.

4.4 Ghana Capacity 21 and Its Implementation

The overall high poverty levels among the population, together with the present high population growth rate of over 2.6% percent per annum, tend to lead to inappropriate resource management for the following reasons:

> (i) "Inadequate information and financial resources to enable the adoption of environmentally friendly technologies; (ii) improper planning leading to undue pressure being put on available resources; and (iii) excessive dependence on available natural resource base for survival. These problems are aggravated by the absence of viable technological options for shifting the population away from primary to industrial and other economic activities which are less directly dependent on the land (Ghana Government, 1997:146)".

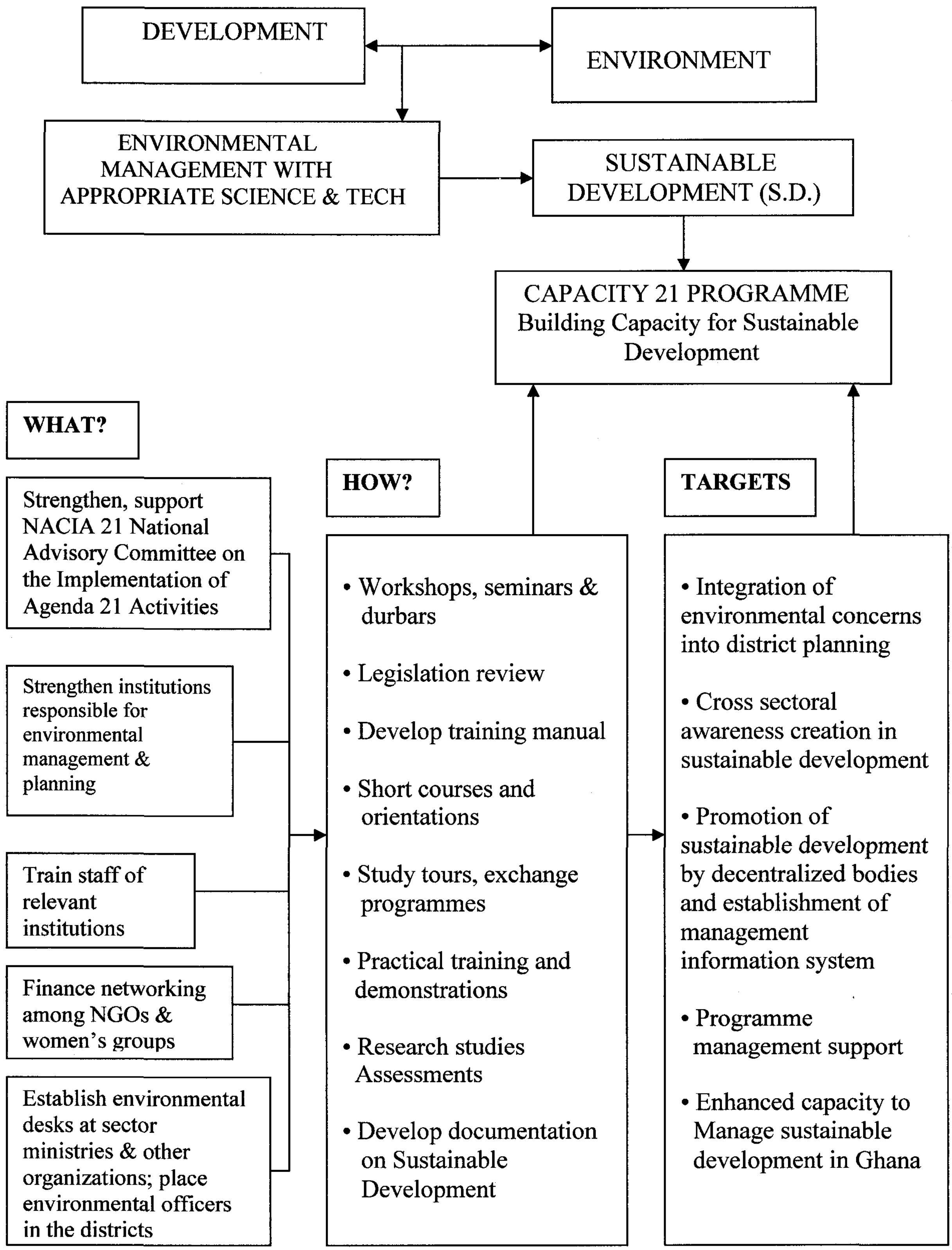
As part of measures to address these environmental problems, the National Committee for the Implementation of Agenda 21 (NACIA, 21) was established with membership from all identifiable stakeholders and partners. The main objective of the committee was to build national capacity, institutionally, locally and individually for the implementation of the programmes spelled out in the Agenda 21 blueprint for action (Ghana Government, 1997). They also include strategic institutional and social interventions necessary to achieve development that is sustainable, environmentally sound and supported fully by appropriate science and technology options.

At the district level, the concern was to maximize participation of local communities by strengthening District Assemblies (DA) through training (with special reference to their district planning co-coordinating units and district environmental management committees), orientation courses and other capacity building activities that will enable them to plan, implement and monitor development programmes in a sustainable manner. The strategy also helped to build district local capacities to incorporate environmental concerns into development decision-making processes. However, environmental data for the districts is woefully lacking. Under the financial decentralization systems, DAs are allocated funds from the District Assemblies Common Fund (DACF) which is supposed to be used solely on development projects which find expression in the 5-Year Development Plans and annual action plans. The impact of the DACF on sustainable development projects is questionable as allocation of funds for environmental projects tends to be limited and unreliable.

One of the major outcomes of the United Nations Conference on Environment and Development (UNCED) in June 1992 was the endorsement of Agenda 21--the blueprint for sustainable development by Heads of State and Governments of both developed and developing countries. The Rio Summit in 1992 agreed on Agenda 21 as a blue print to promote growth which addresses not only the usual social and economic aspects of development but also the environmental concerns which arise out of such development (Kannae and Appiah, 2001). This is because development and the environment are inextricably linked and appropriate policies will have to be designed and applied in the use of natural resources and the production of environmental management systems. Local environmental problems often have global dimensions, and solutions to global environmental problems also require local initiatives (UNDP, 2000). To assist developing countries to implement their Agenda 21 Programmes, the Summit came out with the Capacity 21 Programme which is being implemented by the United Nations Development Programme (UNDP). The UNDP-Ghana Capacity 21 aimed to improve upon the culture of science within societies and improve funding of science and technology for poverty alleviation and sustainable environmental management, especially in the development of the District Assemblies (DAs) (Figure 4.1). Human capacity is the ability of individuals and institutions to make and implement decisions and perform functions in an effective, efficient and sustainable manner.

Capacity 21 was launched in 1997 but actual implementation started in 1998. After the launch, however, programme implementation suffered a further setback in the second quarter of 1998 when the national programme co-ordinator resigned and a new co-ordinator had to be employed (Saaka, 1999). The fact that the programme does not have full-time staff in the pilot districts and municipalities has implications for the attention that the local people in the districts accord the programme. Activities that were carried

Figure 4.1 The UNDP/Ghana Capacity 21 Programme in Perspective



Source: Saaka, 2001

out included awareness creation and sensitization of people, and training workshops on environmental management, development planning and computer training for the pilot districts. The training manual represents the information which the consultants prepared and used to create awareness on current environmental issues. Critical to the successful implementation of the Capacity 21 project in Ghana was the understanding of sustainable development issues in the context of what makes up the environment, how the environment affects people and how their activities also affect the environment. The programme assists in building and reinforcing the capacities of individuals, national institutions such as DAs in the area of environmental management and the enhancement of sustainable development. It is also designed to strengthen capacities in the application of appropriate science, technology and knowledge systems for sustainable development (UNDP, 2000).

A wide range of activities are implemented under Capacity 21. These include human settlement planning, soil erosion, coastal and river erosion, pollution of beaches and rivers, noise pollution, inappropriate use of chemicals, land degradation, agro-forestry mismanagement, deforestation and industrial pollution. This study focuses on the natural resource management component of the project which emphasizes continuous conservation and/or replacement of the natural resources. Hence, the popular cliché, "when you fell a tree, plant another tree to replace it". The purpose of the environmental component is to improve the knowledge and skills of communities in integrating various factors, including environmental, institutional and financial factors, to ensure sound and sustained development. Data and information are available to district policy makers. This is demand-driven and proving to be an important tool for addressing the informational needs of District Assemblies and community organizations for natural resource management in Ghana. At the district level, the concern was to maximize the participation of local communities by strengthening District Assemblies through training, orientation courses and other capacity building activities that will enable them to plan, implement and monitor development programmes in a sustainable manner (Aforo, 2001). As a matter of principle, the programme should ensure the design and installation of a participatory monitoring and evaluation system. To date, the programme has no credible monitoring and on-going system, resulting in a number of management problems. The problem is who monitors what and how are resources allocated? Building capacities in this area will not only help in the efficient management of the programme but also assist participating districts and communities develop in-house capability in monitoring other development initiatives.

In order to achieve these objectives, a series of workshops was organized on a regular basis to learn vital lessons on environmental resource management and put them into practice. Institution strengthening programmes were also organized in some selected communities where the indigenes and community members were invited to find ways of minimizing some of their environmental problems such as soil erosion and land degradation. Eight districts were earmarked for the Capacity 21 project out of the total of 138 districts in Ghana. These districts and activities include:

1. The Afram Plains District Assembly organized a seminar on afforestation and related issues. The Assembly also initiated action on tree nursery production with the view to raising seedlings for distribution to other member communities.
2. The Dangme West District Assembly held workshop on tree growing, agro-forestry and sustainable farming practices. This was also followed by nursery activities for replanting.

3. The Sekyere West District Assembly organized charcoal burning and undertook demonstration on the use of "pit-pot" technology of charcoal production.
4. The Accra Metropolitan Assembly organized workshops on human settlement planning.
5. The Tolon-Kumbugu District Assembly organized workshop on land degradation and deforestation for gravel winners, opinion leaders, charcoal burners and firewood traders.
6. Juaboso-Bia District Assembly organized training workshops on deforestation and soil conservation and the Expanded Sanitary Inspection Compliance Monitoring and Environment (ESICOME).
7. Abura-Asebu-Kwamankese District Assembly Workshops were organized in subject areas of soil erosion and land degradation, environmental management initiatives and environmental restoration practices for various categories of people.
8. Bongo District Assembly. This district offered support to prepare its second Medium-Term Development Plan which will reflect the true letter and spirit of the Capacity Building Target of Developing capacity to integrate environmental considerations into District Planning Level.
(Source: UNDP, 2000)

A major weakness with the design of the EIS programmes was the institutional framework and management arrangements proposed. They were fundamentally flawed. The management system proposed for the implementation of the programme was not consistent with Ghana's decentralization policy which actively supported decentralized development planning and management (Aforo, 2001). This was due to the fact that the management arrangement was top-down, giving little development planning and management responsibility to the DAs, which play a central role in local development processes. In 2001, the Capacity 21 Project focused on several activities which include, among other things, charcoal production, seedling production, tree planting, human settlement planning and sustainable development in some of the DAs. Particularly, the programme helped in the development and promotion of an Environmental Management Information System in the form of the District Environmental Resource Information System (DERIS) by the DAs. All eight pilot DAs were selected by Capacity 21 to experiment with the DERIS. GIS-dedicated computers were procured to meet specifications from the Centre for Environmental Remote Sensing and Geographic Information Services (CERSGIS). CERSGIS was established in 1998 and was originally named the Remote Sensing Applications Unit (RSAU). RSAU started operation in 1993 under the auspices of the Department of Geography, University of Ghana. It was mandated to produce a national digital map of current land use and accompanying bulletins for each administrative region at the scale of 1:250,000 using satellite image data under the Ghana Environmental Resource Management Project (GERMP) (EIS Africa, 2002). Since the completion of the GERMP project, RSAU offers Remote Sensing and GIS services on contractual, cost recovery and financially self-sustaining basis. RSAU became a company registered by guarantee, with the University of Ghana and the Environmental Protection Agency (EPA) as the guarantors, and its name changed to the Centre for Environmental Remote Sensing and Geographic Information Services (CERSGIS). CERSGIS provides user-focused services, undertakes research, and facilitates capacity development in environmental information management and applications in natural resource management.

The computers were used for the purpose of establishing the DERIS. The CERSGIS was contracted to develop the DERIS and given the mandate to train the DERIS officers (district planners), offer advisory services for the procurement of equipment, installation of and overall operation of the system. Needs assessment surveys of the eight DAs were carried out resulting in the selection of the District Planning Officers as the focal persons for the implementation of the DERIS. The Capacity 21 DERIS Project was recognized as one of the most pressing needs in capacity development for enhanced environmental resource management due to an inadequate information base for decision-making in natural resource management (Amamoo-Otchere, 2002).

Two packages of training were arranged for the focal persons, one for training on ArcView GIS, and the other for operationalization of the system. After the installation and commissioning, CERSGIS continued to visit the DERIS desks of the eight pilot districts in order to facilitate proper use of the systems. The systems have been used to create some DA-level development-related maps for exhibition and reporting (Amamoo-Otchere, 2002). The other levels of activities were the remotely sensed images of the DAs to be interpreted for community level resource and resource utilization maps. Specific resource maps which were developed by District Planning Committees (DPC) include community forest/woodland areas, water bodies, agricultural soils, feeder road networks, settlements and degraded areas. Other non-image data sets include community-based public health, education and market facilities. CERSGIS activities also involve visiting each DA, and showing image scenes from Landsat ETM, ASTER, SPOT 5 of year 2001/2002 and demonstrating a range of natural resource-based investment maps that could be derived from them (Amamoo-Otchere, 2002). The current regime of digital geographic and image intelligence offers an enormous wealth of information for community level database development and natural resource management.

Capacity 21 was implemented at various levels of government. At the national level, environmental policies and programmes were initiated. At the district level, the concern was to mobilize participation of local communities by strengthening DAs through training, orientation courses and other capacity-building activities that enable them to plan, implement and monitor development programmes in a sustainable manner. There were several seminars and workshops, some of which were aimed at equipping participants with essential knowledge and skills in effective environmental management (UNDP, 2001). Two of the 8 implementation districts were studied in this research to determine the impact of EIS on community-based natural resource management. These DA were the Abora Asebu Kwamankese District and the Sekyere West DA.

Essentially, the UNDP/Ghana Capacity 21 programme targets three primary geo-political levels: national, regional and district levels (Aforo, 2001). At the national level, the programme sought to build capacities relevant for key institutions such as the Environmental Protection Agency (EPA) and Town and Country Planning Department. At the regional level, the Regional Coordinating Council (RCC) reviews and approves programmes of activities initiated by the National Committee for the Implementation of Agenda 21 (NACIA 21). These activities include preparing natural and human resources profiles and inventories of the region and its constituent districts followed by the identification of appropriate capacity building needs for their mobilization for sustainable development in the region. Similarly, at the district level, NACIA 21 was to operate through the District Planning Coordinating Units (DPCU) and the District Environmental Management Committees. At the District Level, the concern was to maximize participation of local communities by strengthening District Assemblies through training, orientation courses and other capacity building programmes (Aforo, 2001). Hence, the responsibility at the District level is mainly the utilization of acquired capacities and provision of feedback on the effectiveness and deficiencies of these acquired capacities.

This institutional arrangement described above had a lot of technical problems and weaknesses. Whilst the programme seeks to promote decentralized and participatory processes, excessive management responsibility and power is vested in the NACIA 21. It is also puzzling how the designers of the programme expected a committee with a membership of more than 20 from different institutions to carry out the stated functions effectively. At the district level, indications are that the implementation of the programme does not always receive priority attention from the focal persons. Most of the focal persons already have very tight schedules and heavy workloads. Naturally, they tend to devote more attention to their official duties.

4.4.1 Capacity building and Local Care Systems

Each of the pilot districts under the Capacity 21 Programme was provided with two personal computers. The delivery of the computers to the districts was followed by a training programme on computer literacy. The training covered (1) Introduction to computers (2) Microsoft Word for Windows and (3) Microsoft Excel for Windows. In all, 102 staff of the DAs participated in the training activities, which involved both theory and hands-on practice. It was found that 70%, 26% and 4% of the participants were beginner, intermediate and advanced learners respectively (UNDP, 1999). It is intended that further training will be organized for the DA staff to enable the DA to build management information systems to support sustainable development.

CERSGIS was contracted to organize and provide training for participants and DA staff. Some of the equipment was transferred to the districts to set up the DERIS (UNDP, 2000). The Local-level Integrated Information System (LIIS) initiative focuses on the community level, and seeks to address the development of information and knowledge needs at this level. The initiative provides a framework for systematic collection, facilitating access to, and sharing of information and knowledge in support of processes towards the attainment of the Millennium Development Goals (MDGs) at the local-level. Information collected for this process was, first and foremost, responsive and relevant to local needs, rather than focusing on the MDG indicators *per se.* The LIIS provides mechanisms for capturing, documenting and distilling information, knowledge, experience and progress made on activities and processes "on the ground" (UNDP, 2000). It also facilitated communication, information sharing, and knowledge transfer and learning how to apply useful knowledge. In addition, it supported the development of profiles of the district for effective planning and resource allocation. Participatory and people-centred processes were adopted for identifying specific local issues and processes with a view to understanding the priorities, social context, systems and values by which people in the respective communities can create meaning from the information and use it. A unique feature of Capacity 21 was that information and knowledge were packaged and disseminated using culturally appropriate ways, including story-telling, drama, local-language newspapers, community radio, and satellite-based digital radio/data casting technology.

Building adequate human and institutional capacity in environmental management and care systems on a continuous basis is a fundamental vocation of the UNDP/Ghana Capacity 21 Programme in the struggle against over-exploitation of natural resources and the degradation of the environment (UNDP, 2000). A series of intensive training programmes on environmental management and care systems in West Africa was held at the Cisneros Hotel at Sogakope in the Volta Region of Ghana and other locations in

2000. The workshop was aimed at educating and equipping participants with the requisite knowledge to address environmental issues and effective environmental management through a more constructive solution to environmental problems. However, such training programmes do not cover everything necessary in the areas of environmental management but rather provide opportunities for the examination of key areas of natural resource management. In addition, though the training programmes and workshops were expected to equip participants with knowledge of key environmental issues and the skills to effectively plan, implement and evaluate environmentally sustainable development projects. There are misgivings among the participating communities surveyed about the benefits of such initiatives vis-a-vis their needs, expectations and tasks.

Since its inception, the Ghana Capacity 21 Programme has organized about 50 sensitization workshops and seminars either directly or in conjunction with other institutions for about 3,000 participants. Durbars (a traditional gathering of chiefs and people for public deliberations, adjudications or festivals) have also been organized for nearly 2000 broad-based participants and 150,000 copies of reading, information and educational materials (comprising maps, brochures, charts, posters etc.) have been produced and distributed to the districts (UNDP, 2000). These include 15,000 copies of maps and calendars, 15,000 copies of the Capacity 21 brochures, 20,000 copies of charts and over 80,000 copies of posters (UNDP, 2001). The Convention to Combat Desertification, for instance, was translated into 10 Ghanaian languages. As part of the implementation of the Capacity 21 Programme, workshops were organized on sanitation, environmental health and waste management. The workshops promote self-reliance through upgrading skills and transfer of knowledge with particular reference to human resources and institutional development by articulating the concept of Sustainable Human Development (SHD) (Saaka, 2001). At the Abura-Asebu-Kwamankese District, 50 people were selected from five communities and trained in good environmental practices. At the Sekyere West District Assembly, sensitization workshops were organized at the local level on the effects of charcoal burning on the environment. Individual charcoal burners were organized into District Associations to facilitate education and to use the workshop as a medium for the introduction of appropriate technologies, such as the Pit-Pot technology for charcoal burning (Saaka, 2001).

4.4.2 Integrated Energy Conservation and Biodiversity Management Practices

As part of indirect initiatives and efforts to reduce pressure on the diversity of tree species for domestic fuel, Capacity 21 supported the Ministry of Food and Agriculture (MOFA) and the Ghana Regional Appropriate Technology Industrial Service (GRATIS) by supplying energy-efficient Liquefied Petroleum Gas (LPG) smokers to some coastal districts in Ghana. The smokers replace the incessant dependence on trees, shrubs and other plant matter for fish smoking. Such innovative technologies are relatively friendly to the environment and health of fishmongers. Unfortunately, there is unequal distribution of the new technology to all the communities along the coastal districts due to shortage of supply. Only Moree in the Abura-Asebu-Kwamankese District Assemblies (UNDP, 2000) benefited from this initiative.

The programme also provided funds to organize training for women's groups on energy-efficient earthenware cooking devices. This programme supported the Ghana Association of Private Voluntary Organizations in Development (GAPVOD) with funds to organize training for women. Participants were drawn from the Sekyere West and

Bongo districts which were noted for charcoal burning, destructive crop farming and wood cutting and attendant problems of land degradation (UNDP, 2002). The GRATIS Foundation also aims to introduce sustainable agro-processing techniques, by stepping up resource conservation and sustainable farming techniques in some of the designated pilot Districts. However, during a meeting of Capacity 21 participants on May 17th 2001, the GRATIS Foundation explained that the manufacture of stoves had been delayed because beneficiaries were not in a position to make the 10% contribution due to financial constraints and therefore would not be able to access the needed assistance from the Village Infrastructure Project (VIP) as originally planned (UNDP, 2001).

In Collaboration with the Renewable Energy Services Project (RESPRO), the Capacity 21 Programme linked some of the pilot districts to the rural energization efforts. RESPRO is sponsored by UNDP and Global Environmental Facility (GEF) for the provision of solar-based electricity to communities not connected to the national grid especially in the East Mamprusi District where about 300 individuals have been provided with solar-based electricity. The cost per unit of this solar-based electricity is between 10,000 cedis and 15,000 cedis per month. Even though not many people can afford this energy source, it is envisioned that the activities of RESPRO will be extended to other areas (Saaka, 2001). This has helped to ease the pressure on areas undergoing environmental degradation.

Most of the progress reports and assessments of activities under the Capacity 21 provide encouraging figures about the number of workshops conducted in the districts, duration of workshops, number of participants, total seedlings planted and the quantities of logistics supplied to the districts, among others. Little monitoring and evaluation has been conducted to determine the extent to which knowledge, skills and logistics given to these communities are being utilized in their natural resource management activities. Undoubtedly, there is little analysis of the impact of these initiatives on reversing biodiversity loss and enhancing agro-diversity conservation.

In addition, Capacity 21 produced educational posters, a simplified version of the UN Convention to Combat Desertification and a guide for the establishment of tree nurseries translated into ten major Ghanaian languages. The posters have already been printed (UNDP, 2001). Under Programme, Area B of Chapter 11 (Combating Deforestation) of section 2 (Conservation Management of Resources for Development) and Programme Area B (Combating Land Degradation) of Chapter 12 (Combating Desertification and Drought), the Capacity 21 Programme has supported pilot DAs to establish tree nurseries and to demonstrate the use and application of appropriate technologies for conservation of forest resources. These initiatives include the "pit-pot" technology for charcoal production in the Sekyere West District and energy-saving cooking stoves in Sekyere West, Tolon-Kumbungu, Abura-Asebu-Kwamankese Afram Plains and Bongo Districts which raised a combined total of 150,000 seedlings of various species. It is also worth emphasizing the interesting cases of the formation of Charcoal Burning Association in the Sekyere West District through which tree growing activities can be facilitated and the improvement of sacred grooves (UNDP, 2001).

Capacity 21 penetrated the district level into the communities with training programmes on subjects such as environmental management and development planning, noise abatement, sustainable farming practices, bush fire prevention and erosion control. This is because Capacity 21 was implemented as a pilot programme in some of the districts and needs to be extended to other districts and continued beyond the pilot phase. The scope and coverage of the programme is insignificant considering the widespread nature of biodiversity loss and resource degradation in Ghana. In addition, there was a lack of local capacity for sustainable development. It is necessary to have also developed local capacities to understand the implications of the impact of the environment on development, activities to address these impacts, technical support for sustainable development and the cost of developing in an unsustainable manner.

A unique feature of Agenda 21 is the establishment of District Community Environmental Management Committees (DCEMC). The DCEMCs were made up of Assembly members, relevant decentralized departments and NGO representatives to assist in the formulation of policies and programmes including the enactment of local by-laws to protect the environment. The DCEMCs are also empowered to form Community Environmental Committees (CECs) at the village level to take local action on issues like land degradation, rehabilitation activities, bush fire control and desertification prevention (Saaka et al., 1999). In the first half of 1996, most of the DAs in the dry regions of Ghana had drawn up their medium-term development plans, including some desertification control activities/proposals alongside other proposals. These committees helped to create awareness about the problems of land degradation, sensitization of the local people about the need to conserve biological diversity and above all, educated people to acquire the necessary knowledge and skills for the management of degraded areas. Activities such as vegetation cover protection and improvement through the establishment of tree nurseries and growing of trees, water resources development and pasture development, were quite germane (Saaka et al., 1999). However, not all aspects of the project were successful as envisioned. Notably, the goal of "food and energy self-sufficiency" turned out to be too ambitious to attain. There were no clearly stated goals and practical steps that would involve all people within the communities to achieve these objectives.

4.5 United Nations University Project on People Land Management and Environmental Change (UNU/PLEC)

In the early 1990s, the issues pertaining to the population-environment nexus moved into the forefront of international attention. Prominent among these issues was conservation of biodiversity (UNCED, 1992). Chapter 5 of Agenda 21, on "Demographic Dynamics and Sustainability" identifies the strengthening of research programmes that integrate population, environment and development as central themes in the implementation of international agendas (Uitto, 1997). Further, Chapters 14 and 15 of the United Nations convention on "Promoting Sustainable Agriculture and Rural Development" and "Conservation of Biological Diversity," became central themes of the Project on People Land Management and Environmental Change (PLEC). PLEC is a global network of country clusters, set up by the United Nation's University (UNU) in 1992. From 1998 to 2002, it was funded by the Global Environment Facility (GEF) via the United Nations Environment Programme (UNEP). The PLEC brings together regional clusters of scientists for action-oriented, policy-relevant research on small-farmer management of biodiversity in the tropics. The West African cluster is the WAPLEC. All PLEC clusters are multidisciplinary with natural and social scientists and local farmers working together.

In order to implement these international ideals and environmental initiatives, a team of UN agencies, academics, scientists, and indigenous people (mainly expert farmers) devised plans, programmes of action and environmental initiatives in different countries. PLEC members, coordinators and advisers work out of over 60 institutions in Brazil, China, Ghana, Guinea, Jamaica, Kenya, Mexico, Papua New Guinea, Peru, Thailand, Tanzania, Uganda, Britain, the USA, Japan and Australia (Brookfield, 2003). Due to the nature of its work, PLEC focuses on particular small areas in each country where scientists are able to develop close relations with farmers, learn about their knowledge in environmental management methods and assist them with information and expertise in many technical ways.

PLEC recognizes that the means to conserve biodiversity include a place-specific knowledge system held variably by different people and includes understanding of myriad interactions between people and environment (Brookfield, 2003). In Ghana, pilot PLEC work started in 1993 under United Nations University (UNU) funding with a focus on understanding agro-ecological changes and the reactions of smallholder farmers to these changes. The PLEC approach in Ghana is to collaborate with farmers and local communities in identifying appropriate conservation approaches that are environmentally, socially and financially sustainable and enhance biodiversity. By integrating locally developed knowledge of soil, climate, biological resources and other physical factors with scientific assessments of their quality in relation to crop production, a set of sustainable agricultural technologies can be devised so that crop diversity and management options are maintained.

The PLEC has demonstrated the potential to counter biodiversity erosion, conserve other biophysical resources, protect ecological integrity and, thereby, improve the basis of rural livelihoods, by sustainable land management practices, including 'agro-diversity' (agricultural biodiversity, including all management and organizational aspects). The PLEC has been instrumental in pioneering a methodology and local level system for integrating traditional sustainable agricultural knowledge with modern, scientific techniques. However, PLEC's results have not been spontaneously replicated because the former regional project did not have the capacity to address local and national barriers to up-scaling. Furthermore, beneficial impacts of promoting bio-diverse and sustainable land practices are mostly anecdotal and have not been of sufficient scale to achieve real impacts on ecosystem stability and productivity. If farmers do not see the latter, and if there are no supportive local regulations and policies, they will not have enough incentives to sustain these changes to their production system.

The PLEC approach in Ghana was aimed at collaborating with farmers and local communities in identifying appropriate conservation approaches that are environmentally, socially and financially sustainable and to enhance agro-diversity management. PLEC's basic investigative work and primary focal areas involved studies around the following sites;

1. Gyamfiase Adenya (originally named Yensiso site), Sekesua-Onsonson (originally named Sekesua and Amanase-Whanabenya (originally named Amanase), all located within that forest savanna mosaic zone of southern Ghana;
2. Jachie in the humid forest zone in central Ghana, and
3. Bongnayili-Dugu-Song (originally named Dugu) which together with Nyorigu-Benguri-Gonre (originally named Bawku-Manga) a subsidiary site, is located in the interior savanna zone.

These areas were settled in the early parts of the 20^{th} Century by migrant cocoa farmers. All the areas are located in the Eastern Region within the forest-savanna transition zone. By 1996, the first objective had become "to develop methodologies for collaborative linkages between professionals and local people in the design and implementation of conservation management" (PLEC, 1996). From 1998, PLEC emphasis shifted onto (a) identification of those aspects of farmer land usage that appear to be particularly effective for conservation of agrodiversity (biodiversity within agriculture) and (b) applied work that involves demonstration of sustainable management of agrodiversity at the study sites. This is geared towards development of 'demonstration sites[1] to foster agrodiversity conservation.

4.5.1 EIS and LKS Applications at PLEC in Southern Ghana

Although Ghana is one of the world's biodiversity hotspots, current satellite pictures of southern Ghana show little forest. What remains is a mosaic of remnant woodlands interspersed between cultivated fields. This is the general scenario of areas that PLEC activities take place in southern Ghana. Participatory work in Ghana, aimed at generating first hand information was carried out in 1993. The field work was based on 1974 aerial photographs (1:40,000) because satellite imagery was too expensive in the early days of PLEC (Gyasi et al., 2003). The farms at Amanase were generally intercropped with cassava and maize as the principle crops. The aerial photographs showed that continuous

[1] "A place where PLEC scientists, farmers and other environmental stakeholders carry out work in a participatory manner to conserve and even enhance agricultural and biological diversity and the biophysical resources underpinning it. It is an area where the scientists work with farmers in the creation of projects that are (the farmers') own and (where, together, the scientists and farmers) demonstrate the value of locally developed techniques and technologies'. It belongs to the farmers in that the work done in a demonstration site is the farmer's own. The role of scientists is only to facilitate, measure and evaluate local methods and help to select the method most likely to be sustained" (Abdulai et al., 1999).

cropping had led to noticeable soil impoverishment and decreased crop yields in spite of the use of artificial chemical fertilizer and improved crop varieties. Sekesua, which was settled by migrant Krobo people on the basis of the linear Huza agricultural land use system, showed near complete removal of the forest cover for cropping. The fallow periods ranged from one to two years. The air photos revealed that active farms tended to concentrate within the first 1000 m from the settlements, especially in Amanase and the proportions of fallow and other uses showed rather irregular variation along the traverses (Agyepong and Kuforghe, 1997). The images also showed a change in the environment from forest through perennial cocoa crop to seasonal arable crops.

The air photos provided general baseline information, and the location of the sites (Sekesua-Onsonson and Amanase-Whanabenya) had to be found within reasonable traveling distance on this image. It was however difficult to identify cropped land and fallow lands separately. Fallow and cropped land at various stages contains common elements of crops and non-cropped land at various stages (Agyepong, 1997). However, considering the fact that the aerial photos were 19 years old at the time of the inception of the project, they were not current and did not reflect accurately the physical expansions of settlements, land tenure practices and the status and dynamics of land uses at the time.

From 1996 to 1999, PLEC developed systems in which scientific understanding of the farmers' ways contributed to improvements in the PLEC's activities. Still following the original research intentions, some groups continued to use the transect methods for agro-ecological and biodiversity monitoring of EIS projects with which they were familiar and which had in fact been encouraged in the early stages (PLEC, 1995). The success of the transects and quadrats was largely due to efforts made by scientists to elicit the cooperation of local people, especially agreement from chiefs and other leaders who often have good knowledge of agro-environmental history of the area (Gyasi, 2003).

The transect walks were participatory, comfortable and allowed local people themselves to gather information about biophysical characteristics of their farms and surroundings. Transect walks helped to document the when, how and why of changing farming practice and the environment. These involved changes in vegetation, weed associations, cropping systems, crop yields, weeding work loads, availability of land and hiring arrangements (Brookfield, 1995). With their participation, mapping of fields and settlements was carried out. This helped to create a standardized database for demonstration sites (Abdulai, et. al., 1999). This initial participatory approach created a sense of belonging which eventually led to the formation of farmer associations and understanding of village dynamics including issues relating to women, child marriages, single mothers, and how they affect livelihoods and biophysical environment (Gyasi et al., 2003).

The initial participatory fieldwork was essential for better understanding between scientists and farmers. The PLEC team also acknowledges that indigenous knowledge had been of great use in the past (Amanor, 1994). Hence, the smallholder farmers have evolved agro-ecological knowledge and successfully solved food production problems and enhanced biodiversity conservation. One of the interesting discoveries was that there were considerable reserves of biodiversity in the sacred groves, of which there are large number. Some of these were originally burial grounds for chiefs, and plants that have grown there have been left undisturbed (Gyasi and Uitto, 1997).

PLEC-sponsored value-generation activities were carried out through Farmers' Associations in Ghana. Also, an interdisciplinary study undertaken by the Ghana (West Africa) cluster of PLEC in the forest-savanna ecotone in Ghana examined the conditions of environmental change or ecological succession (ecological succession is the sequence of changes that occur in the structure and functioning of a biotic community at a particular location in water or on land over time).

4.5.2 Expert Farmers and Demonstration Activities

PLEC has acquired an enviable reputation for working with farmers in their fields using farmers' own ideas, knowledge and evaluation criteria. On the work with farmers (PLEC-members and non-PLEC members), special emphasis is placed upon understanding how, on the basis of traditional knowledge, farmers manage agro-diversity. This is because traditional knowledge reflects local conditions including popular values. It can be assumed to offer a sounder basis for developing locally adaptive resource management models in line with grassroots, bottom-up development paradigm.

Expert farmers solve production problems by using knowledge and information obtained from demonstration activities for biodiversity conservation. At the demonstration sites, there is expert farmer-to-farmer training. Brookfield (2003) notes that in "Tanzania, the farm becomes the chalkboard, the expert farmer a teacher, the scientists and technicians become facilitators and participating farmers the adopters, modifiers or improvers of the technology" (p3). In several PLEC sites for instance, experts help to identify the species and varieties of crops and other plants during the biodiversity surveys conducted in the landholdings of selected farmers. However, in the technical field, forestry officials and other environmental specialists still have difficulty accepting that the farmers they work with are capable of mastering highly technical indigenous skills, sometimes better than they do themselves (Ndione et al., 1995). Expert farmers are known by other villagers to have the best gardens, to plant a greater diversity of crops and produce the highest yields per crop. In addition, some of the selected expert farmers are the ones who have managed to diversify their agroforestry fields as well as to be engaged in managing forests for multiple uses, including the diversification of habitats for wildlife (Brookfield, 1999). The farmer-to-farmer training promoted by PLEC contrasts with the top-down intervention adopted in some projects in Ghana. However, the process of identifying an expert farmer has proven to be long and complex (Pinedo-Vasquez et al, 2001).

The expert farmers were organized into farmer associations to facilitate popular PLEC scientist-farmer interactions. Knowledge flow occurs between farmer and scientist and professionals in a two-way direction. The specifics of the relationships and the processes are unique to each group and are different from one community to another (Brookfield et al., 2003). One important contribution has been the passing on of knowledge held by folk on the ecology and biology of species and ecosystems to conservation organizations. This increases the chances of success of regional conservation programmes (Table 4.3). There is no fixed template for the successful transfer of knowledge at demonstration sites, except that both agricultural practices and social relationships must be considered in facilitating the process of agro-diversity knowledge transfer (Brookfield et. al., 2003).

Later, Ghanaian associations were built with support around prominent or outstanding farmers having particular forms of expertise, whether or not farmers had chiefly social roles (Gyasi, 2001). The role of expert farmers is not the same everywhere. In all cases, they are the farmers with whom PLEC scientists principally interact and who also interact with external specialists brought on to the site. In a few instances, they have become the true leaders of demonstration site activity. To facilitate harmonization of method and to help overcome the reluctance of some scientists to adopt farmer-to-farmer methods, the management group formed a second internal advisory group on demonstration activities in 1999. Given the varied physical, social, and political conditions of the PLEC countries, it was never imagined that all demonstration sites could follow the same methods and this was stated explicitly by Padoch and Pinedo-Vasquez (1998). PLEC thrives on diversity and every group has adapted the general approaches in its own way.

The idea of a demonstration site is to be the place where PLEC scientists, farmers, and other environmental stakeholders carry out work in a participatory manner to conserve and to enhance agricultural and biological diversity and the biophysical resources underpinning it (Gyasi, 2004). At demonstration sites, biodiversity management systems are developed and demonstrated primarily on the basis of small holder farmer knowledge which is an integral part of PLEC's approach. PLEC's operational definition of a primary demonstration site measures approximately 10 X 10 km. Such an area facilitates focused in-depth field work but is large enough to show

Table 4.2 Selected Management Regimes / Practices and Their Advantages in PLEC Demonstration Sites in Southern Ghana

Practices	**Major Characteristics and Advantages**
Bush/fallow land rotation using fire to clear land	A means of regenerating soil fertility and conserving plants in the wild
Minimal tillage and controlled use of fire for vegetation clearance	Minimal disturbance of soil and biota
Mixed cropping, crop rotation, and mixed farming	Maximizes soil nutrient usage: maintains crop biodiversity; spreads risk of complete crop loss; enhances a diversity of food types and nutrition; favours soil regeneration
Traditional Agro-forestry: cultivating crops among trees left in situ	Conserves trees; regenerates soil fertility though biomass litter; some trees add to productive capacity of soil by nitrogen fixation
Aprowka, a no-burn farming practice that involves mulching by leaving slashed vegetation to decompose in situ	Maintains soil fertility by conservation and stimulating microbes and by humus addition through the decomposing vegetation; conserves plant propagules, including those in the soil, by the avoidance of fire
Usage of household refuse and manure in home gardens	Sustains soil productivity
Use of nyabotso (Neubouldia laevis) as live stake for yams	The basically vertical rooting system of nyabotso favours expansion of yam tubers, while the canopy provides shade and the leaf litter mulch and humus; it also is suspected that nyabatso fixes nitrogen
Staggered harvesting of crops	Ensures food availability over the long haul
Storage of crops, notably some species of yam, in situ In the soil for future harvesting	Enhances food security and secures seed stock
Conservation of forest in the back yard	Conserves forest species; source of medicinal plants at short notice; favours apiculture, snail farming and shade-loving crops such as yam.

Adapted from Gyasi et al., 2003

significant internal agro-ecological variations and to permit study by aerial photographs and satellite imagery (Gyasi et al, 2005). Demonstration plots are established within designated farms that have been purposely selected together with the farmers. In PLEC demonstration activities, villagers usually learn from and exchange ideas, information and experiences with farmer-demonstrators or expert farmers. As part of demonstration activities, PLEC recommends 'working expeditions' where all participants visit the fields, fallows, house gardens, orchards and forests owned by the farmer-instructors (Brookfield, 2001).

Table 4.3 Benefits of Agro-forestry as Perceived by Farmers in the Demonstration Sites

VALUE / BENEFITS	SOURCE% FREQUENCY	RANK
1. Enhances dietary balance	100	1
2. Spreads risk of crop failure	100	1
3. Contributes to ecological and environmental stability	100	1
4. Enhances medicinal plant supply	100	1
5. Enhances fuel wood supply	97.4	2
6. Minimizes soil erosion through vegetative cover	94.9	3
7. Spreads marketing risks	82.1	4
8. Renders meals more enjoyable	69.2	5

Source: PLEC Survey in 2000

From PLEC experience in Ghana, a potential demonstration site has the following parameters; (1) richness of existing agricultural and biological diversity, (2) extent of threat to diversity, the level of threat to diversity and (3) level of documented knowledge about the site (Gyasi et al, 2005). The two PLEC sites which form part of this investigation are Amanase Whanabenya (Suhum-Kraboa Coaltar District) and Sekesua

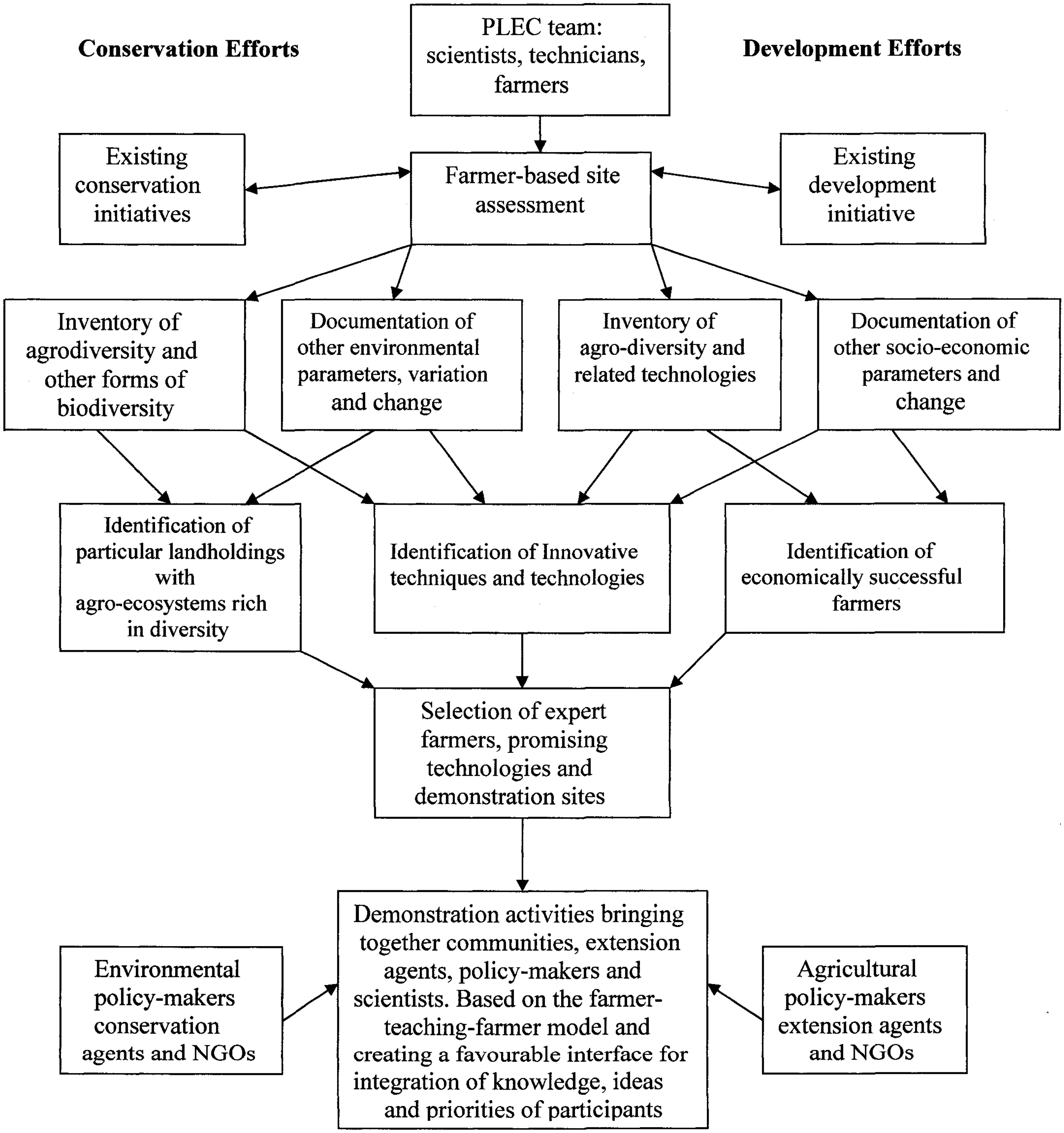
Onsonson (Upper Manya Krobo District). Wherever agro-diversity is found to be under threat, studies of agro-ecological conditions may proceed (Table 4.4). In the initial investigative studies, local people, especially chiefs, other leaders and expert farmers are involved in the applied work in participatory mapping. An important initial step is participatory mapping of settlements with involvement of local farmers which among other things may serve as a basis for the creation of GIS towards a standardized database for demonstration site.

The basic PLEC goal is to identify the best ways of conservation, especially of biodiversity within agriculture, through a participatory approach that draws on local, traditional or indigenous knowledge. A measure of the increasing success and promise of sustainability of the PLEC initiative is the growing self-reliance of the pivotal PLEC farmers associations. Information emanating from research and field assessments is translated into demonstration activities (Figure 4.4). This is a very challenging task due to the variation in the socio-economic and community settings. Perhaps the greatest challenge is the tendency for demonstration activities to become standard development and conservation initiatives (Pinedo-Vasquez, 2001). There is also the penchant for demonstrating 'modern' or 'improved' techniques developed by agronomists, extension officers and other scientists which may not augur well for unique local biophysical conditions (Pinedo-Vasquez, 2001). Hence, concerted and constant efforts are made so that PLEC activities do not merely copy traditional extension and training models.

Table 4.4: Demonstration Site Activities

ACTIVITY	OUTPUT/OUTCOME/RESULT/ IMPACT/ACHIEVEMENT	LOCATION
1. Use of selected farms as agroforestry models	• Still under assessment, but initial findings appear to be generally consistent with claim by farmers • Apparent improvement in soil fertility and crop yield • Increased fuel wood	All sites in southern and central Ghana
2. Use of home garden as germplasm bank and source of food, medicinal and other useful plants	• Spread of home gardening • Reported income increase • Growing modeling of school gardens on home garden principles	All sites in southern Ghana
3. Experiment in regeneration of forest	• Rehabilitation of degraded grassy patches resulting from deforestation • Adoption by other farmers including migrant-settler tenant-farmers	Amanase-Whanabenya in southern Ghana
4. Conservation of sacred forest groves through PLEC-farmer associations	• Conserved assorted trees and diversity of other plants • Popular awareness of prospects of conserving biodiversity through conserved forest	All sites in Ghana
5. Medicinal plant conservation through arboreta	• Conserved assorted medicinal plants, which in the case of Osom Djeagbo has started yielding a modest income • Popular awareness of methods and prospects conserving medicinal plants through arboreta	Amanase-Whanabenya and Sekesua Onsonson, southern Ghana
6. Demonstration of plant propagation by grafting/budding and the split-corn techniques	• Over 100 farmers have learnt the techniques from the ARS and subsequently, through farmer-to-farmer demonstration and training, with an estimated 40 of them actually practicing. • Inspired privately owned nurseries operated on commercial basis. • Propagation of rare exotic and endemic plant species	Initially, limited to southern Ghana, but now spread to all sites in the country.
7. Forest conserved in the backyard for beekeeping (for honey and wax) as a means of generating income	• Remarkable spread of beekeeping involving over 30 farmers. This development has attracted substantial financial support of a Ghanaian affiliate of an American GNO • Spread to other sites in southern and Northern Ghana	Initially, Sekesua Onsonson, but has now spread to other sites in southern and northern Ghana
8. Integration of high yielding citrus into traditional farming	• Initial group owned citrus started flowering and bearing fruits • Many farmers have adopted	All sites in southern Ghana
9. Pig and sheep raising may be integrated into the conservation process on a commercial basis	• Activity still in formative stage • Pregnant sows and sheep	Amanase-Whanabenya and other Southern Ghana sites
Source: Adapted from PLEC Fieldwork Activities, 2002		

Figure 4.2: The PLEC Demonstration Approach



Source: Pinedo-Vasquez, Gyasi and Coffey (2002)

Field assistants are required to spend a great deal of time with the expert farmers and to become familiar with all the production technologies demonstrated. The role of field assistants is not to supervise the participant farmer but rather to observe adaptation, assimilation or rejection of demonstration activities. The monitoring of demonstration activities includes documentation of interactions between the expert farmer and the participants. Information on how the technologies demonstrated are accepted or rejected at the time and later by the different actors is more critical than recording the number of participants in demonstration activities (Brookfield, 2001).

However, integration of conservation and development objectives within a single project is not unique to PLEC (Bruch, 2000 and Agarwal 1997). A review of recent projects in the fields of conservation and development reveals that although the two ideas are often linked, they are rarely truly integrated (Pinedo-Vasquez, 2001). One of the key features of demonstration activities is the use of visual aids such as photos, sketches and posters to help the expert farmer explain production of management techniques (Brookfield, 2001). In Ghana, team members organize materials such as photos of activities, displays of many varieties of a specific crop and maps of microenvironments. PLEC demonstration activities show that when expert farmers are acknowledged, their technologies and experiences are valued and quickly assimilated by the other farmers. Demonstration activities are usually based on knowledge gained through research into the farmers' natural and social environments. The assessment team in the PLEC project is interdisciplinary, and they bring varied backgrounds and specialized knowledge to the task (Figure 4.2). A variety of ethno-scientific methods were employed for the site assessment including the reconstruction of landscape histories and interviewing of knowledgeable villagers. The results of this research have not only helped PLEC scientists understand trends in local biodiversity management but also have helped identify particularly dynamic, resourceful and resilient components of the village. These inventories provide an understanding of the innovative technologies that farmers are developing which might be especially important in helping their neighbours to cope with looming problems or to take advantage of likely opportunities. Local farmers play a special role as members of the assessment team. Their knowledge of the community, local production technologies, resources and landscapes is invaluable to a perceptive and reliable inventory process.

One of the criticisms leveled against the PLEC monitoring or environmental assessment team is that they are too limited or narrow in their expertise and the broad-based results necessary for successful PLEC demonstrations. For instance, teams whose members were mostly botanists tended to concentrate on identifying and recording lists of species and varieties present on farmer's lands but collected limited information on the production systems or conservation practices that gave rise to this biodiversity (Brookfield, 2001). Those teams that are composed largely of soil scientists focused on important trends in erosion and land degradation but left the biological diversity especially of cultivated varieties, as well as management diversity under-reported. There is no cross-fertilization of ideas on the relationships between soil types identified on a demonstration site and the cropping regimes and production systems applied on the land. This limited scope of assessment creates limited categories and stunted technical diversity used at the stages of EIS implementation. (EIS in PLEC is not discussed)

Another limitation in the identification, documentation and selection of farmer-developed technologies stems from a mechanical or perfunctory use of categories and concepts. Some of the terms commonly used to organize their crops such as mono-cropping, poly-cropping or intercropping actually reveal little that is useful about the diversity of the farming system or how it adapts to change.

Other integrated food production and land conservation methods include the application of nurseries from where seedlings are transplanted and sent to the farms. The need for the establishment of nurseries emerged from the realization among farmers that certain species of value are growing scarce. Farmers and scientists have become aware that in-situ conservation of valued species is still entirely possible, sometimes by importing germplasm from nearby areas where it survives into areas from which it disappeared. Exhibitions of rare and endangered species of fauna and flora have been organized at workshops and other occasions to make the situation more widely known among the local population.

PLEC scientists assist farmers to set up nurseries to propagate introduced species at farmers' request and also indigenous species and assist the expansion of forms of agrodiversity suitable for local conditions. Ndione et al. (1995) argue that micro-nurseries are well known. There is no real market for forest seedlings, apart from fruit trees, except on the outskirts of large towns. Nurseries can therefore remain economically viable only with the financial backing of projects which buy the seedlings or pay farmers who nurse the seeds (Ndione et al., 1995). This included assistance in the exchange and importation of germplasm and the encouragement of conservation though fairs and open days. Very specifically, it has involved the encouragement of biodiverse farming, the introduction of fruiting trees to diversify income sources and support for other activities that create value out of biodiversity (Brookfield, 2003). Sometimes, endangered species are exhibited and the public is sensitized about the threats posed to biota and to the wider ecological and socio-economic implications of the threat. Public shows also popularize the awareness of practical measures that may be encouraged at grassroots level to stem threats to agricultural and biological diversity and to enhance environmental quality. Members of the demonstration team sometimes exchange knowledge between expert farmers and members of his family. Exchange of seeds, seedlings and other forms of germplasm is conducted during demonstration activities. Farmers may contact the expert farmer on what to plant and the planting materials and learn specific techniques. The interaction among expert farmers and local farmers and among farmers within the communities helps to disseminate new ideas and planting materials. Their participation in family reunions has greatly helped to promote the production system. The informality and social ambience in working groups during particular labour operations facilitates the transfer of production techniques among participants.

4.6 Netherlands TROPENBOS International

Tropenbos International (TBI) is an international Non-Governmental Organization (NGO) that aims to improve tropical forest management for the benefit of people, conservation and sustainable development. It holds a vision in which knowledge and skills play a central role with regard to improving forest governance and management. TBI is currently operating and developing research sites in Cameroon, Suriname, Colombia, Côte d'Ivoire, Ghana, Guyana, Indonesia, Indonesia and Vietnam through international cooperation between research institutes, local people and governments.

TBI first appeared on the Ghana scene in May 2000 as a result of an agreement and partnership between the Ghanaian Government, under the auspices of the Ministry of Lands and Forestry and TBI. The agreement provided a legal framework for the development and implementation of the project. The aim of the programme was to (1) bridge the gap between policy, management and science; (2) provide a forum for discussing rain forest issues; and (3) carry out relevant research and training. In the past five years, TBI-Ghana has carved a niche for itself in promoting dialogue in the Ghanaian forestry sector through focus group discussions. These discussions involve all stakeholders in the national forestry discourse, including seemingly marginalized ones like farmers and forest fringe communities. In April and July 2005, TBI-Ghana organized two focus group discussions on 'Alternative livelihoods and sustainable forest legislation' respectively. TBI also implemented various livelihood and biodiversity projects.

Forest fringe communities in Ghana which are constrained by poverty rely heavily on forest resources to satisfy present livelihood needs. In satisfying these needs however, they give little consideration to the future goal of sustainable forest management. A biodiversity project was implemented with support from the Regional Network for Synergy between the UN Convention to Combat Desertification and the Convention on Biodiversity. An integrated approach to education, awareness raising, training and logistic support was used to address poverty and promote sustainable resource management in ten communities.

About 2000 community members, including women and children, received education in biodiversity conservation. In addition, 200 farmers including women and migrants were exposed to sustainable farming and agro-forestry practices and tree planting. By the when of the project, about 20,000 seedlings had been planted and 22 of the farmers had started grasscutter and snail farms. The farmers who benefited from the project formed associations to monitor successes and to offer mutual support to other community members.

The other aspect of the TBI project is the GORTMAN project which developed procedures for collecting data on tree resources and capacity for GIS applications. Even though appreciable amounts of information exist on resources inside forest reserves, only one inventory of Ghanaian off-reserve tree resources exists, from 1995, and this focuses solely on timber species. The Gortman project offered on-the-job training for staff of collaborating institutions and provided opportunities for students from the International Institute for Geo-information Science and Earth Observation (Enschede, the Netherlands) to do fieldwork in Ghana. The project also allowed lecturers at Kwame Nkrumah University of Science and Technology (KNUST) to update their knowledge of GIS application and natural resource management.

The TBI- Ghana programme launched its research site at Asumura near Goaso in the Brong Ahafo Region on July 17, 2002. Since then, the project has been implemented in other districts including Offinso, among others. In an elaborate programme development process, many stakeholders were consulted to identify the problems related to sustainable forest management in Ghana. The main goal of TBI activities at the Goaso and Offinso districts in Ghana is to promote research and knowledge for the conservation and sustainable use of tropical rain forests. It is also geared toward the needs for knowledge, information, methods and techniques for policy makers and forest managers to contribute to the sustainable management and conservation of tropical rain forest resources. Most EIS applications under the Tropenbos Project are in two parts; (1) Information system application and (2) socio-economic studies. The Information system components of the Tropenbos projects took the form of collaborative work between the Tropenbos office in Kumasi, the Forestry Commission of Ghana and the International Institute of Geo-Information Science and Earth Observatory (IIGSEO), while the Socio-economic component is a collaborative effort between the Resource Management Support Centre (RMSC), Forestry Commission, Department of Geography, University of Ghana and the Rural Youth Association.

Most of the field research included image classification and change detection using remote sensing images such IKONOS, ASTER, Landsat and aerial photographs to study the utility and impact of human activities on off-forest reserve (OFR) tree resources in the Goaso Asunafo district of Ghana. Generally, the products, both tangible and intangible, derived from these tree resources help contribute to sustainable agriculture, food security and rural household economies. Reliable and cost-effective information at present can be retrieved from remotely sensed images and different classifiers such as object-oriented classification.

4.6.1 EIS Applications in Off-Forest Reserve Management

Adu-Gyamfi (2005) reports how GIS and Remote Sensing were used to facilitate timely acquisition of reliable data and information for Off-Forest Reserve (OFR) spatial validation of identified ecological indicators, timber certification and OFR timber resource management in the Asunafo District Assembly. Images from passive sensors like ASTER (2004 image) and LANDSAT were used for land cover analysis and change detection in the Forest Reserve (FR) and OFR areas. In addition, GPS was used to demarcate and locate the centres of sampling plots for the study areas. However, the presence of thick shade trees, such as cocoa and bushes often hindered the reception of signals from satellites images in space.

Supervised classification of the ASTER 2004 image was carried out using the Maximum Likelihood classifier. Also, a landsat 2002 image was classified and normalized. Eight land cover classes were identified; (1) Agricultural crops, (2) Perennial cocoa, (3) shade trees, (4) perennial cocoa with fewer or no shade trees, (5) grass, (6) planted trees (plantation), (7) Old Tree Fallow, and (8) Infrastructure. The two images were overlaid on each other to create a land cover change map to ascertain changes caused by logging. However, the ASTER and Landsat sensors have different spectral signatures. In spite of this limitation, from the enhanced capabilities of GIS and Remote Sensing techniques, the digital change detection approach, patching analysis, and map overlay operations, land cover change between 2002-2004 was considered to have been influenced by logging operations. The post-classification change detection approach for 2002 and 2004 aided in establishing stocking levels and the depletion rate of the OFR tree resources (Adu-Gyamfi, 2005). This study assisted in generating information to support the OFR Timber Management as well as the proposed OFR Timber Certification based on ecological indicators. This helped to develop measures to combat violations relating to the existing protection regimes. The incidents of logging violations were therefore used to assess the level of compliance in relation to this regulation. This helped in the development of a local level plan to ensure effective integration of agriculture and forestry especially in those areas that have been zoned out from those landscapes restricted from logging, like hill sanctuaries.

Another collaborative effort between TROPENBOS, the Forestry Commission of Ghana and ITC helped to investigate possible options for Trees-Off-Forest (TOF) assessment in the Brong Ahafo region of Ghana, particularly the area noted for successful management of in and outside reserve trees. Hailemariam (2004) revealed that the contribution of TOF to conservation of biodiversity as well as carbon sequestration either directly or indirectly is significant. Isolated trees and windbreaks are important for conservation of both local and regional biodiversity. Over the period 1990 to 2000, the annual rate of deforestation in Ghana was about 1.7% a year (FAO 2003). Even more disturbing is the increased level of degradation occurring on OFR trees owned and managed by individuals and local communities (Hailemariam, 2004). According to Owubah *et al* (2001) in principle, merchantable tree species in TOR belong to communities, and loggers are required by law to compensate farmers for damage to food and cash crops resulting from logging operations, but they rarely comply. This, in addition to frustrations in claims processes, has resulted in some farmers illegally destroying valuable tree species on their farms before concession companies have access to them.

In this project, an ASTER image was used to monitor the extent and rate of deforestation. The ASTER instrument observes and measures cloud properties, land vegetation, surface mineralogy, soil properties, surface temperatures and landscape homogeneity (Hailemariam, 2004). Mapping was accomplished using ASTER images with spatial resolution of 15 metres of Object-Oriented Classification (OOC). The ASTER images were geo-referenced using projection parameters which helped to create a relationship between the ASTER image and real world coordinates. A Kolmogrove_Smirnov Normality test was used to determine whether functions of trees influence their distribution. The assumption was that a particular tree species might be chosen by farmers for their economic value.

The research also used IPAG (Pocket PC and personal digital assistant) and GPS to identify sampling plots. After a reconnaissance survey, it was discovered that the average farm land except the fallow lands in the study area was about 0.3 hectares and included lands occupied by annuals, cocoa with TOF and grass. However, in most cases, fallow lands are dense and consist of substantial amounts of trees and climbers. The function of each tree species was recorded. The assumption was that a particular tree species might be chosen by the farmer for its value related to service or economic function. The resulting land cover classes are presented in Table 4.6

Table 4.5: Area per land Cover Class

Land Cover Classes	Total Area in Hectares	Percentage Cover
Annual	2,5947.69	35.80
Cocoa with TOF	15318.56	21.14
Fallow	20256.52	27.95
Grassland	7251.21	10.01
Built-up	1726.11	2.38
Perennials without TOF	1796.35	2.48
Cloud/Shadow	173.56	0.24
Total	**72470**	**100**

Hailemariam, (2004)

Table 4.6 indicates that 35.8% of the land in the study area is classified as annual cropland (lands used for food production). It is followed by fallow (27.95%), cocoa (21.14%) and grassland (grass mainly, *Pennisetum*), Perennials without TOF indicate lands occupied by cashew nut, oil palm and pure cocoa, fallow lands (land left uncultivated for one or more growing seasons and colonized by vegetation).

The frequency of particular tree species is different in different land covers. The study revealed that fallow land includes the highest amount of trees, followed by cocoa with TOF, annual and grassland. Fallow lands have the make up the large proportiaon of land because the more the land rests, the higher the likelihood that it will possess more trees.

4.6.2 The Tropenbos International GORTMAN Project

The GORTMAN project was undertaken at the Goaso Forest District. Various components of this project were handled in collaboration with other stakeholders in the forestry sector as well as the University of Ghana, ITC, Netherlands, and the University of Freiberg, Germany. The University of Ghana team collaborated with the Collaborative Resource Management Unit (CRMU) of the Resource Management Support Centre, Kumasi of the Forestry Commission to handle the fieldwork aspect of the socio-economic study of the project on "Geo-Information Application for Off-reserve Forest Tree Management in the Goaso District".

The socio-economic data collected for the survey involved the administration of a household questionnaire and focus group discussions were carried out in the sampled communities. In addition, market surveys of non-traditional food products were carried out at Kasapin and Sankore markets. Interviews were conducted with selected logging companies, Forestry staff and staff of RUDEYA, in the Goaso Forest District. Most of the settlements surveyed were typical of rural communities in Ghana whose livelihood relies mainly on cash and food crop farming. Farmers were knowledgeable about tree species. A majority of them (75.1%) conserved tree species in a scattered pattern on their farms (Ardayfio-Schandorf and Agyei-Mensah, 2005). Apart from the use of timber, many assortments of other products, generally labeled as non-timber forest products (NTFP) are obtainable from the forest and used for various domestic and industrial purposes. 36 NTFP were identified, with a majority of them being food. Cocoa ranked the highest in terms of importance (Ardayfio-Schandorf and Agyei-Mensah, 2005). This is followed by food crops and oil palm farms in that order. This survey was designed for preliminary information on the relationship between the management and utilization of off-reserve tree resources and the depletion of tree resources in the project area.

Farm sizes are generally between 1 and 5 hectares: 23.4% ranged from 6 to 10 hectares (Ardayfio-Schandorff and Agyei-Mensah 2005). Most of the residents were knowledgeable about common trees species on their farms and the areas where they are found (Table 4.7). A socio-economic survey conducted by Ardayfio-Schandorff and Agyei-Mensah (2005) revealed that there are differences in preference of trees between mail and female counterparts. Men were more aware of the commercial timber species like Odum (*Milicia excelsa*). The utility of the trees species on the farms was for far reaching purposes like shade provision, prevention of soil erosion, water shed protection, furniture, fuel wool, charcoal, medicinal, food, household goods, building and construction. The most common trees used on the farms are Onyina (*Ceiba pentadra*) trees (9.8%), Odum (*Milicia excelsa*) 8.8% and Otease (*Pycananthus angolensis*). Tree conservation practices change over the season. During the dry season, the major conservation practice was fire prevention (49.8%) followed by regular patrols (30.8%) and planting of shade trees, compliance with bush fire laws and closed seasons.

Tree management practices have a relationship with conservation practices. Tree management practices include pruning, lopping, singling, weeding and ringing. Of these practices, pruning is the most popular activity undertaken in the management of the trees consisting of an appreciable value of 32.4% of all the respondents. A majority of the

Table 4.6: Most Common Trees Species Found on Farms by Percentage

Common Tree Species Found on the Farms	Botanical Name	Percentage (%)
Ofram	*Terminlia superba*	14.8
Onyina	*Ceiba pentadra*	9.8
Emire	*Terminalia ivorensis*	4.1
Wawa	*Troplochiton scleroxylon*	2.8
Kyenkyen	*Antiaris toxicaria*	2.1
Avocado	*Persia americana*	1.8
Kakapenpen	*Ranvofia vomitoria*	1.6
Mahogany	*Kaya* spp.	3.7
Odum	*Milicia excelsa*	8.8
Otease	*Pycananthus angolensis*	5.2
Others		31.5

Source: Ardayfio and Agyei-mensah, 2005

farmers (75.1%) conserve tree species in the scattered zones on their farms, a total of 6.43% did so in the middle and at the peripheral areas, and 18.7% conserved along water courses (Ardayfio-Schandorff, 2005). Some of the women indicate that they leave trees to give their young plants shade when planting. When the cocoa is matured, they cut some of the trees near the cocoa plants and leave the rest to keep the farm cool. Various production and land use systems provide these NTFPs to households. Respondents noted the relative importance of different land use systems as sources of NTFP supply to their households for consumption. Besides forests, cocoa farms, fallow vegetation and food crop farms followed in that order as the next most important source of supply of NTFPs to households (Table 4.8).

Table 4.7: Land Use System and Relative Importance for Supply of NTFPs to Households

Land Use Systems	Ranked Importance (%)*
Reserved forests	67.0
Unreserved forests	44.0
Cocoa farms	36.4
Fallow fields	30.8
Food crop farms	27.6
Other cash crop farms (e.g. cashew)	8.4
Oil palm plantations	5.5
Grasslands	4.9

Source: Ardayfio-Schandorff and Agyei-Mensah, 2005

4.6.3 TBI Building Initiatives and Alternative Livelihood Activities

By linking research institutes in the South with those in the North, TBI enables the exchange of students and expertise. Local capacities and strong institutions are crucial to achieving sustainable forest management. The programme supports indigenous people who are involved in research at the universities (FDCFU, 2000). By creating indigenous research working groups, TBI facilitates the exchange between traditional indigenous knowledge and academic knowledge. As part of the need to promote a bottom-up flow of information, TBI Ghana offers training sessions (using videos, info sheets and project posters) which were organized with forest-adjusted communities (forest fringe communities) and focus group discussions with various stakeholders such as researchers, farmers, community leaders, policymakers and forest users. Relevant information is repackaged in info sheets that target specific stakeholders in the forestry sector.

Capacity building strategy is done at the individual and institutional levels. It focuses on knowledge acquisition, skill building and change of attitudes. In addition, TBI offers infrastructure and opportunities for: (1) On-the-job training, (2) Education of MSc and PhD students and (3) Post-doc research. On-the-job-training in computer use, GIS and Remote Sensing communication techniques and other topics is also provided (TBI, 2004). Training is geared towards meeting the capacity needs of its partner organizations with exchange of students and expertise between the North and the South. However, TBI's efforts at training are not all directly linked to research but rather to the multi-cultural and multi-disciplinary approach that creates the environment for cross-fertilization of ideas and common identification of resource management problems which helps to address urgent needs of communities. However, these objectives can only be achieved if research, its conception and implementation pay due respect to the needs and aspirations of forest users, managers and policy makers. This strategy enables TBI to generate relevant information, train human resources and build institutional capacity. Unfortunately, there are no well laid out structures and mechanisms to translate research results in a way that is accessible for policy makers and forest users so that they can put them into practice (TBI, 2002).

To facilitate the uptake of research findings, TBI works in close collaboration with the Forest Services Division of the Forestry Commission and local communities that live closely and depend directly on the forest for their livelihood. Collaboration of various stakeholders is done on a participatory basis where each stakeholder provides input into the decision making process. As a global player, TBI collaborates with four types of organizations;

(a) Research organizations and programmes

(b) Information management organizations

(c) Training and extension agencies dealing with forest management

(d) Funding agencies

Alliances with each type of organization invariably support specific elements of the Tropenbos programme (TBI, 2001). Among some of the collaborating institutions are the Forestry Research Institute of Ghana (FORIG), the University of Aberdeen, UK and the Institute of Renewable Natural Resources, (I.R.N.R), Kumasi. Clearly, Tropenbos is adapting prevailing concepts of development cooperation and partnership. But it maintains its successful approach of mobilizing research capacity on long-term sites where a bridge is built between scientific knowledge and local practices (TBI, 2005). In continuing to generate strategic knowledge and strengthen capacity for the conservation and sustainable use of tropical rain forests, a new phase lies ahead for "rain forest research that makes a difference".

In 2001, stakeholder collaboration and consultation were organized in Ghana and Indonesia, aimed at identifying the needs for information, methods and techniques among policy makers, forest managers and local populations (TBI, 2001). Responding to increasing recognition of the important role that assessment of biological diversity plays in sustainable management and conservation of tropical forests, TBI concentrates on the development of indicators to assess the quality of forest ecosystems and the impact of human interventions on biodiversity and productivity (TBI, 2001). By so doing, the programme fills gaps in knowledge of tropical forest ecosystems, about the conditions for sustainable timber production and the possibilities for maintaining or enhancing the productivity of tropical forests.

Alternative Livelihoods (AL) are activities intended to help economically disadvantaged members of society to meet their daily subsistence needs in a manner that is dignified, locally appropriate and environmentally sustainable. The concept is perceived to represent a range of activities that utilize indigenous local customs and knowledge to take advantage of available natural resources for the benefit of individual and societal needs (CEDEP, 2004). AL is seen by many as a viable way to improve rural livelihoods and reduce excessive dependence on natural resources (TBI, 2005). According to Gerster and Zimmermann (2003), Livelihood systems comprise a complex and diverse set of economic, social and physical strategies which involve adaptation to new circumstances. These strategies are realized through the activities, assets and entitlements by which individuals make a living. They can therefore only be understood and addressed in an integrated manner. However, the basis of this optimism is premised on mere conjectures and little empirical evidence. AL that may not have anything to do with the forest are varied, and knowledge as well as experiences with these options indicate that as much as they are successful, there is the need for training, skill acquisition and credit before engagement. Many of these activities, like snail farming and grasscutter rearing, require, specialist training to ensure that the activities are successful.

Experience has shown that in as much as many projects have succeeded in the pilot or infant stages, many challenges remain when institutional support is withdrawn from the communities. Individuals and groups do not have the requisite knowledge and expertise to cater for them. Again, it is important to ensure that ALs provide a steady stream of cash flow because most of the communities that engage in the alternative activities have to grapple with the lean or off season periods of their current economic activities. Complementarities are also explored in this regard, for example the establishment of woodlots to supplement the use of fuel efficient stoves. To ensure sustainability, there is the need to integrate any interventions in ALs into local governance structures for continuity and sustainability. In some cases, further processing or packaging of the final products has to be taken as key components of the promotion efforts.

4.7 Summary

The location, climate, and soil characteristics of Ghana, have led to a unique formation of major vegetation zones which account for the agro-ecological characteristics within which various economic and livelihood activities are undertaken. However, the rate of population growth, economic pressure and expansion in agricultural activities continue to reduce fallow periods and soil fertility in most rural communities, many of which also lack basic social amenities. The problem is compounded by a lack of adequate data and information on the state of the environment, the extent of human impacts on it and the relative impacts of resource management routines initiated by international donor agencies.

The UNDP/Ghana Capacity 21 programme was initiated in Ghana to build capacity at the district level through training, workshops, information systems supplies and environmental management care systems. The program also collaborates with other institutions for the provision of energy-efficient and solar energy devices to lessen the pressure on fuel wood. In addition, it supports various tree nursery and tree planting activities aimed at replenishing degraded forests and enhancing biodiversity conservation. Capacity 21 is initiated from MEST and implemented at the district level. It is characterized by a top-down, expert-led approach and communities participating at the implementation stage.

Since 1992, the UNU/PLEC with funding from the GEF has initiated a number of programmes in Sekesua Onsonson, Amanase Whanabenya in Southern Ghana, among others. Data and knowledge about the environmental conditions are collected through collaborative effort between PLEC scientists, expert farmers, and local farmers. These programmes include transect walks, demonstration activities, and ecosystem restoration and biodiversity through germ plasm, nurseries, and tree planting. PLEC's approach is largely a farmer-led activity with greater reliance on integration of LKS and scientific knowledge for effective management of agro-diversity and agro-forestry practices.

The Tropenbos programme on the other hand, was introduced on the Ghanaian scene through a joint agreement between the Netherlands and the Government of Ghana. The TBI is geared towards knowledge generation and application of information for agro-forestry management and biodiversity conservation. The programme also involves capacity building, stakeholder collaboration and AL development as a means of easing the pressure on forest resources.

These projects have specific mechanisms and strategies for EIS and LKS application in natural resource management. Some of these approaches are similar whereas others are different based on the skills, needs, and expectations of the communities or districts. Hence, success or failure of these programmes depends on the relative efficiency or effectiveness of the human resource, institutional, and socio-economic factors that influence the implementation process vis-à-vis the intended resource management objective.

CHAPTER 5: ANALYSIS OF THE IMPACTS OF EIS AND LKS ON AGRO-FORESTRY MANAGEMENT AND BIODIVERSITY CONSERVATION

5.1 The Nature of EIS and LKS Assessments

Assessing effectiveness, efficiency and sustainability of EIS and LKS applications in natural resource management requires as analysis of how they have been applied at various levels (National, District and Local) in Ghana. This is because the level of sophistication, type of information system and knowledge systems used vary from one level of project design and implementation to the other. Generally, computer-based GIS tools are used predominantly at the national and partially at the district level but not at the local or community level where local knowledge systems are predominant. The two knowledge-based systems are not mutually exclusive but complementary as contextual factors such as project mandates, modus operandi, logistics, infrastructure, financial outlay, institutional policies and social structures dictate. Interplay of these contextual factors shapes the efficiency or effectiveness of knowledge-based systems for sustainable agro-forestry and biodiversity conservation within the communities where the TBI, Capacity 21 and PLEC projects are implemented.

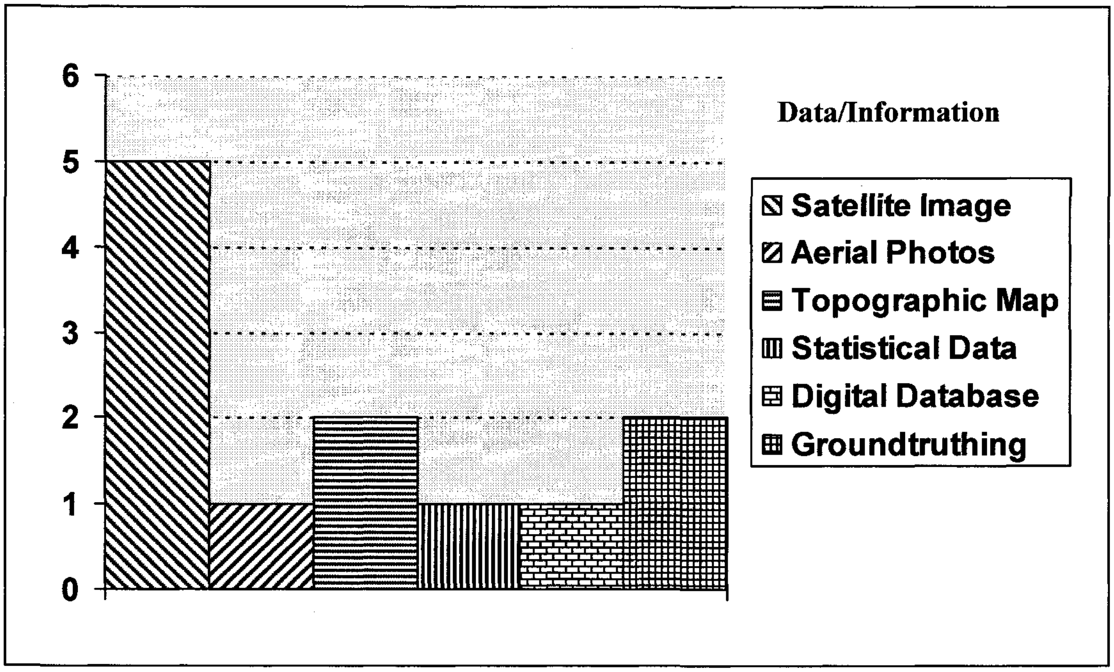
Interviews with service providers at the national level, resource managers (planners) at the district level and focus group discussions with farmers within the local communities revealed the nature of the contextual issues and the extent of EIS and LKS application in agro-forestry and agro-diversity management within the projects that were investigated. Analysis of the responses from the survey is based on in-depth comparative evaluation of the successes and failures of EIS and LKS applications in agro-forestry management among the three case study projects which traverse different agro-ecological zones. The analytical approach adopted in this study is two-fold: (1) within case study examination, and (2) cross-case comparison of the UNDP/Ghana Capacity 21, PLEC and TBI projects vis-à-vis EIS use in agro-forestry management and agro-diversity conservation. The contextual issues include the type of information and knowledge systems used; the nature of differential access to relevant and reliable information systems; how EIS and LKS have shaped agro-forestry management and the extent to which training and skill development programmes have re-oriented users' knowledge and effectiveness in EIS and LKS applications in natural resource management as identified in the conceptual frameworks in Figures 3.1 and 3.2. Critical analysis of the survey results brings to light the pathways of EIS and LKS applications and the utility of integrating these diverse knowledge systems into community-based natural resource management.

5.2 TBI EIS Data Acquisition and Use in Agro-forestry Practices

The perpetual conversion of forestland to other forms of land use, especially agriculture has created serious environmental problems; logging and bush fires are also major causes of environmental problems. In order to identify these problems, various types of data and information systems are used. The interviews unraveled the types and sources of information and how they have shaped agro-forestry practices (See conceptual frameworks in figures 3.1 and 3.2).

Under the Tropenbos project, landcover maps were the main sources of information which resource managers used to assess the ways in which forest and off-forest reserve areas have been transformed by farming practices. When TBI service providers attached to the Forest Services Commission (FSC) were asked to select the types of information systems used (Question 2 of Appendix E), the majority picked satellite images which account for 41% of the total sources of information used for assessing ownership, land use and resources (Figure 5.1). This is supplemented by topographic maps (17%) and groundtruthing (17%). The maps and satellite images help to ascertain areas undergoing land degradation. Consequently, maps were produced showing resource situations.

Figure 5.1: Tropenbos International Project Data/Information Sources



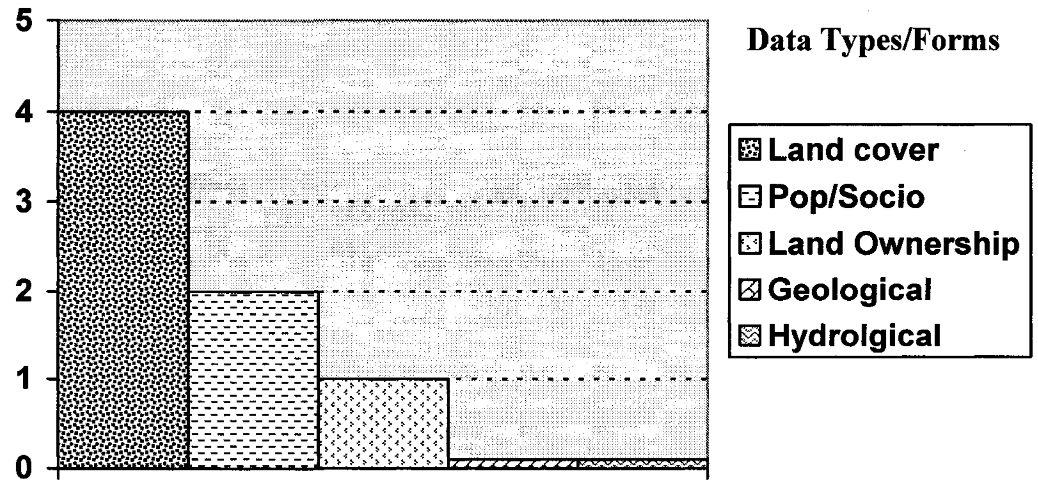
Source: Field Survey 2005-2006

TBI service providers observe that it is really difficult to set up a standardized land ownership map in Ghana. There are always litigations over land ownership and property boundaries. Land ownership data is obtained from traditional chiefs who have a vested interest in lands and arbitrate in land ownership disputes in the villages. "You cannot sit down to draw where the boundary is but you can draw the agreed boundary before you can draw a line", a forester with the FSC explained. In view of the fuzzy nature of land boundaries, there is always a disclaimer that this does not constitute a map that can be used for legal purposes.

The Tropenbos Project has systems operated by personnel of FSC based in Kumasi who are specialists in EIS application. The project focuses on the collection and analysis of spatial data (both biophysical as well as socio-economic) on off-reserve tree resource conditions. Such information is used for land management which will ultimately lead to development of scenarios for future land use recommendations. Socio-economic data account for 8.3% of the sources of data used under the TBI project (Figure 5.1). While the FSC regularly monitors the conditions of forest reserves under its authority, relatively little is known about the quantity and condition of tree resources outside these reserves. The TBI technique tends to take inventory of the current situation, assess productive potential of lands and explore various options for change, including alternative farming systems. The TBI GORTMAN Project for instance developed and tested methods and tools focusing on the collection and analysis of especially spatial data (of both biophysical and socio-economic nature) of off-reserve tree resource conditions and current and past use/management practices. Ultimately, there will be the development of scenarios for improved land use management in the Goaso District of Brong Ahafo Region. The TBI service providers prepare and print posters for TBI field workshops and education programmes.

The predominant types of data and information used are topographic data and remotely sensed images that have been collected and processed into maps which show land cover and related tree density as well as changes. Land cover and land use maps, account for 66% of the data about the extent of forest degradation (Figure 5.2). These maps, in combination with data on species and tree regeneration, give a good impression of the status of degradation of off-reserve areas in Goaso forest district and are essential for informed decision making. The FSC used this information to ascertain the extent of degradation of off-forest reserve resources. Land cover and land use maps are the largest sources of information used by FSC in comparison to the other data sources in the other projects. Second, socio-economic data accounts for 33% of all information used by resource managers associated with the TBI project (Figure 5.2).

Figure 5.2 Tropenbos International Data Types/Forms



Source: Field Survey, 2005-2006

EIS service providers with the TROPENBOS project are personnel from the Forest Services Commission in Kumasi. They use land cover/land use maps (ALSTER) to identify areas that have been degraded or are undergoing degradation especially in places affected by logging operations and bush fire caused by harmful hunting techniques and slash and burn agriculture. Some of the data sources employed are topographic sheets which date back to 1974 and the latest being ASTER images from 2003. These image sources are supplemented by Landsat TM. “We update our satellite images every 5 years” a technical officer of FSC explained. Subsequently, maps were produced to show resource situations so that policy makers can be better informed to make judicious decisions that will make trees available for sustainable use whiles protecting and enhancing the regenerative capacity of the resource base. Such information makes distant managers aware of fragile and sensitive areas undergoing heavy degradation so that they can direct their efforts towards protecting these off-reserve trees. TBI information analysts argue that it is extremely difficult in Ghana to come up with a standard land ownership map, especially in the areas of ‘stool lands’ (traditional chiefs are custodians of these lands). Timber companies may have boundaries for exploitation but the boundaries are not clearly defined. This is usually resolved at the district level. Unlike the Capacity 21 project, PLEC and TBI have on-line information systems at the Forestry Commission for easy access and timely outreach and this makes information easily available from outside.

Responses from EIS users revealed that in all three cases, the degree of usefulness of the information and data generated by the service providers averaged 4 on a scale of 1-5. This reflects the relevance of the data and information for assessing resource conditions.

Farmers assert that they readily obtain the kind of information they are seeking. Most of the users interviewed in the three projects indicate that they have a higher degree of confidence in the information they use with similar ratings as the usefulness of the information. The specific type of information and data used in each of these projects vary considerably depending on the circumstances and setting in which the information and data is used.

There is no indication of application of other sources of data. From interviews with the farmers, it emerged that only those trees that have explicit functions in farming systems or in rural livelihoods are allowed to grow to sizeable dimensions. This implies that the function of a tree is very much the key to its occurrence, protection and preservation on farmlands. The involvement of local communities is undoubtedly crucial, and information on the uses and functions of trees in rural livelihoods is essential to ensure the proper protection and management of off-reserve tree resources and curtailment and even reversal of their degradation.

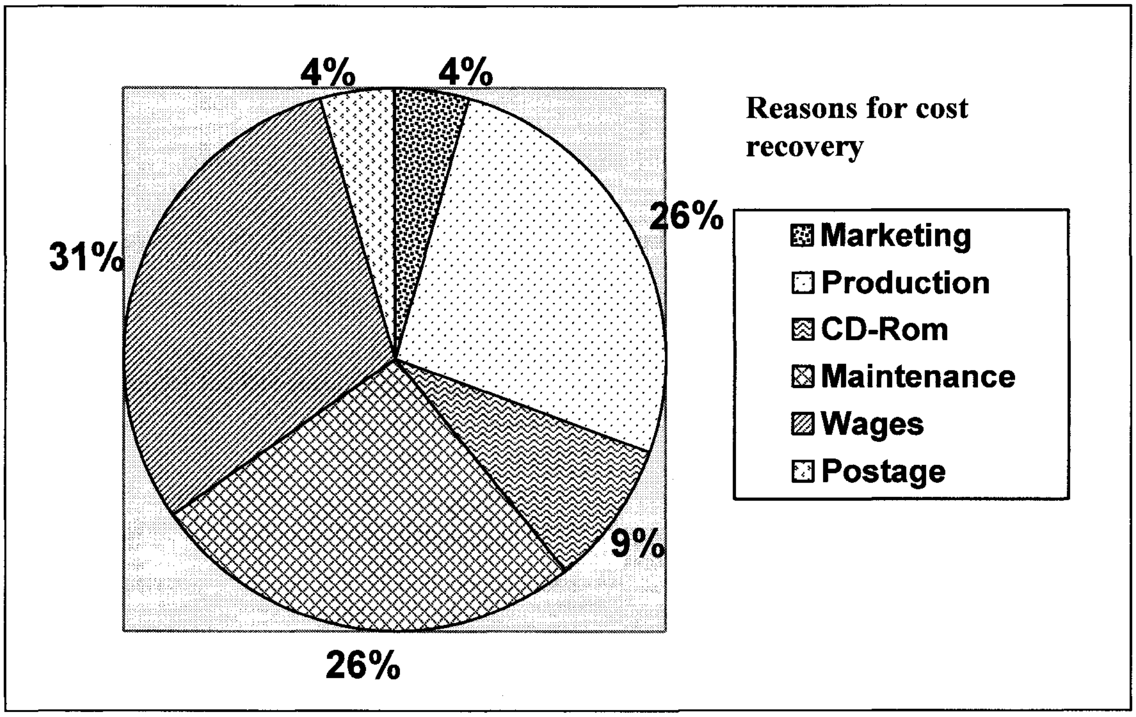
5.3 TBI: Training, Skill Development and Associated Financial Regimes

Effective implementation of EIS in Ghana therefore depends on a number of human resource factors. Effective capacity building for EIS application in resource management depends on (1) the level of computer literacy of the individuals involved, (2) the age, (3) the level of education of the trainee, (4) the required task to be performed, (5) level of appreciation of the use of GIS, and (6) the logistics and financial requirements of the training programmes. Hence, a number of training, workshops and skill development programmes are undertaken to enhance the capacity of individuals and groups to use the technology effectively. In the course of the survey, TBI service providers were asked to describe the type and duration of training they offer (Questions 11 and 14 of Appendix A). Most of the respondents indicated that the type, intensity and duration of EIS training depend on the needs of resource managers and the cost of training. They provide training on software application programmes which usually proceeds with computer literacy education. TBI service providers are of the view that training programmes are adequate to ensure user understanding of the data and information. It is easier to train personnel who are either recent graduates or students of Kwame Nkrumah University of Science and Technology. The TBI computer-based training programmes usually take two weeks. Workshops and symposia are also organized to educate people within the farming communities about the best way to utilize resources. The service providers assert that EIS application is designed for non-technical decision makers and the inclusion of manuals with the software applications package assists users in efficient application of the system. "There is also step-by-step description of how to retrieve and display data" a trainer at the FSC clarified. In addition, service providers grant technical information on the attributes of datasets and specific details concerning data generalization.

Computer-based training programmes and video projectors usually were employed for workshops at farming communities. The TBI service providers assert that the data and information they provide clients are adequate and contain all the relevant information that clients request. "We don't have dissatisfied customers or client users". However, one service provider reminisced on cases where clients expressed dissatisfaction about the data, "I have encountered a situation where a user complained about the data. A lot of the time, there is a disclaimer that this does not constitute information that can be used for legal purposes", EIS trainer noted. Although data quality has been one of the main concerns expressed by users, cost of data acquisition and use also has been one of the most significant factors to access to information.

The contentious issue with regard to EIS application in resource management is the extent to which ad-hoc donor funding guarantees continuity of EIS application in natural resource management. The main financial regimes that were identified in the survey are open access and cost-recovery (Questions 18 and 20 of Appendix A). The TBI project itself does not practice cost-recovery but provides information free to the public. However, the service providers attached to the TBI project each practices a separate financial regime depending on their mandate and cost of operation. The Resource Management and Support Centre (RMSC) of the Forestry Commission in Ghana supports the TBI project with requisite information through a contractual arrangement. The RMSC does practice cost-recovery. The survey revealed that 31% of the cost-recovery goes into payment of wages of workers (Figure 5.3), maintenance (26%), and production costs account for 26% of the reasons for cost recovery. "We are now business-like and we are conscious of cost-recovery to break even", a forest manager explained. Some of the data (satellite images) is too expensive and individuals cannot afford it. This limits access to vital environmental information and may hinder continuity of monitoring and evaluation of resource conditions in off-reserve areas of Goaso where agro-forestry is practiced. The least frequent reasons that resource managers cited for instituting cost-recovery are postage (4%) and marketing (4%) because most clients walk-in to obtain their information and there is very little investment in publicity. In contrast, the TBI Information Centre at Kumasi offers free communication training. "In the past communication training has been able to acquire funds, so we don't ask them to pay anymore" a Communication officer asserts. This free access to training and information is practiced because the project is already donor-sponsored. In both projects, there are no restrictions of secondary uses of the data and information. TBI expressed the desire to be acknowledged for the data they provide.

Figure 5.3 TBI Service Providers: Cost-recovery and Charges

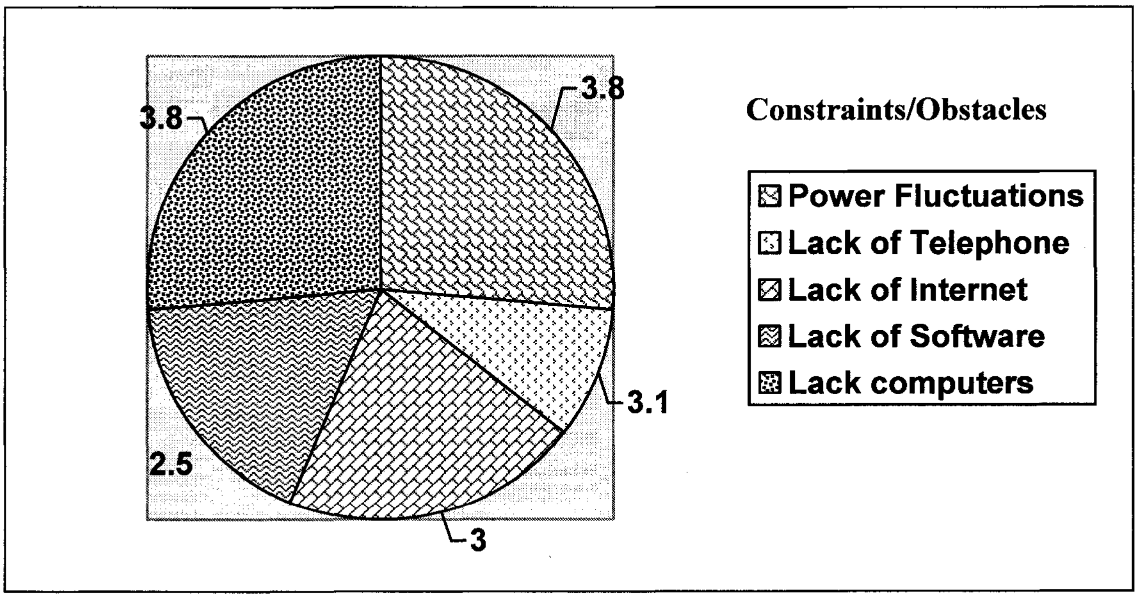


Source: Field Survey 2005-2006

5.4 Obstacles to EIS Implementation in TBI Project

During the field interviews, district planning officers and resource managers employed under the various projects ranked the obstacles and constraints to EIS implementation in order of seriousness (Question 9 of Appendix A). The mean of the rankings revealed the nature of the challenges encountered in the implementation of environmental information systems. The type and severity of constraint varied from one project to another. Personnel of the TBI office in Femusua, Kumasi cited frequent computer and plotter crashes and power fluctuations as the two most serious problems militating against effective use of information systems for managing environment at Goaso and surrounding villages. GIS personnel at TBI ranked power outages and system crashes as 3.8 on a scale of 1 (least) to 5 (highest) among the problems they face (Figure 5.4). Personnel attached to the Information Centre of TBI assert that there is no stand-by generator and this has become very serious when power is off. These technical hitches cause disruption of services and delays in EIS application.

Figure 5.4 TBI: Distribution of Mean Rankings of the Obstacles and Constraints of EIS Application



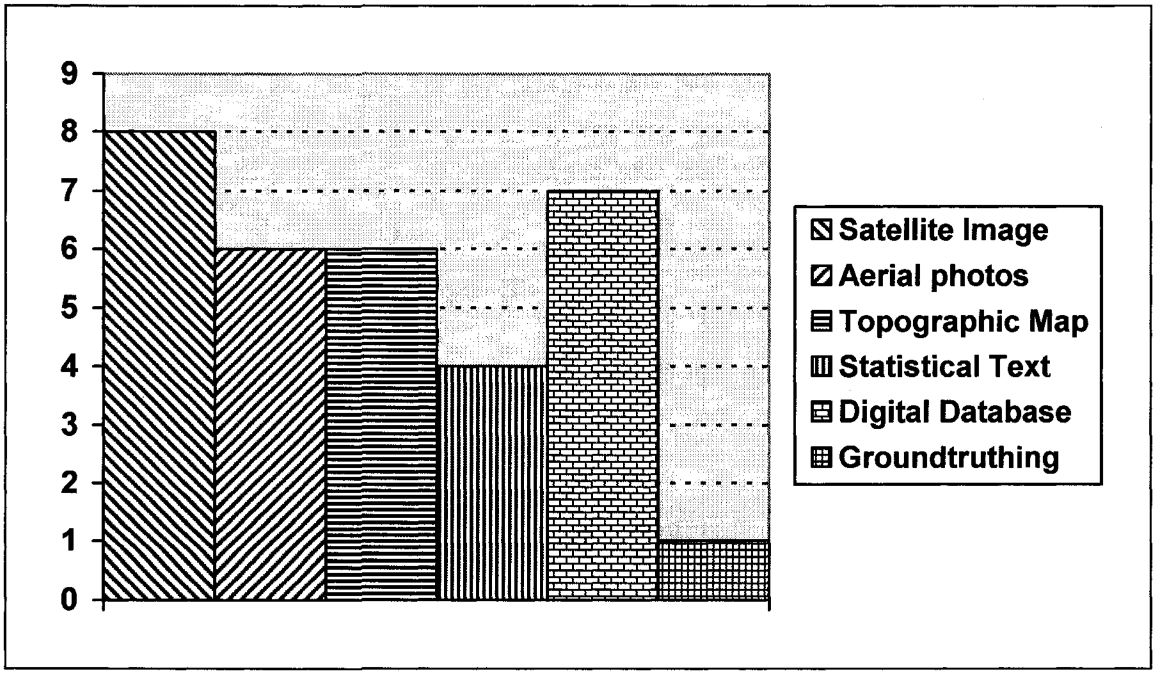
Source: Field Survey 2005-2006

An information system analyst attached to the TBI project observed, "Technology is growing so fast, when you buy hardware today, may be 2 or 3 years it is behind time". The problem is compounded by a shortage of personnel with requisite technical knowledge. "We depend largely on internal knowledge of hardware. We have few people out there to configure it", a system analyst noted. The system issues cited by personnel include CD-ROM, video card and mother board problems. TBI depends on external system analysts to fix the problems, but making a computer work with a digitizer is not their job. Another related issue is that some of project coordinators hire their own consultants who have little or no knowledge of the environmental and social context in which EIS is used. There is sometimes divergence between what the system is designed for and the needs as well as environmental problems that resource managers face. After consultants leave, the project grinds to a halt. Lack of internet services and frequent server problems were ranked as the second most serious problem militating against access to and retrieval of information for natural resource management. On the other hand, GIS software acquisition and licensing and telephone communications are the least of the problems faced by TBI as most workers own a personal cell phone which they rely on in the event of technical problems with the office phone.

5.5 Capacity 21 Data Types, Sources and Applications

The Capacity 21 project established the District Environmental Resource Information System (DERIS) project which provides information and data. For example, resource and infrastructure maps have been used as a basis for physical and environmental management. Satellite images account for 25% of all sources of data. This is supplemented by database information which constitutes 22% of the total data sources (Figure 5.5). Information on various thematic issues of the environment are gathered, processed, stored and disseminated for planning, development and management purposes. The fact that resources and base maps can be developed at the district level instead of the previous practice of relying on regional and national authorities to meet information needs has been a great relief to the beneficiary districts such Sekyere West and Assin Fosu. In order to use the DERIS system effectively, capacity 21 district planning officers were trained by CERSGIS (the data providers). The planning officers use satellite

Figure 5.5 Capacity 21 Data and Information Sources



Source: Field Survey 2005-2006

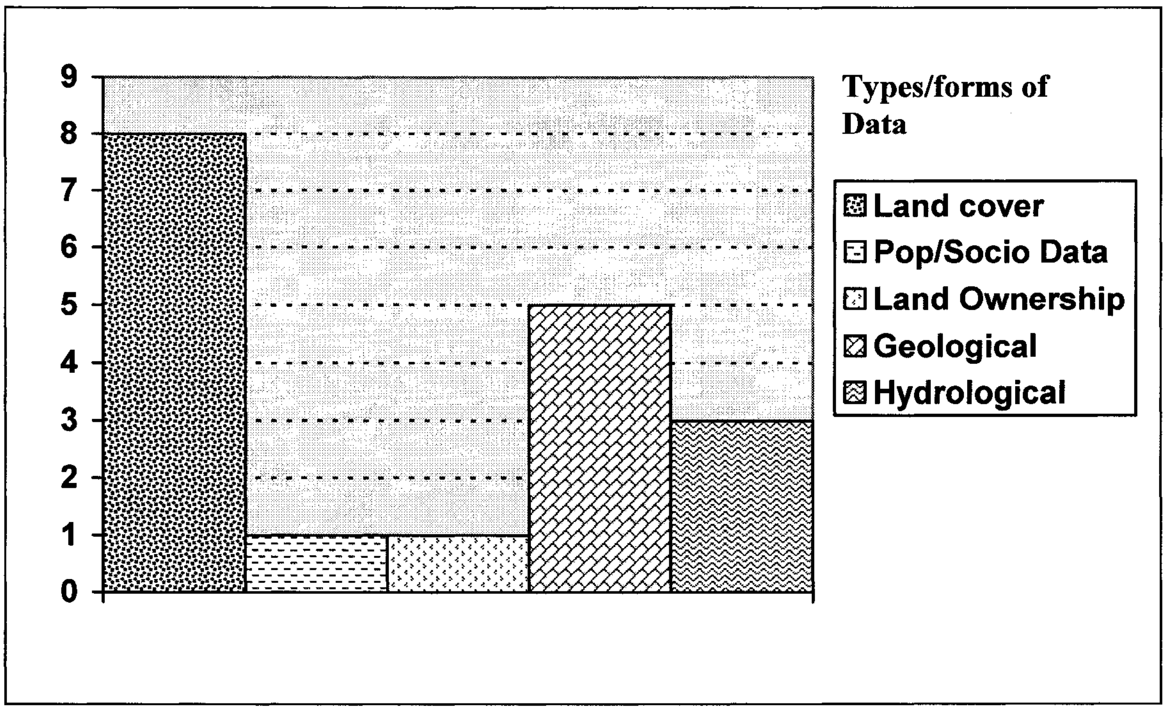
images such as Landsat, usually procured by CERSGIS through funds provided by the capacity 21 programme. Ground truthing is the least (3%) source employed for Capacity

21 personnel. Although satellite images reveal large-scale regional and sometimes district level agro-ecological characteristics and land degradation, it becomes problematic because the scale at which the images are produced is too small to be of any use for large-scale and detailed analysis. The spatial resolution of the satellite images at a parcel level makes it extremely difficult to capture details in terms of agro-ecological variations and has little relevance for local application. Aerial photographs and topographic maps tend to be a much more useful means of small scale assessment of ecological variations at the landscape level and each accounts for 19% of all sources of data (Figure 5.5).

The interviews with the Capacity 21 service providers revealed that district planning officers are trained to interpret satellite data and images and conduct analysis about land use changes in the areas. "Commenting on the usefulness of land cover maps, a resource manager associated with the capacity 21 project notes, "At a glance, you see patches of vegetation which people destroy in the process of farming, poaching, charcoal and bush burning caused by grass-cutter hunting". The image interpretation is integrated into the decision making process and service providers at CERSGIS argue that the system is designed for multi-purpose functions (resource management and district planning decisions). Although digital data, topographic maps and socio-economic data are available on demand, they do not have an on-line information system which could make it easy for planners across the districts to assess from their respective jurisdictions. Three out of four resource managers who were interviewed agree that the data is relevant for their tasks. Vivid information about land degradation obtained from satellite image interpretation and GIS have helped to understand the causes of environmental degradation, especially chain-saw operators and unsustainable farming practices within the communities. This promotes proper monitoring of environmental problems in the villages and formulation of laws to control the spread of degradation in these village communities. EIS knowledge has been used to produce by-laws to check degradation.

In the Capacity 21 Project, land cover and land use maps account for 42% of the types of information used for assessing land degradation and ecology (Figure 5.6). Land cover and land use maps are key sources of information used by all the resource managers to determine forested areas and regions which are undergoing degradation due

Figure 5.6 Capacity 21 Types/Forms of Data



Source: Field Survey 2005-2006

to harmful agricultural and logging practices. District planners use their own intuition to determine environmental problems and propose solutions to them by organizing tree planting exercises on degraded areas. Another important source of information used is soil and geological data (26%) and hydrological information (15%) (Figure 5.6). These data sources have been instrumental in planning for water resource access and allocation for rural communities. Unlike other sources, population and socio-economic figures, land ownership data and climate data constitute lesser sources of information (data) employed in agro-forestry management. Land tenure and ownership are significant for agricultural purposes. The data that resource managers use is mostly satellite images and maps acquired and produced by CERSGIS. The information obtained from CERSGIS shows land cover/land use of the districts. These maps also depict land suitability and the effects of bush-fire on the landscape.

The Capacity 21 DERIS project has a computer-based system with associated digital databases on environmental themes on the districts. Most of the information is provided by CERSGIS which offers training services to district planning officers and key staff selected to participate in this project. As part of the DERIS programme, CERSGIS provides database information and software which are requested and used by clients, mainly district planning offices. Since the Capacity 21 project has no on-line information system, the national coordinator in Accra acts as liaison between CERSGIS and the district planners to ensure that requisite data/information needed for environmental analysis and management are made available to the districts. District planners indicated that through this institutional arrangement, relevant logistics such as computers, printers and environmental databases are made available to personnel of the district assembly. Ease of access to data and information depend on the degree of response from CERSGIS personnel and the laid down protocol for acquiring such information. The district planning officers acknowledged that the database and information they use are adequate since they contain relevant sources of information.

When a resource manager was asked to describe the level of competence (Appendix F) of district planners in the application of EIS, he noted, "If you are competent, whether old or new, you can use it". A GIS application specialist at CERSGIS who has been training clients over past years identified a positive correlation between client's familiarity (past and present) with computer systems and their level of competence in performance during EIS training sessions. "If officers are new to technology; they end up messing up the system", he observed. The time lapse between training sessions and actual application of EIS determines the efficiency or success of the intended hands-on application. About 64% of the trainees who were interviewed indicated that they have not used the system for actual application since the completion of the training sessions. District secretaries and other administrative staff do not apply the skill and knowledge they acquire through their training in natural resource management. Sometimes, district planners call CERSGIS to provide step-by-step instructions on how to use the system.

A district planning officer indicated that the previous Environmental Resource Management Project (ERMP) is a failure. "This time, we don't plan for people, we plan with people" he observed. Planners usually deal with environmetal problems identified on satellite images by tackling the root cause of the problem which usually emanates from the kind of landuse and livelihood activities farmers undertake. The 4 district planners associated with the Capacity 21 project (who were interviewed) reiterated that they organize workshops and sensitization programmes on proper environmental management practices. However, lack of requisite and reliable data/information on the environment makes it difficult for proper remedies to be initiated. To overcome this problem, CERSGIS bought digital maps for boundary demarcation which have been used for poverty and accessibility mapping. The poverty maps show areas endowed with particular resources and areas that are deprived.

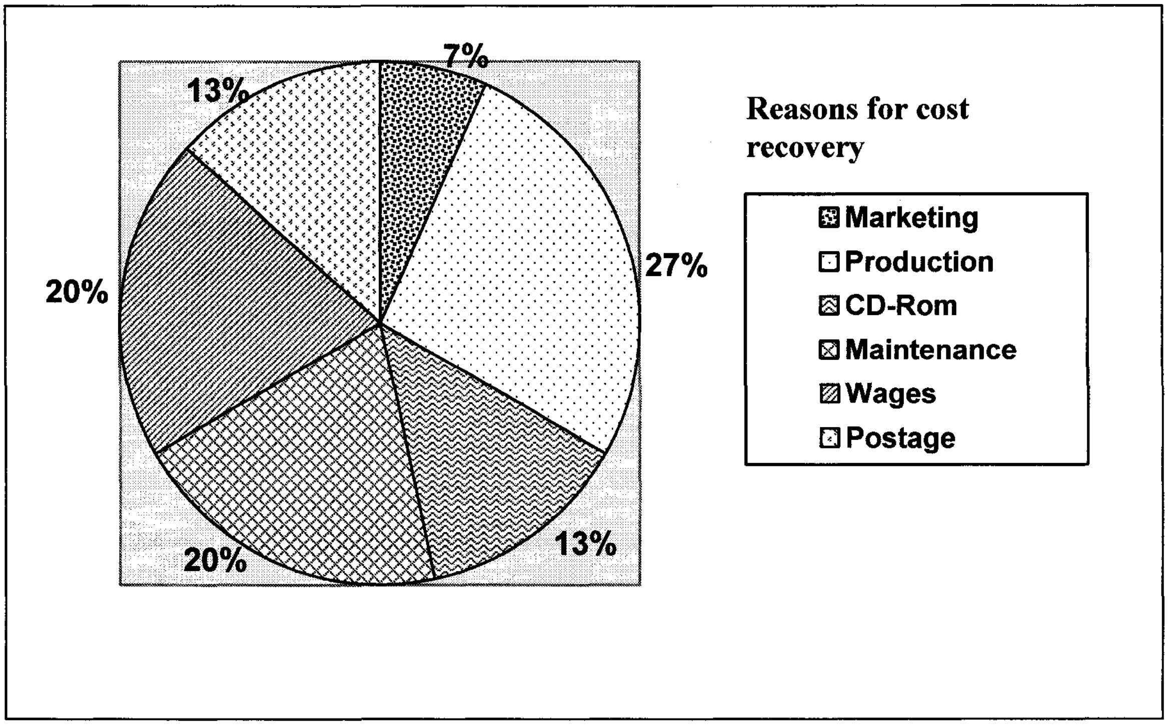
5.6 Capacity 21 Training and Skill Development Programmes and Associated Financial Regimes

In the case of capacity 21, district development planners received training from CERSGIS. Service providers note that the effectiveness of training programmes depends on how much a client is prepared to learn and the costs of training. The interviews with CERSGIS service providers revealed that older folks who have been out of school for a number of years tend to take longer to acquire computer skills whereas fresh graduates or college graduates are faster in catching up with EIS training exercises. The cognitive gap in information technology between older folks and young people is attributed to the fact that computers and information tools were not commonly available to students in the early decades of higher education in Ghana. Hence, the older folks did not acquire computer literacy skills and they are at a disadvantage when it comes to using computers for EIS application. District planners associated with CERSGIS are older folks. On the other hand, TBI attracts young graduates or students from the KNUST who are relatively familiar with computers as compared to trainees under the Capacity 21 project, who are mostly middle-aged personnel working in the district offices. Only a few district planners have good knowledge of computers as a result of various refresher courses that they have undertaken. Also, an individual's pre-disposition to learning, and desire to be familiar with new information technology, plays a major role in learning about information technology and its applications in natural resource management.

CERSGIS trainees revealed that training sessions range from 3 days to 3 weeks (Question 13 of Appendix A). The district focal persons and their assistants received two weeks training in GIS database management at Legon which was organized by CERSGIS. Three days to one week was devoted to general computer training, especially on the introductory aspects, whereas 3 weeks were used for operational and technical training programmes. Manuals also show how to use the data, software and information system. The training has equipped focal persons (district planning officers) to collate district data for 2001-2005 District Medium Term Plans. The district development planning officers agree that training and skill development programmes have improved their knowledge about EIS application in natural resource management. The training sessions have manuals with instructions and demonstrations on how to use data, software and the information system. On a scale of 1-5, district planning officers of Capacity 21 rated the suitability of data and information system as 3 (suitable) and they consider the system user-friendly. One of the 4 district development planning officers agreed that the training and skill development programmes have improved their knowledge on how to use EIS. The remaining district planning officers who participated in the EIS training sessions at CERSGIS revealed that training programmes are not in-depth and not regular. "I am trained, but only for 2 weeks, I cannot use the software efficiently". There were only 2 training sessions over a 3 year period and no follow-up sessions were arranged after the initial exposure. The inadequate and intermittent nature of EIS training and skill development programmes is problematic and does not auger well for effective applications of EIS for sustainable natural resource management. Trainees tend to forget or lose the fundamental knowledge and experience they acquired from the initial training as enthusiasm for the hands-on practice and application wanes over time. Another concern and source of frustration to planners is that the GIS software they were introduced to has expiry dates and they have not been able to renew the license due to high costs. In some of the districts visited, the logistical supplies in the form of computers, printers and databases which were procured for the District Environmental Resource Information System (DERIS) have been diverted and converted into administrative support tools. The only direct user-support that CERSGIS offers is through telephone, e-mails and occasional visits to the pilot districts to demonstrate the utility of the software to stakeholders about how the DERIS database for the districts could be created and managed.

Apart from the institutional issues, cost of data acquisition and training has been a determining factor of the successs of EIS implementation. CERSGIS provides training and data to their clients on a cost-recovery basis. A significant proportion (27%) of cost-recovery is aimed at covering production costs, 20% covers maintenance and 20% accounts for salaries of workers (Figure 5.7). However, district planning officers selected to undergo EIS training at CERSGIS do not pay for the initial data provided as part of the programme. Since the donor funds cover limited areas and a relatively short time span, planning officers are required to pay for subsequent data they need for their tasks after the project completion. Funds earmarked for the entire Capacity 21 project are derived from two main sources as follows;

Figure 5.7 CERSGIS: Reasons for Cost-recovery



Source: Field Survey, 2005-2006

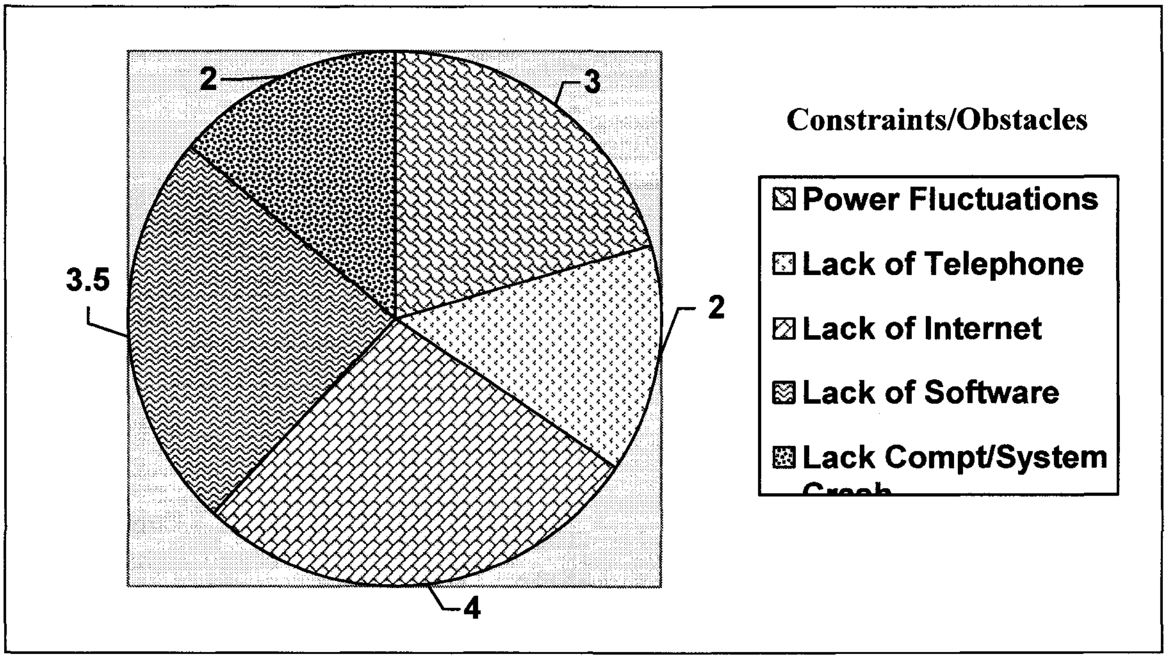
(1) US $800 000 from the UNDP Capacity 21 Trust Fund, referred to as the "Main Programme" component of the budget,
(2) US $500 000 from UNDP (Ghana) Resources often referred to as "cost-sharing" component of the budget.

Lack of an accountant for the programme initially slowed down the process of financial allocation and this affected the way the District Assembly handled their finances. Another problem is lack of continuity and sustainability of funding for the Capacity 21 project at the district level. Although the district identifies the ideals of the Capacity 21 programme, it is yet to be translated into concrete action by the allocation of budgetary resources for environmental activities. Even though the deputy chief development officer reported that the District Assembly had decided to make budgetary provisions to deal with soil erosion, as well as had accepted a proposal on a tree-planting project presented by the natural resource management project, no real action had taken place on the ground. The deputy chief development officer indicated that the District Assembly was constrained by funds (Saaka, 2001).

5.7 Obstacles to EIS Implementation (Capacity 21)

Several infrastructural and institutional issues hamper the effectiveness and continuity of EIS application at the district level. These constraints were ranked in order of seriousness, beginning with 1-least serious to 5-most serious. Lack of internet access was ranked 4 by district planning officers associated with the Capacity 21 project as the most serious constraint to EIS application (Figure 5.8). Frequent system crashes and lack of telephone were ranked 2 which is one of the least of the constraints. The upsurge of cellular phone technology and market has improved mobile communications in the whole country. On the other hand, a district planner asserts, "Whenever the system crashes they have to send the computers to CERSGIS in Accra to fix the problem". This causes all computer-based activities to grind to a halt. Sometimes planning officers are compelled to send it to the nearest city for repairs. Coping measures that planners adopt during such situations include acquisition of basic information like district boundaries and vegetable distribution from EPA and other government departments.

Figure 5.8 Capacity 21: Distribution of Mean Rankings of the Constraints of EIS Application



Source: Field Survey, 2005-2006

The second problem that planners face is the limited software licensing. Planners assert that GIS software is usually procured for training sessions during the implementation of the District Environmental Resource Management Information System (DERMIS) and lasts for a few months after the training is completed. However, once the license expires, the onus lies on the district to renew the license or acquire new software. Unfortunately, the district is not able to purchase software due to the high cost and budgetary constraints. Focal persons lament that apart from the software problems, computers are not readily available for their use by the focal persons. At the beginning of the DERMIS project, two computers were provided for each of the Capacity 21 pilot districts. In 2000, it came to the notice of the National Programme Coordinator of

Capacity 21 that many focal persons of the Capacity 21 Programme in the districts did not have access to the computers. This makes it difficult for the focal persons to practice the lessons that they obtained from CERSGIS. Hence, the coordinator requested that one of the two Capacity 21 computers in each pilot district be allocated for the exclusive use of the focal persons.

Capacity 21 respondents reiterated that intermittent power outages in the districts affect continuous access and retrieval of vital environmental information. "Everyday, the lights goes off between 2-4 hours or a minimum of 45 minutes", a district planning officer explained. Planning officers observe that the Akosombo dam is the main source of electricity production in Ghana and peak power demands in the face of lower water levels in the reservoir have necessitated frequent and unreliable power rationing, current fluctuations and unexpected outage. This tends to damage sensitive computer workstations and peripheral systems. An alternative means of electricity production that they depend on is a generator, but the capacities of some of the generators are too small and cannot power the entire block. In addition, internet infrastructure is not well laid out in the districts. Cost of access to the internet is very high and this is normally beyond the reach of many people. "It is difficult to obtain information especially when the information is not collected collaboratively", an official explained.

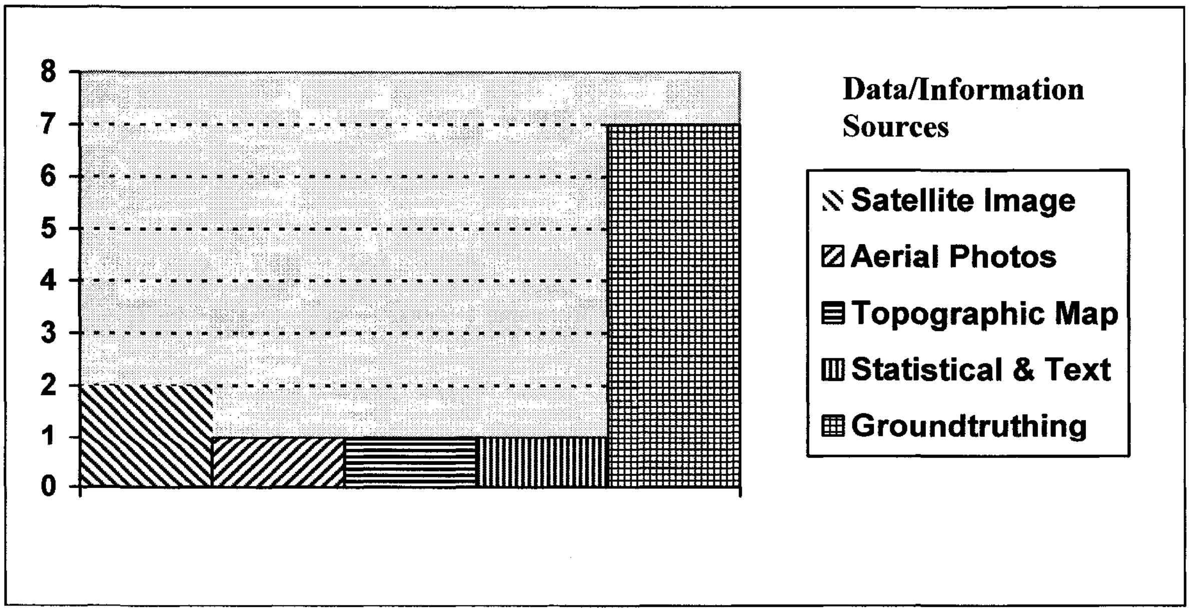
Another problem identified in the Capacity 21 project is the divergence between policy initiatives at the districts and the needs, aspirations and expectations of the communities. A resource manager indicated that, initially, the Capacity 21 project was planned as a network of EIS application in resource management among all the districts but that did not come through. Everything is district-specific except the occasional attendance at workshops which bring other districts together. Eighty-five percent of the district development planners were of the opinion that sometimes they are not involved in the planning of the project. "People at the ministries think that those at the district level do not know anything, so they underrate us", a district planner at Assin fosu noted. On the contrary, the coordinators of the Capacity 21 project note that the management committees meet to decide with the community members. Hence, there is a gap in information flow between the project planners and the communities.

Other related problems experienced are frequent transfer of persons trained by the client organization (CERSGIS). This accounts for the lack of continuity of projects and transfer of knowledge acquired by trainees to new office holders. Another difficulty encountered in the implementation of the PLEC project is the lack of continuity of administrative structure, management procedures and district personnel assigned for the implementation of the PLEC project. "The changeover of personnel at the district assembly office brought the project to a standstill", a farmer at Tuakwa remarked. Interviews with the district planning officers revealed that the change of personnel occurs during a new political dispensation where the ruling party places favourite party officials in key positions at the district assemblies. In some cases, there is complete reshuffling, personnel transfer and consequent overhaul of on-going projects which are viewed as initiatives of a previous government. Farmers and key community leaders at Abura Asebu Kwamankese district noted that if the project had continued, they would have accomplished a lot of things in the area of resource management. A district planning officer commented that the effect of personnel transfer and reshuffling is that vital environmental data and information acquired and stored on district computers as part of the District Environmental Resource Information System (DERIS) cannot be retrieved by new personnel as there are no proper orientation programmes during the transition period for the new personnel who officially succeed the old employees. In some cases, new personnel are totally oblivious of the existence of the vital environmental database which is useful for management of district natural resources.

5.8 Data and Information Application in the PLEC Project

PLEC scientists also combine regional data with ground truthing and secondary sources of information to reveal earlier records of the state of the forest in the country. The field survey revealed that ground truthing and transect walks are the major means of ecological knowledge collection and accumulation under the PLEC project and make up 61% of all data sources (Figure 5.9).

Figure 5.9 PLEC Data and Information Sources

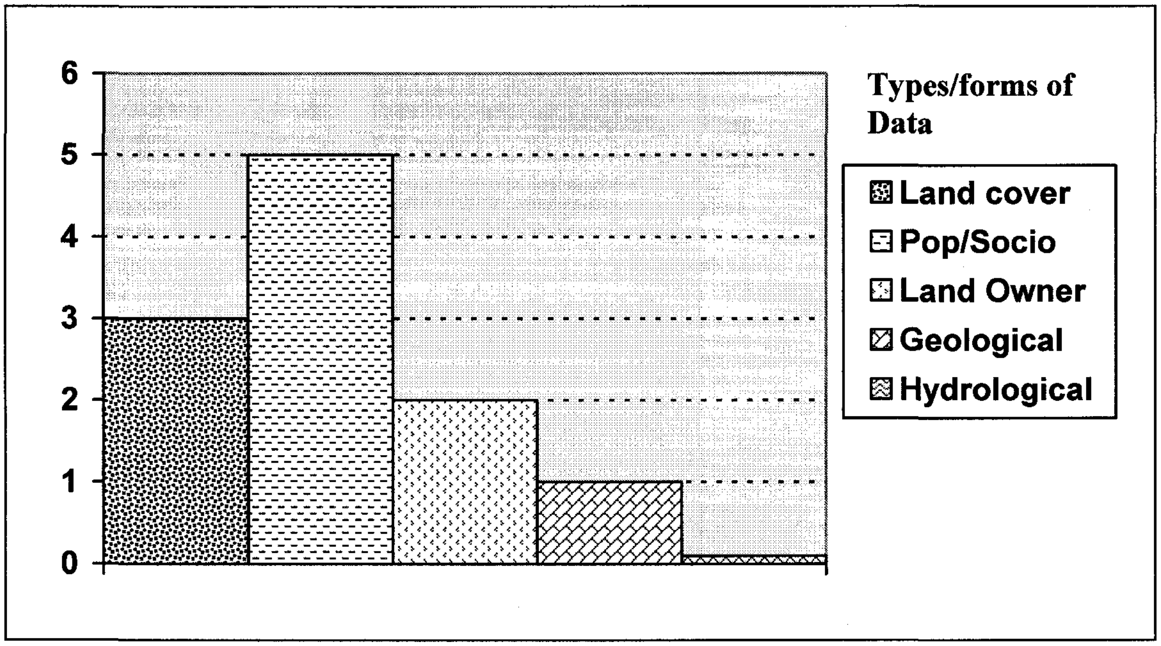


Source: Field Survey, 2005-2006

During transect walks, farmers look out for vegetation, native species and soil variations as they move along the field. This method provides an in-depth first hand technique of agro-ecological assessment based on experiential knowledge and encounter with the environment. The technique is inclusive as it encourages active participation of a majority of illiterate farmers. Apart from ground truthing, satellite images were used in earlier feasibility studies to capture changes in the landscape. It is the second highest means of data collection accounting for 15% of all sources of data under the PLEC project. Evidence of changes in cocoa and timber production systems in Suhum Amanase occurred as a result of extensive agricultural slush and burn method of production. According to PLEC scientists, satellite images demonstrate that only forest reserve areas are intact, as a number of places have been encroached upon by logging and agricultural activities. In the case of PLEC, socio-economic data constitute the major type of data and information used, accounting for 45% of the total sources of data (Figure 5.10).

This is mainly because the PLEC scientists are interested in how population dynamics influence land tenure practices and ecology of farms. Such information is critical to analyzing the interplay between population pressure, land tenure practices and agro-ecological conditions especially in the Sekesua Onsonson area of the Manya Krobo District. Population pressure has led to continuous division of land into smaller parcels which are constantly being divided up and shared among family members and their children. The result is that fallow periods have been reduced drastically to about a year or two, and in some cases the land never rests. Continuous year-round cropping exerts extreme pressure on soil fertility in the region and aggravates land degradation. Hence,

Figure 5.10 PLEC Types/Forms of Data and Information Used



Source: Field Survey, 2005-2006

land cover and land use change account for 27% and are integral source of data and information used by the PLEC scientists (Figure 5.10). Land/cover and land ownership account for 18% of all sources of information used for resource management. Some of the PLEC scientists used soil information on a very small scale through quadrant analysis. Global Positioning Systems (GPS) have also been used for mapping settlements and land use boundaries. The PLEC coordinator explained that with assistance from local people who provided information on sacred groves, community woodlots and grazing fields, mapping was conducted. The locations determined by GPS were plotted on map extracts from Ghana Survey Department (GSD) topographical sheets. Data producers attached to the PLEC project observed that an important output of the mapping exercises was the identification of settlements not located on the official topographical maps. GPS and transect walks were used for collecting environmental information. The main problem with GPS is how to adjust the equipment to fit into forested areas. In Sekesua Onsonson and surrounding villages, Huza strip orientations, unlike the cultivated plots, were identified on aerial photographs. The Sekesua aerial photographs indicated a restriction of the limited dense bush or forest to narrow valleys, steep slopes and other localities of difficult access. Interaction with young people provided much insight into how environmental problems are being conceptualized at present and what types of environmental knowledge are being transmitted from generation to generation in relation to changing conditions. According to PLEC scientists aerial photographs and maps have helped PLEC scientists to build a picture of environmental change in the Manya Krobo District.

Interviews with the PLEC EIS service providers revealed that there is no specific PLEC online digital information system. Only published materials and articles are available. Some of the PLEC scientists indicate that their knowledge about environmental problems has increased, especially in the areas of fire outbreaks and control measures. Most of the PLEC farmers obtain information from PLEC scientists and expert farmers who have been trained by the coordinators in Accra who pay regular visits to the demonstration sites. Also, farmers tend to depend on their expert colleagues who have been trained in aspects of EIS use outside their knowledge pool or base. They have found information useful in enhancing their understanding of environmental problems and are able to practice the lessons they have learned from expert farmers and demonstration activities. On a scale of 1-5, the resource managers associated with the PLEC project rated the relevance of the information they obtain as very useful (rate 4).

PLEC scientists note that most resource inventories, soil capacity assessments and data on changing land use and tenure practices at Sekesua Onsonson, Amanase Whanabenya and surrounding villages are accomplished through transect walks, social surveys and analysis of field demonstration activities done on the farms in remote communities. The team is usually assisted by expert farmers and does not use sophisticated computer-based applications at that level. The expert farmers lead in the teaching of environmental knowledge and help to bridge the communication gap between scientists and local people. Satellite images are not accessible to farmers from a technical and financial point of view. Hence, such methods tend to be unsustainable because once the project is completed, farmers cannot afford to purchase these equipment for their personal use. In addition, effective application of these systems (satellite images and GPS) requires the presence of other computer accessories and technical infrastructure which are not available in most of these rural communities.

5.9 PLEC Training and Skill Development and the Associated Costs

Interviews with the PLEC coordinator and resource managers revealed that GIS-based applications were done by personnel of CERSGIS, in support of the PLEC project. This aspect of information systems was predominant during the earlier feasibility studies or preliminary phase of the PLEC project. Unlike, the TBI and Capacity 21 projects which offer computer-based training to service providers at the district levels, the PLEC project laid much emphasis on farm-based demonstration activities, especially among expert farmers, lay farmers, PLEC scientists and resource managers. PLEC scientists stressed that training and skill development programmes were done every six months or once a year. Each training session takes about 1-3 days or one week especially in the case of the Miniset method for cuttings at Kade. The training programmes were provided by Conservation International (non-governmental Organization affiliated with PLEC) and PLEC produced training modules for Conservation International. The training programmes which are usually based on farm illustration activities aims at maintaining trees to prevent tree fragmentation and enhance continuous forestry. "Also, people from other areas are opened to demonstration activities. We provide manuals but the manuals are interpreted by the experts. Farmers are not able to use the manuals", a technician noted. As one farmer observes, "The manuals do not work because some of the farmers cannot read or write". In view of this, PLEC scientists depend extensively on videos and public address systems in their demonstration activities. Some of the resource managers indicate that when they use the data and information on their own, they have difficulty, but always seek explanation from service providers. The PLEC resource managers explained that they attend training and demonstration programmes on budding, grafting, methods of nursing and preparation of healthy seedlings. Mini-set technology is used to divide yam and other crops into 10-15 grams (small bits and pieces). The Micro-set technology is used to divide tubers into 5-10 grams. The cuttings are dipped in solutions and air-dried. This technique is used for multiple and rapid sprouting of crops and this enhances propagation. In the case of yam, it is possible to obtain about 50-60 pieces of new yam buds depending on the size. The split comb technique has also been used for budding and grafting of citrus, mangoes, avocadoes and other plants. Other lessons farmers obtained, apart from budding are on nursing and preparation of healthy seedlings. Farmers assert that the skills acquired through the training programmes have helped them to improve vegetable seeds, increased yields and enhance the quality of fruits which are resistant to pests and diseases.

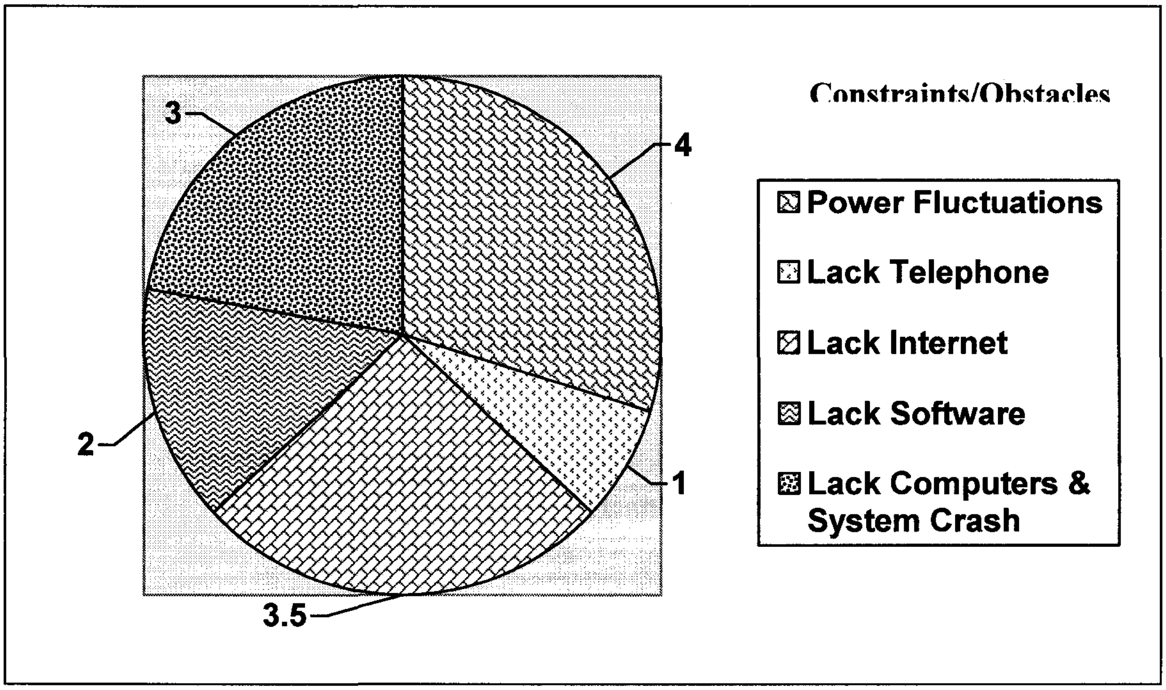
Scientists associated with the PLEC project practice an open access regime. The cost of training and provision of training manuals are all incorporated into the cost of the project. PLEC believes that farmers are poor and are unable to purchase some of the data and information provided by Conservation International. Hence, reasons provided for the need to charge for data and information in both the TBI and Capacity 21 projects are not applicable to the PLEC project.

5.10 PLEC Challenges to Agroforestry Management

Under the PLEC project power fluctuations account for the highest of the problem faced by national coordinators of the project (Figure 5.11). This is due to the factor that coordinators of the PLEC programme are in charge of the daily administrative work and management of databases on the PLEC project. However, this problem does not pose a serious threat to field demonstration activities carried out by scientists and expert farmers. Second, lack of internet and computer crashes were cited as another major problem that confronts coordinators of the PLEC project in Ghana. Again, this problem has no direct effect on the activities of farmers.

However, most PLEC farmers complained about lack of financial support and loans to expand the facilities for storing grains and other crops during bumper harvests. In addition, they do not have the necessary facilities and technologies for processing grains and fruits after harvest. Another problem is lack of effective transportation systems to convey their produce to the market in the cities. These problems are akin to the situation

Figure 5.11 PLEC: Distribution of Mean Rankings of the Constraints and Obstacles to EIS Application



Source: Field Survey 2005-2006.

faced by other farmers associated with the TBI and Capacity 21 projects. This often results in pests, rotten food products and post-harvest loss. Coping strategies adopted by PLEC farmers to overcome poverty and inadequate financial and resource support involve collaboration and networking. Farmers support themselves in obtaining resources and exchanging information such as good seeds, seedlings (for new planting seasons) and best approaches for dealing with the menace of insect pests and diseases.

5.11 Comparative Analysis of Information Sources, Approaches and Issues of EIS Impelementation

The extent of EIS application in natural resource management in Ghana depends on the objectives of the project its location and problems, as well as the needs of the communities involved. Comparative Analysis of EIS Application in the TBI, Capacity 21 and PLEC projects depicts parallels and divergences at various jurisdiction and project levels. More sophisticated sources of information systems (e.g. satellite images) were used in the TBI and Capacity 21 projects predominantly at the district and institutional levels (data providers). In addition, unlike, the TBI and PLEC projects, which are independent of government management and influence, the Capacity 21 project was integrated into the District Assembly Programme. Hence, EIS application under the Capacity 21 project is done mainly at the district level with support from CERSGIS and district planning officers. The DERIS project was used for general district planning purposes which include water sanitation, agriculture and forestry.

The TBI project coordinators at Fomesua, Kumasi relied on forest managers and EIS experts from the Forest Services Commission who were tasked with the provision of tailor-made data and information for natural resource management. In the case of the PLEC project, computer-based systems were used mainly during the initial feasibility studies and exploratory activities prior to project implementation. In the course of project implementation, there was minimal and remote support offered by individual GIS technicians from CERSGIS, Legon. On the whole, groundtruthing and farmer-based knowledge systems were the predominant sources of data and information used during the PLEC project.

In terms of costs of capacity building programmes, service providers attached to the TBI (Forest Services Commission) and Capacity 21 (CERSGIS) practiced cost-recovery. Table 5.1 provides a breakdown (percentages) of the reasons that respondents (FSC and CERSGIS) cited for practicing cost-recovery. In contrast, the PLEC project endorsed on open access regime. This is because the approach was more farmer-based, cost-effective and did not require high technical skills and the procurement of sophisticated GIS. Also, it is important to state that some of the donor funds associated with such environmental projects are long-term, while others are short-term and their sustainability depends on the continuity of the funding.

Table 5.1: Service Providers Reasons for Cost-recovery and Training Charges

Reasons for Type of Financial Regime	RMSC TBI Percentage	CERSGIS (Capacity 21) Percentage	SCIENTISTS (PLEC) (Open Access)
Marketing	4.4	6.7	NA
Production cost	26	26.7	NA
CD-ROMs	8.7	13.3	NA
Maintenance cost	26	20	NA
Salaries of workers	30.4	20	NA
Postage	4.4	13.3	NA
Total	100	100	NA

Source: Field Survey, 2005-2006
NA = Not applicable due to open access financial regime

The survey also revealed the nature of contextual problems (infrastructure, logistical, policies etc.) which adversely affect EIS implementation. Power outage is a common problem in Ghana. The impact of erratic electricity supply is pronounced on the TBI, Capacity 21 and PLEC projects due to the reliance on computer-based information systems, especially at the national and district levels (Sekyere West, Assin Fosu, Kumasi and Goaso). Futher probing into the rationale behind the power rationing revealed that water levels in the Akosombo Dam reservoir (main source of hydroelectric power production) have been decreasing constantly as a result of low rainfall and drought. Table 5.1 provides a comparative summary of the mean rankings of the obstacles and constraints to EIS implementation among the three projects.

Another problem is whether the existing environmental information systems designed by experts are compatible with users' needs, skills and tasks. There are concerns about whether or not EIS application in biodiversity conservation and agro-forestry management are ecologically and socially appropriate for the intended community user groups. Environmental initiatives such as UNDP/Ghana Capacity 21, PLEC and TBI in Southern Ghana, as with many other environmental initiatives, are currently predominantly, if not exclusively donor-driven and the inherent cost determines who gets what (data/information) how and why. Hence, this study explored other coping mechanisms and LKS that communities rely on for sustainable management of the environment.

5.12 Role of Indigenous Knowledge in Agroforestry Management

The field survey also explored the social contexts of EIS and LKS application. Some of the issues investigated during the focus group discussions hinge on participation, information exchange, community initiatives, actual conservations practices and the outcomes of resource management approaches as outlined in the conceptual framework (Figure 3.2). At the community level, types of information and knowledge based systems used are not sophisticated computer-based systems. The local knowledge of natural resource management that is held collectively by the local population is culturally relevant, informed by people's social-cultural traditions and structures how they explain the world and view events. These community-based information systems are based on experiential knowledge of farmers; tacit, informal rules and practices that have been handed down from generation to generation. This is a vital part of groundtruthing information which is supplementary to computer-based information systems. Indigenous knowledge systems are relevant to EIS application in local communities because they promote locally-based initiatives in the actual management and conservation of natural resources. Satellite images help to uncover environmental problems, assess the nature of environmental problems and monitor environmental trends spatially and temporally. By detecting environmental problems, satellite images, aerial photos and GPS serve as vital decision support tools for informed environmental management. However, computer-based systems do not necessarily rectify practical environmental problems on the ground in Ghana. Locally-based knowledge systems, either captured in GIS or demonstrated by indigenous people, have been useful in promoting and sustaining people-centered conservation activities on the the ground. This is seen as a vital extension of information systems applications in Ghana. Integration of LKS into EIS is relevant in communities which have few or no computers, technical skills or scientific expertise.

Environmental management by farmers and other land users involves a wide range of decisions and activities which influence management of tree and crop genetic diversity, the variation in abiotic and biotic environments and other interactions in many different ways and at different levels of the district where land degradation is predominant. Through generations of innovations and experiments, smallholder farmers have applied LKS to nurture a great diversity of plants and animals, both wild and domesticated and accumulated a rich knowledge of their local biodiversity. They influence crop diversity by deciding on the crops and plants to cultivate and the crop sequences to follow. Hence, there are many variable and dynamic ways whereby farmers use natural diversities of the environment for production, including their choice of crops and animals. Farmers' management decisions are always taken in an agro-ecological and a socio-economic context. The processes of learning, experimenting and innovation continue throughout southern Ghana. Cultural adaptations to the varied biophysical environments are obtained from traditional farmer's intimate understanding of the agro-ecological environments as a delicately structured ecosystem whose survivability depends upon minimal disturbance. Such time-tested indigenous land management systems include rotational agro-forestry, intensive kitchen and home gardens and compound farming, which are inherently self-regenerative and protective of soils and biological diversity.

EIS is best used by district level management staff and planning officers in understanding environmental problems, sometimes at the macro-level. EIS has therefore been relevant in assisting district planning officers to direct communities to undertake tree-planting excercises and other farm management procedures. At the community or farm level, agroforestry practices usually begin with an intention to develop a more sustainable form of land-use that can improve farm productivity and the welfare of rural farmers as a whole. In Ghana, trees have been used in farming systems unconsciously for maintaining soil productivity and have favourable effects on crops. Trees also have the potential of mitigating deforestation and soil nutrient depletion and thus help to alleviate rural poverty. The promise of nitrogen fixing trees for improving soil fertility in cropland

and pasture are important. In some cases, increasing demand for fuelwood, fodder and timber have greatly affected the practice of leaving trees on farms.

The following section illustrates some of the environmental initiatives in Ghana which use different knowledge systems for agroforestry management.

5.13 TBI Agroforestry Management Initiatives

Residents of Gyaman Krom (Ashanti Region) indicate that TBI uses posters to show how to plant trees and rear snails and grasscutters, which are alternative livelihood activities which are encouraged to ease pressure on forest resources for economic trees and other food resources. Various approaches are used to encourage farmers to engage in agro-forestry practices. TBI educated farmers on the importance of trees. Farmers who participated in the focus group discussion were made to understand that the trees belong to them and trees help the land and prevent bush fire and erosion. Before the introduction of the TBI project, local activities of farms caused bushfire (especially hunters and palm wine tappers). Farmers have realized that such activities destroy the land. In some cases, farmers forget to put out the fire. There are cases where fire has burned villages and bushes. Currently, activities of volunteer fire squads have helped to ensure that people do not set fire indiscriminately. Most farmers are encouraged to undertake agro-forestry management.

Agro-forestry practices under the Tropenbos project involved mixed cropping--tree planting interspersed with crop farming at the Goaso and Offinso districts (Questions 7 and 8 of Appendix C). As part of the Tropenbos programme, a series of workshops and courses were held at Kwadwo Ahenekrom, Nyankomago, Biaso (Goaso district) and

Konkon, Amoanim, Sarfo Krom (Offinso district). Farmers were taught lining, pegging, pruning and tree planting (depth of hole for planting). Eighty-five percent of the farmers indicated that they have learned how to plant cocoa, palm and maize in order to obtain higher yields: "Before the course, we used to plant trees anyhow but because of the workshops, we have changed the way we do things". However, respondents from Kowdwo Ahenekrom noted that pegging is hard to do and farmers cooperate and assist each other to use the technique effectively. A cross section of the farmers asked Tropenbos for seeds of wawa, and odum so that they can use them as boundary markers for their farms.

Economic trees such as odum *(Milicia excelsa)*, cocoa *(Theobroma cacao),* cashew *(Anacardium occidentale),* oil palm *(Elaeis guineensis)*, mahogany *(Kaya* spp*),* acacia *(Acacia nilotica)* and wawa *(Triplochiton scleroxylon)* are preferred because of the high export market returns, and fruit trees such as banana *(Musa* spp*),* pawpaw *(Carica papaya),* and coconut *(Cocos nucifera)* are grown on a subsistence basis, usually to supplement daily food intake. Apart from the domestic and economic value attached to trees, farmers cite other ecological reasons for why they prefer certain types of trees on the farm. They cite benefits such as increased foreign exchange earning and use of trees for roofing. Other benefits cited by farmers include use of wood for furniture, construction, and moisture retention in soils. "We have trees on the land to provide shade and moisture", a local farmer noted. Mahogany is not only used as timber for furniture but also used for stomach, fever, jaundice and boil treatment. Residents of Biaso observed that forest enhances rainfall and clean air. Some of the farmers elaborated that they take care of the woods so that they will be there for future generations. TBI assists farmers to obtain seedlings and this has made it easy to practice agro-forestry. "Before TBI, we were doing our own tree-planting, and so we used to buy our own seedlings. But with the inception of TBI activities we've received 10,000 seedlings free of charge", a farmer observed.

The people of Konko where the TBI project is being implemented have experimented with Emire *(Terminalia Ivorensis)*, Ofram *(Terminalia superba),* palm *(Elaeis guineensis),* cashew (*Anachadium occidentale*) and Acacia (*Acacia nilotica*) (Table 5.3). These types of trees are commonly preferred because of their utility for furniture, construction, high tension poles and medicine. However, a survey of the Gyaman Krom revealed that not all the community members are involved in the tree planting exercises due to a lack of land to plant trees or seedlings. "We told TBI people that we need seedlings and they asked us to inform the agriculture extension officers at Goaso" an informant noted. At Amoanim demos were used to illustrate the relevance of trees and the local people were taught not to farm close to rivers. Posters are used profusely and they are worth more than thousands of written articles as they appeal well to illiterate farmers (Appendixes A- D). "The demos were easy for us to understand and the posters were so clear", a resident explained. The posters are tailor-made information sheets which demonstrate the collaborative nature of forest management. They also illustrate how deforestation and charcoal burning cause soil erosion and techniques for addressing these problems (Appendix C). Through posters and on-site demonstrations, farmers were exposed to alternative livelihood activities such as beekeeping, snail rearing and mushroom growing as a means of diversifying their local income-generating activities. This helps to ease undue pressure on agricultural lands and forest resources.

Residents of Nyankomago cite lack of land and capital as major factors hindering agro-forestry practices. "When you plant trees, you need to weed around them for 2 or 13 times and without weeding, they will not grow".

Also, the posters helped to draw comparisons and illustrate the benefits of using trees on the land and the problems associated with deforested lands. The pictures and posters are self-explanatory and were interpreted easily. This pictorial comparison enhanced understanding of the benefits of planting trees on the land. Only a few farmers at Konkon argued that though they were given posters, they were not taught how to plant trees. At the time of the field interview it was discovered that the TBI activities had just started in some of the communities. Other farmers expressed misgivings about the implementation strategy. "After the TBI brought the seedlings, they never appeared here again for us to give them feedback", a farmer asserts.

The people at Amoanim noted that they have never met together or shared information. Also, "The TBI has just started and we don't really understand in detail what it is about it", a farmer observed. "Apart from the demo/posters, we have not had any training" a chief linguist explained. An initiative that the people of Nkwakwaa adopted is that they organized themselves into Tree a Growers Association where they engaged in tree planting exercises only. "I know that the training helps a lot and also the project is beneficial so I try mobilizing or bringing others to the meetings". Group farmers developed their own model for forage planting, depending on their current land use conditions. Secondly, some of them developed demonstration plots on their farms so that they could gain experience and show others the best way to manage their farms.

5.14 TBI: Constaints on Agro-forestry Management

A major challenge with the implementation of the TBI project is that it offers training but does not provide input for implementing the training. The field survey revealed that there is no in-built mechanism for supplying logistics to farmers. The main challenge is how to obtain a regular and reliable supply of materials, tools and logistical support for agroforestry management. Lack of seedlings and logistics is another constraint to the adoption of agro-forestry in the study area. "It is frustrating, no help from anywhere" a local farmer lamented.

In the past, the Forestry Services Division (FSD) provided farmers with free seedlings for planting but that assistance has ceased. It was only recently that TBI supplied farmers with 10,000 seedlings but they have not shared them yet. Another farmer was given 300 seedlings and he has already planted all of them since June, 2003. Unlike the Capacity 21 project where tools where made available to farmers to enhance communal agro-forestry practices, such provisions and logistical support were lacking in the TBI project. "We need inputs such as cutlasses, raincoats, Wellington boots, mattocks, bicycles, wheelbarrows and watering cans", a farmer at Kwadwo Ahenekrom observed. In a bid to overcome this challenge, farmers at Kwadwo Ahenekro turn to ADRA for assistance. ADRA usually helps farmers with tools, seedlings of cashew (cash crop), and fertilizer and the farmers planted these close to their homes to provide fresh shade for themselves. According to farmers, the trees check soil erosion, serve as wind break, help to prevent fire and reduce poverty.

A cross-section of the farmers note that they occassionally receive logistical support from the Adventist Development and Relief Agency (ADRA). The Tropenbos farmers expressed dissatifaction about the timing of the seedling supplies by ADRA. "ADRA comes at the wrong time, especially when planting season is over" a farmer remarked. An interaction with the National Coordinator of the TBI project in Accra revealed that the modus operandi of the TBI project is basically research. Hence, management of the project usually directs farmers to banks so they would obtain financial assistance in order to purchase the needed materials and resources. However, the difficulties most of the farmers face in obtaining loans from the financial institutions is a lack of collateral security and high interest rates (35%) associated with payment of loans obtained from the banks. Another issue is the irregularity and ad-hoc nature of follow-up visits from the team of TBI personnel. Farmers who participated in the focus group discussion at Adwenso argue that there is need for constant visits from TBI officers. TBI farmers cite the lack of continuity of the workshops and training programmes as a problem that hampers effectiveness of EIS and LKS application in natural resource management. Farmers desired that the TBI project continue in order to assist them materially and financially.

Another challenge to LKS application is that not everybody has land. This is typical of Nkwankwaa and other villages. Ironically, "Some people are interested in the project but do not have land and some have the land but do not have money to start", a farmer observed. A private developer stressed that he has tried to expand his agroforestry practices with 32 acres of cederella and teak and other tree species but financial problems will not allow him to expand. In order to overcome this obstacle, some farmers have entered into convenient contractual agreements with landlords to obtain land for farming. At Nkwankwaa, there is a practice called "Do ma yen kye" This arrangement between a farmer and a landlord permits the farmer to cultivate a parcel of land, and then share the harvests or proceeds with the land owner.

The issues of soil degradation differ from one locality to another. Hence, the soil management approaches tend to differ from one project to another. Some of the farmers observed that prior to the inception of the TBI project, they used to have problems with bush fires and soil erosion. Before the project, there was serious erosion" a farmer reiterated. The people at Nyankomago explained that they have soil problems. "When it rains, the surface run-off causes cocoa to be uprooted". Torrential rains spoil the land and cause rich loamy soils to be washed away. These soils are conducive for plant growth in the area. Initially, the farmers did not know how to solve this problem. Some of the farmers observed, "They started to participate in the programs, these problems have reduced and the condition has improved considerably". According to the farmers who participated in the focus group discussions, the TBI training sessions provide them with vital skills and techniques for addressing the problem erosion.

5.15 Capacity 21 Agroforestry Management and Soil Conservation Practices

The need for agroforestry management under the Capacity 21 project is critical in the Nkwanta, Adidwan, Bomi (Sekyere West), Tuakwa, Asebu and Abura Dunkwa (Assin Fosu) communities due to increasing chain saw operations and activities of charcoal producers who have depleted sources of wood and yound seedlings. In some of the communities, ADRA provided seedlings (about 400) which were planted to serve as wind breaks. Resource managers of Capacity 21 rely heavily on maps obtained from the districts, and ADRA promotes tree planting exercises. These initiatives have increased the interest of community members in agro-forestry management. Hence, they established tree nurseries of about 60,000 seedlings for transplanting at Tuakwa and other communities. Farmers undertake pegging and row planting of seedlings. They also apply a technique that straightens up the seedlings and prevents them from leaning sideways.

When capacity 21 farmers were asked to describe how they use local information for resource management (Question 7 of Appendix G), they explained that they have successfully established tree nurseries at villages like Tuakwa and Modmodua which has encouraged tree planting among nearby communities. For instance, a Capacity 21 tree planting sensitization programme at Amoamang in the Sekyere West district led to the formation of an Agro-forestry Association in 2000 as an institution for environmental preservation. With assistance from the Sekyere West District Assembly, the association acquired 300 acres of land for tree planting. By 2001, 10 acres of land were planted with acacia *(Acacia nilotica)* tree seedlings, inter-cropped with beans *(Phaseolus lanatus),* groundnuts *(Arachis hypogaea)* and yams *(Dioscorea* spp*).* Respondents observed that the Agro-forestry Association is financially handicapped in terms of acquisition of tree seedlings, groundnut seeds, land preparation and weeding. "We don't have money to buy a tractor for large scale planting" a farmer lamented. Also, farmers intercropped trees such as cashew and mango with maize, tomatoes, pepper, akro, plantain, yams, and groundnut. Most of these crops are used as household food sources. Although trees have been planted alongside farm crops, the majority of the trees that farmers planted in 2002 were Acacia and Teak which were intercropped with cassava, *(Manihot esculenta)* and maize *(Zea mays).* It has been discovered that crops like cassava when grown close to teak tend to be bitter and poisonous. Farmers explained that cassava usually absorbs some water from the roots of the teak and thus becomes very bitter and poisonous for consumption. This is true for all other root tuber crops which are planted close to teak. When farmers were asked to recount how they verify this problem, a farmer notes, "People have complained of various ailments such as diarrhea, dizziness, and drowsiness after eating cassava planted close to teak". This is not unique to Capacity 21 farmers as similar observations were made by PLEC farmers during the focus group discussion.

Other trees preferred by farmers in agroforestry practices are citrus, palm, coconut and mango because of their economic value. Further, a large tract of land of more than 30 acres was given to the Association by the Odikro of Amoamang for expansion of Agro-forestry activities. A resource manager indicates that row-planting is good but it is difficult to get an extension officer to peg the trees. Inadequate staffing (extension officers) and lack of tractors for large scale tree planting are major problems hindering agro-forestry practices under this project. At Abura Asebu Kwamankese district, Junior Secondary Schools (JSS) and Primary schools were provided with seedlings and participated in the tree planting exercises especially in areas that have been affected by illegal small-scale mining operations ('galamsey'). Farmers cite environmental preservation, stream protection, erosion avoidance, drought prevention, fuel wood production and storm breaks as some of the reasons for engaging in Agro-forestry practices.

In addition, the Capacity 21 field training programmes have helped farmers to change their attitudes and behaviour toward management of trees. Farmers avoided indiscriminate logging of trees and stopped bush burning as a hunting technique for trapping grasscutters. Some respondents joined fire volunteer squads to learn the techniques of bush fire protection. Women tend to acquire and keep knowledge about which trees are conducive for firewood, medicine and fruits. There are various selected species which are used for treatment of diseases. The focus group discussion revealed gender differences in knowledge about the values of trees. Farmers' wives and traditional healers have specialised knowledge about the medicinal value of trees. Also, elderly women tend to have particular knowledge about trees used for treatment of child diseases, and leaves used for making pormade and various skin ointments. Most women farmers preferred certain types of trees like nim *(Azadirachta indica)*, Mahogany *(Kaya spp)* and acacia *(Acacia nilotica)* because of their utility for the treatment of fever, hernia and hypertension respectively. Mahogany is also used as a blood tonic. In a follow-up question to ascertain the efficacy of these trees as medicinal sources, a respondent explained, "After drinking water used to boil the leaves of acacia, you feel the ailment has gone down".

Medicinal cures including roots, leaves, barks, seeds, stem fluid and fruit of trees are used to treat a variety of ailments. Examples of ailments include malaria, bilharzia and venereal diseases. The medicinal knowledge and wisdom about trees are passed on from older women to younger women relatives by informal teachings and observations. Women were more inclined to nurture and protect trees for firewood and fruits. These trees are kept within close proximity to farms and gardens. Most of the farmers have experiential knowledge of the value of trees in surroundings and the environment. Farmers are not only able to identify valuable tree species but they are also aware of trees that are rare and endangered.

Farmers at Tuakwa in the Abura Asebu Kwamankese district assembly displayed some of the tools they received from Capacity 21 during the field tour to the chief's house where they had gathered. Respondents indicated that they use these tools collectively as part of communal self help projects. On the contrary, farmers at Bomi in the Sekyere West District decided not to use the tools because some of the farmers received the tools while others did not due to limited supplies. Farmers got cutlasses and wellington boots and so they decided to keep them to avoid any feeling of resentment towards the project coordinators for showing perceived favouritism in the distribution of the tools. They preferred not to use the tools in order to keep the communal cohesion and spirit of goodwill towards one another. This position taken by farmers is rather unfortunate since they could take turns to use the limited tools.

As part of soil conservation methods, farmers associated with the Capacity 21 project use two main techniques for conserving soil (Question 9 of Appendix C). The first method is creation of channels to direct rain water. The farmers note that diversion ditches or waterways help to reclaim surface runoff away from the gully head. The waterways are designed and laid out to avoid runoff across the entire land surface and prevent subsequent erosion on the farms. In some cases, farmers plant cover crops and trees to stabilize the soil and beds of gully. Establishing vegetation or biomass in the bed of gullies decreases sediment carrying capacity of surface runoff. Capacity 21 farmers also indicated that in extreme cases they use wood terracing to check erosion. Terraces prevent erosion by shortening the long slope into a series of shorter, more level steps.

5.16 Capacity 21 Exchange of Seedlings, Data and Information Sharing

As part of community participation approaches in agro-forestry, Capacity 21 farmers share information and knowledge about seeds and high yielding crops. When farmers were asked to explain how networking and community participation have enhanced LKS application (Questions 14 and 15 of Appendix C), they explained that most of them obtain the best tomato seedlings from their colleagues. However, sustainable agro-forestry has not been practiced at the optimum level because whenever farmers request seedlings from their collegues at the end of harvest season, they usually sell everything they harvest with virtually nothing to plant the next season, and then have to go back to their colleague's seed for the next planting season. Apart from exchanging seeds, farmers share information about good seedlings or rare plants found on their farms.

Farmers have acquired a range of knowledge on tree planting, management and use and this has changed their attitude towards tree planting and utilization, and in most cases they have discarded old and ineffective means of tree management. In addition to this, persons of the Capacity 21 project organize in-service training on the proper way to burn trees for charcoal. These demonstration activities are usually accompanied by posters and pictures which enhance understanding of training sessions. Farmers who participated in the group discussion readily showed us posters. The posters depict the nature of the land prior to disturbance, the type of human activities that cause disturbance, and approaches designed to rectify the problem. Under the Ghana Capacity 21 project, some agencies such as the National Disaster Management Organization (NADMO), the Ghana National Fire Service and ADRA offer training programmes on tree planting and fire prevention techniques (Question 17 of Appendix C). Farmers note that they have learned techniques of creating fire belts to prevent the spread of bush fire onto their farms. Other forms of training and demonstration activities focus on the efficient use of cook stoves. Efficient use of firewood in cookstove is a major means of energy saving in communities where firewood is difficult to come by within proximity of village communities. When farmers were asked if they provide feedback to officers who offer the training, a farmer observed, "Yes, we do give feedback and they do come here to teach us about the methods to use". Some of the people are of the view that no agricultural extension officer comes to help. Farmers note that recently agriculture extension officers brought water pumps for the nursery during a drought. Some of the trainees are given an allowance for payment of accommodation, food and lodging. Sustainable agroforestry management is seen in tree planting, taking good care of trees, avoiding indiscriminate felling of trees for firewood and preventing bush fires caused by hunters, and palm wine tapers.

5.17 Capacity 21: Challenges of LKS Implementation

Although farmers associated with Capacity 21 are better off in terms of logistical supply, they are concerned about the lack of continuity of logistical provisions. Some of the tools that were initially provided between 2000 and 2001 were worn out at the time of group discussion. "We need cutlasses, some of the things they brought us have worn out" a farmer lamented. Also, at least 2-3 farmers were not supplied with tools for agroforestry activities at Bomi in the Sekyere West District.

In Abura-Asebu-Kwamankese ditrict, one woman did not get a cutlass and another man did not get a raincoat. Irregularities of logistical supply sometimes discourage farmers who are willing to take an active part in the project. The seedlings do not arrive early enough for transplanting. When the seedlings finally arrive, it coincides with the dry season which causes most of them to die few months after transplanting. In view of this, key leaders of the farmers have taken the initiative to create their own nurseries.

In addition, Capacity 21 farmers in Tuakwa were apprehensive about the claim by officials of this project that the seedlings they were asked to prepare would be bought by the project officials and used for afforestation activities. "We were also made aware that some people will come and buy the teak but no one came to buy them". Farmers assert that they spend considerable time off their farm to engage in tree planting and use their own money as per diem. "They promised to give us money but they did not honour their promise" a farmer explained. Lack of financial support for farmers which otherwise could have served as reasonable reward or justification for the time they take off their farm work is a disincentive for active participation in the implementation of the environmental resource management component of the Capacity 21 project.

Under the Capacity 21 project, representatives of farmers also attend training programmes which are similar to the PLEC expert farmer training except that PLEC farmers tend to engage in more site demonstration activities. Training and workshops last for 3-5 days. In the Sekyere West district, the training programmes varied from 1 day to 2 weeks. The training programmes have helped farmers' abandon obsolete and unsustainable farming techniques which tend to destroy large space of land and turn prime agricultural lands into unproductive wastelands. However, some farmers observe that the training manuals, leaflets and documentations are English, which is of little use to farmers, the majority of whom can neither read nor write in English. Capacity 21 distributed more than 150 000 copies of illustrations which show picturesque illustrations of the impact of human activities on the natural environment and provide alternative remedies for restoring disturbed areas and enhancing sustainable utilization and management of resources. As a Chinese proverb reveals, a picture is worth hundreds of written articles. The only alternative is where inscriptions on illustrations have been translated into 10 local Ghanaian languages from the convention to combat desertification.

5.18 Role of Agro-forestry in Sustainable Resource Management (PLEC)

The geographical region where agroforestry is practiced under the PLEC includes villages such as Prekumase, Sekesua Onsonson, and Adwenso in the Manya Krobo District and Amanase Whanabenya and Aboabo in the Suhum Kraboa Coaltar distrct. Years of experience in farming practices under different agro-ecological zones have led to acquisition and accummulation of vital agro-ecological knowledge which is transmitted informally through family members (who take up farming from their older parents) by oral tradition, folktales, song and customs. Expert farmers who were interviewed demonstrated in-depth indigenous knowledge of trees and their economic, medicinal as well as ecological importance. Farmers in these regions leave trees that have medicinal values, produce nuts, bear fruits, and are important for livestock fodder. Large trees such as acacia, nim and others are left on the farms as shade trees under which farmers occasionally rest during farm chores.

They noted that trees serve as boundaries of home gardens and properties, for moisture retention, and windbreaks. Other reasons cited by PLEC farmers for keeping trees on their farms include for fuelwood energy, timber for construction, and moderation of water flow. Farmers' experiences and acquisition of agro-ecological knowledge over the years shows that Wawa *(Triplochiton scleroxylon)* is good for timber though it consumes a lot of water. PLEC farmers indicated that Onyina *(Ceiba pentandra)* is associated with small gods, and plantain *(Musa paradisiacal)* grows around them. Also, yam *(Dioscorea spp)* combines well with trees. Farmers cited indigenous fruit trees such as bananas, papayas and pear as very relevant for meeting household food supplies. Fruits are left in the field because they are an important source of food while working on the field.

Mixed cropping is practiced by most PLEC farmers. "Due to limited land, we try to make maximum use of land", a farmer observed. Farmers decide on different types of crops on the same land based on household consumption, food preferences, land and labour availability. They plant leguminous crops like bean *(Phaseolus lanatus)* or vegetables such as tomatoes, and cereal grain crops (maize, sorghum and millet). Once the harvesting of one crop is finished, farmers can depend on the others for sustaining their families. PLEC farmers plant a variety of crops in one place such as maize, cassava, and sometimes pepper (Table 5.3). The farmers note that when there are no trees, they plant vegetables like pepper, maize and onions. Conversely, where there are trees, they plant food crops such as plantain,yams, cocoyams, oranges and pears together on the same farm. Farmers mentioned numerous advantages of mixing trees and crops: more efficient use of the land, especially where land is limited in Krobo; saving labour; enhancing soil fertility. Larger crops provide shade against direct rain drops; serving as security against risks of crop failure which usually occurs in mono-cropping.

When PLEC farmers were asked during the focus group discussion to recount knowledge of any problems of agro-forestry practices (Questions 19, 20 and 22 of Appendix C), they were quick to point out a few problems of planting other tree crops. Owateku *(Cola gigantean)* has huge, broad, thick and leathery leaves which do not decompose easily and tend to be bad for crops. Also, farmers have observed that when cocoyam *(Xanthosoma saggitifolium)* grow close to trees, they look green and healthy but do not bear a lot of tubers (combs). Further away from the crowns' shade in the open, they tend to yield nice combs. However, crops such as cassava do not. Farmers note that cassava that is planted close to acacia tends to be very bitter and people fall sick after eating them. Respondents also note that maize *(Zea mays)* does not combine well with shaded trees such as mango *(Mangefera indica)*. Farmers assert that they plant fruit trees such as pawpaw, pear and mangoes. A majority of farmers favour tree planting but they are very careful about planting more trees because it requires many hectares of land or space and can deprive them of adequate land for food production.

Woodlots have become one of the major breakthroughs for the PLEC project. The availability of adequate electric poles and fuel wood has established goodwill for the project in the eyes of villagers. Women who formerly took five hours to collect one head load of firewood now need only two hours. Women from the farmers' association are organized into groups numbering 4 to 10 and produce seedlings in the association's nurseries. Women respondents associated with the PLEC project take tree and seed presevation seriously. They usually employ two approaches: (1) Ex-situ conservation of seeds by extracting the seeds from fruits of trees and dryin them. After drying them, they put them in a bottle or tie them in a specially made container and hang them in their kitchen ceilings or roof to allow access to air and to prevent insects and rodents from destroying them. (2) Women also practive in-situ conservation of rare-plant species found close to thier home gardens.

Gender division of household and farm work influences the type of activities that women engage in with regard to land management. Whereas weeding and tillage are predominantly undertaken by men, women frequently undertake gathering, planting and harvesting. Women usually sweep plant materials and livestock droppings from the household compound and dump the refuse at their backyard gardens. Home gardens are managed by women because they need certain crops for cooking such as pepper, tomatoes and okro. Farm practices near homesteads of the local people reflect their local and experiential knowledge of the natural environment. All the farmers involved in the focus group discussion noted that they practice planting, mixed-cropping or multiple cropping. Farmers grow major staple and cash crops. Unlike the technique of mono-cropping promoted by extension officers, PLEC (small holder farmers) farmers practice mixed cropping, multiple cropping or intercropping. Biodiversity relies on other crops instead of one crop rotation. Intercropping helps to reduce farm size and maintain biodiversity. Cassava for instance is rotated with beans which allow nitrogen fixation into the soil. Nitrogen-fixing trees reduce surface erosion during heavy rainfall. It also helps to restore soil fertility and improve crop productivity. In some cases, there is intercropping of plants and vegetables. They also developed techniques for wild yam planting and harvesting. "The yam tuber can grow big like the size of a human body" a farmer at Sekesua noted. Some of the PLEC farmers have gone into commercial farming and other livelihood support programmes. Most of the knowledge and skill development programmes are from suggestions offered to the farmers.

In home gardens, refuse is used for maintaining fertility of the soil. Home gardens are an important way of securing, storing and caring for food species. In-situ conservation of farmlands protects trees of rare species. A number of home gardens seem to be managed by women because they have need for certain crops for domestic cooking such as pepper, tomatoes, and okro. They sweep compounds and dump refuse at backyard gardens at Sekesua Onsonson and surrounding villages and manage farms by slash-and-burn. Alternative livelihoods include snail rearing, bee-keeping, livestock raising and mushroom farming. Droppings of livestock add organic matter to the soil which enhances the fertility of the soil for agricultural production. Non-PLEC farmers have always wondered why PLEC farmers get good and high quality harvests. A NON-PLEC farmer once told a PLEC farmer, "Nature is listening to your commands, more than it is doing to me". PLEC farmers who have learned secrets of proper farming and sustainable land management practice produce higher yields on a sustainable basis. "If farmlands are not properly managed, then you will be spelling out your own doom", a farmer observed.

In response to the questions on how LKS have changed resource management and soil conservation (Question 11 of Appendix C), PLEC farmers described major techniques they employed to retain soil nutrients (fertility) and improve productivity of the land. They cited bush-fallowing as a major practice in which two or three plots are used for farming. Farmers cultivate a piece of land for at least 2 years after which they move to another plot. Some of the families who have relatively higher income can afford to leave their farms to fallow for one or two years. Fallowing is one of the key means of soil conservation and nutrient enrichment but not all farmers practice it. Farmers at Amanase said one cannot leave the area to fallow for a number of years due to shortage of land for cultivation. This problem is compounded by increased population growth and changing land tenure and ownership regimes. Population pressure has led to multiple land divisions and shorter fallow periods. This phenomenon has become very critical at Sekesua Onsonson area. Since land is limited, people make maximum use of land. This type of land use system is good because different crops extract different nutrient requirements from the land.

A special traditional method of land management in the Manya Krobo region is proka. Due to limited land and shorter fallow periods (2-3), most famers are meticulous about fertility of the soil and take pragmatic measures to enhance nutrient content of the soil. Since fallow periods are shorter due to high population growth, frequent land division and extreme pressure on land for agriculture, farmers have adopted a soil conservation technique to produce compost. Leaves of trees and crop residues are left on the land and commonly used as mulch, a technique locally called 'proka'. PLEC farmers observed that decaying organic matter or breakdown of complex organic matter usually mixes with the soil. The leaves decompose and add nutrients to the soil. Other farmers apply natural manure such as a mixture of sawdust and animal droppings (sheep, goat) and other plant residues which are left on the land to decompose and enhance the fertility. The breakdown of organic matter improves soil fertility and prevents run-off. Other PLEC farmers practice 'slash and burn' methods to improve soil fertility. Burning of plant residues after harvest is practiced on a limited scale due to cases of bush fire. Studies by More and Voughan (1994) found that burning is a very effective method for conferring high fertility (increases calcium, potash and phosphates) on less fertile soils. However, farmers complained that uncontrolled burning in some cases spread quickly and caused devastation to surrounding farmlands.

According to PLEC farmers, another major problem is that tenant Ewe (ayigbe at Sekesua Onsonson) use hoes frequently in tilling the land and this causes soil erosion problems. They also overwork the land to obtain higher yields and rapid returns on their investments to enable them pay for the cost of the land rent. The key soil conservation technique used by farmers is terracing. Usually, rocks and stones are used for terracing to to prevent soil erosion. Where there are no stones erected, pegs and refuse are stocked in gulleys which act as a fence wall to check the strengh of surface run-off. Farmers indicated that they do share knowledge and take advice about land tenure practices from other practitioners. Knowledge of soil conservation techniques is acquired and transferred from one farmer to another through group disccussions and demonstration activities. The PLEC farmers meet to share ideas, exchange planting materials and seeds of crops and rare plant species.

Bush fire is one of the major problems, especially during the harmattan (dry) season. There are coercive means of checking indiscriminate burning of forests for agriculture in southern Ghana because the burns spread to and destroy the other nearby farms. “Anybody who causes havoc to farms always stands a chance of meeting the wrath of the people”. “We are told that excessive burning destroys soil nutrients and kills trees”. A farmer argues that they have found ways to protect the land. The absolute no burn concept does not work. “The way our lands are if you don’t burn, you cannot plant tomatoes on the farm" a farmer observed. About 16% of the farmers burn prior to cultivating the land.

5.19 Community Participation in Agroforestry and Soil Conservation

Not all farmers in the Manya Krobo and Suhum Kraboa Coaltar districts participate in the PLEC demonstration activities. Non-PLEC farmers explained that they lack understanding of the value of the agroforestry initiatives. A majority of non-PLEC farmers are of the view that they do not get accurate information about PLEC activities. In the course of the focus group discussion with farmers at Prekumase and Bormase, it came to light that those who did not participate in PLEC activities were seeking monetary rewards from the project. After discovering that there is no direct financial reward, they immediately withdrew from the programme. Another factor that accounted for lack of participation in agroforestry activities by non-PLEC members is the perceptions and feelings of farmers about the significance of alternative livelihoods. The survey revealed that when PLEC farmers started beekeeping, they were mocked. PLEC farmers reminisced that they were initially ridiculed for leaving their tomato farms to attend training on beekeeping. When the rewards of adopting PLEC agroforestry techniques began to unfold, those farmers who initially shunned the project came back to inquire about how to employ the techniques to enhance their farm management practices.

Another unique characteristic of the PLEC is recoginition of customs and taboos which are deeply entrenched in belief systems strictly adhered to from one generation to another. It is not surprising that even though these belief systems defy scientific rationality and objectivity, reverence to the gods and fear of the wrath of Asaase Yaa

(Mother Earth) serves as a deterrent to those who have inclination to breach these taboos. For instance, there is a ban on farming on specific days in some communities in southern Ghana. When farmers were further probed and encouraged to explain the rationale for this cultural observation and ban on farming, they explained that they believe the gods and dead ancestors rule in the affairs of the living and there are perceived penalties unleashed by the gods against deviants. Farmers further reminisced that those who dared to disobey these customs in the past saw strange creatures in the wild and were traumatised. Another person was bitten by a wild snake and his legs rotted from bottom-up until he died. Other farmers claim that low rainfall and drought conditions result from a breach of taboos by people who farm on sacred days. However, mysterious as these taboos are, from a regulatory point of view, they have been effective informal tools used by the local authorities to enforce environmental conservation practices.

One of the indirect conservation measures adopted by farmers is appropriate techniques of charcoal burning. The new technique that the Capacity 21 project taught farmers is efficient use of wood so they obtain higher returns in terms of charcoal. "If you have small woods, you get a lot of charcoal from it, so we don't waste trees" a farmer notes. As part of Capacity building initiatives, trainees of Capacity 21 are taught the proper way to cut and burn selected trees for charcoal production. New methods of charcoal production are simple and much more efficient than the old one. The method also saves time as the old method takes about 2 weeks to burn the charcoal as compared to the new methods which usually take 3 days. The old method involves digging a hole and sometimes it is difficult to get soil to cover it.

All farmers affiliated with the Capacity 21 project assert that they leave plant residues on the fields to decompose. After harvests, crop residues are also piled in heaps, burned, and the ashes are spread over as much of the field as possible with hoes. Although burning is discouraged due to the high probability that it might get out of control, Vaughan (1994) has discovered that burning is very effective for conferring high fertility (increased calcium, potash and phosphates) on less fertile soils. Whether or not burning actually increases soil fertility, households experiencing labour shortages will continue to burn crops as it is a quick and efficient means of breaking down crop residue and unwanted weeds. In the case of the Sekyere West district, 22 farmers went for in-service training at the Mampong office. The trainees in turn passed on the knowledge to other farmers. Typical information that is acquired and transmitted from farmer to farmer includes types of trees and plants suitable for specific socio-economic and environmental conditions.

Farmers seek environmental information about the time and season to plant crops which enhance seed germination (Questions 4 and 6 of Appendix C). Expert farmers undertake farmer-to-farmer visits to share germ plasm (sustainable soil utilization). Expert farmers indicated that they develop small scale nurseries from where species of trees are distributed to other PLEC farmers. In addition farmers observed that the cultivation of maize brings more yield as knowledge acquired from extension officers is transmitted from one farmer to another. "We share ideas and knowledge but one problem is that some try to be independent and selfish". This observation by a PLEC farmer in southern Ghana is akin to experiences in Peru and Brazil where PLEC expert farmers are frequently unwilling to share their knowledge with all of their farmer neighbours

(Pinedo-Vasquez et al, 2001). In addition, there is promotion of farmer-led conservation measures and gradual collaboration with agricultural extension agents and other appropriate government and non-governmental institutions. Some of the farmers have created their own model of planting forage that was appropriate to their local conditions. Sometimes they reject the adoption of other technologies if they find them inappropriate for their chores. It was evident from the discussions that most of the farmers were aware of the advantages of planting forage for feeding animals.

Extension officers have helped farmers to improve seeding and row-planting of crops. Miniset production of yam and plantain and split comb techniques have been developed and used by farmers. PLEC farmers acknowledge that extension officers educate them about multi-cropping, row planting and crop spacing. They have also combined row-cropping with yam cultivation. PLEC resource personnel interventions have given them the real benefits of land conservation. Agriculture extension officers come there regularly and farmers praised thier invaluable role. Agricultural extension officers assisted them to deal with the problem of pest infestation and other diseases. The farmers explained that Faculty of Agriculture officers came down to offer unique assistance and techniques during workshops. There is not too much pressure on the land to reduce the labour-intensiveness of farming.

5.20 Cross-Project Comparison of Agro-forestry Practices

Farmers associated with the three projects practice agroforestry management. This includes mixed cropping of economic and medicinal trees as well as food crops (tubers, tree fruits etc.). Reasons such as windbreak, construction materials, medicine, food,

Table 5.2 Tree Species Grown on Farms (Agroforestry Managment)

Types of Trees			Tropenbos Int	Capacity 21	PLEC
Local name	**Botanical name**	**Value economic/domestic and medicinal**	**Semi-deciduous & Transition**	**Semi-deciduous & Transition**	**Semi-deciduous & Transition**
Oteae	*Pycananthus angolensis*	timber, fever	+	+	_
Mahogany	*Kaya spp.*	blood tonic, typhoid, piles, hernia treatment	+	_	+
Acacia	*Acacia nilotica*	malaria, fever, charcoal, fuelwood	_	+	+
Wawa	*Triplochiton scleroxylon*	Furniture	+	+	_
Cashew	*Anacardium occidentale*	fruit snack, export crop	+	+	_
Mango	*Mangefera indica*	Fruit, fuelwood,	+	+	+
Odum	*Milicia excelsa*	Timber, furniture construction	+	+	+
Owateku	*Cola gigantean*		_	_	+
Onyina/ Onyaa	*Ceiba pentandra*	fever	+	_	+
Ofram	*Terminalia superba*	timber, furniture construction	+	+	_
Emire	*Terminalia Ivorensis*	timber, construction	+	+	_
Avocado	*Persia americana*	snack	+	+	+
Pawpaw	*Carica papaya*	fruit snack	+	+	+
Banana	*Musa spp.*	fruit snack	+	+	+
Baobab	*Adansonia digitata*	water, building, oil material	_	_	_
Neem	*Azadirachta Indica*	fever, hypertension building, fuel wood	+	+	+
Oil Palm	*Elaeis guineensis*	oil, fuelwood	+	_	+
Cocoa	*Theobroma cacao*	beverage, butter chocolate	+	_	+
Coconut	*Cocos nucifera*	fruit, oil,	_	+	_
Orange	*Citrus spp*	fruit	+	+	+

Source: Field Survey, 2005-2006
+ Predominant tree species grown in that ecological zone
_Less predominant tree species grown in that ecological zone

Table 5.3 Common crops and vegetables planted on farms

Types of Crops and Vegetables		
Local name	**Botanical name**	**Value economic/domestic**
Cassava	*Manihot esculenta*	gari, fufu,
Cocoyam	*Xanthosoma saggitifolium*	food
Sweet potato	*Ipomea batata*	food meal
Okra	*Ablemoschus esculentus*	Stew, soup
Cowpea	*Vigna unguiculata*	stew, soup
Pepper	*Capsicum anuum*	stew, soup
Lima bean	*Phaseolus lanatus*	snack, stew, soup
Garden egg	*Solanum melongena*	stew, soup
Agushie	*Cucumeropsis edulis*	stew
Plantain	*Musa paradisiaca*	
Yams	*Dioscorea* spp	
Maize	*Zea mays*	
Tomato	*Lycopersicon esculentum*	
Groundnut	*Arachis hypogaea*	

Adapted from Ardayfio Schandorff 2005, Gyasi et al. 2004 and TBI, 5005

fuelwood and nutrient enhancement, were cited by farmers for practicing agroforestry management. Common food crops found on farms include cocoyam, okro, maize, plantain and yams, among others. These crops are the mainstay of family food sources and farm income. Other sources of farm livelihood activities include beekeeping, snail and grasscutter rearing and livestock breeding. The diversities of agroforestry practices have engendered decades of farm management practices and resource conservation measures.

All farmers practice crop rotation, 'proka' (no burn tillage) and bush fallowing, among others. Bush fallowing is one age-old farm management technique practiced by farmers associated the three project areas. This has helped farmers to improve soil fertility on a sustainable basis. However, population pressure and constant land divisions have led to continous all-year farming. Hence, there is variation in the number of years that farmers associated with each of these projects leave the land to fallow. PLEC farmers at Sekesua Onsonson have limited land available for farming. Hence, the fallow periods are extremely short (1-2 years) as compared to farmers at Asunafu Goaso district where the Tropenbos project is implemented. "We leave the land to rest with intervals of 5 years so that the land is rejuvenated or replenished in its nutrient at all times" a TBI farmer asserts. On an average capacity 21 farmers leave the land to rest between 1-3 years).

Another discrepancy among the three projects is that the Capacity 21 project made provision for wellington boots, shovels, wheelbarrows and other tools for farmers. This initiative is not an integral part of the Tropenbos and the PLEC projects as a majority of farmers associated with the latter projects have expressed misgivings about the utility of training programmes as there is no logistical support to implement the knowledge they obtain. Even among the Capacity 21 farmers, there were issues with limited logistical supplies. Farmers at Domi in the Sekyere West district noted that they could not share the limited number of cutlasses among themselves so they did not use them at all because of fears that this could trigger tension among members of the farming community.

Farmers in the three projects have been victims of indiscriminate felling of trees by timber companies who have been given concessions by the government. The trees destroy their crops and other young seedlings. Compensation usually proceeds with assessment of the cost of the destruction on the farm. Farmers at Amanese hinted that in some cases, timber contractors bring their own evaluation officers to assess the extent of farm damage and then provide no or very meagre financial compenstation which is not comensurate to the loss of farm crops and trees. Ironically, TBI, Capacity 21 and PLEC farmers resort to cutting down the trees on their farms before the concession companies get them. This practice tends to be counterproductive and defeats the purpose of agro-forestry management.

5.21 Evaluation of Sustainable Agroforestry Practices

Sustainable agroforestry management meets the needs for food, fibre and income in pepetunity across generations. Management of genetic diversity in southern Ghana aims at maximizing the use and benefits of resources while at the same time ensuring thier availability for present and future generations. The study revealed that diversity of genetic resources and knowledge systems which are applied in the various livelihood activities are crucial for the sustainability of agroforestry practices. Diversity was seen in the context of people's livelihoods. Farmers cultivate crops, plant trees, rear livestock and grasscutter, keep bees and nurse medicinal plants to support family needs for food, fodder, fibre and medicine on a continuous basis. Income security is ensured as livelihood activities are diversified; (1) The genetic diversities on the farms enhance the fertility, nutrient cycling, moisture retention and productivity of agroecosystems of southern Ghana; (2) Food security is ensured as a result of mixed farming practices. Different crops and trees adapt to different environmental conditions spatially and temporally; (3) livestock rearing generates alternative food sources which support families in event of drought, forest fires, pests outbreak and floods. Livestock droppings also serve as vital source of organic manure through composting which enriches soils (4) social networks and family ties add an impotant dimension to sustainability of livelihood activities. Agro-ecological knowledge about wild food sources, techniques of rapid propagation of crops, knowledge of rare medicinal plants and expertise in farm management are acquired, modified, maintained, and exchanged within generations and transferred across generations among farmers in southern Ghana.

Farmers in southern Ghana have experimented with and used diversity of tree and crop species in agro-forestry practices. Diversity of trees, crops and livelihood activities ensures complexity, stability and resiliency of agro-ecosystems, food supply income. These activities have enhanced agroforestry management over the years. Essential services of the nutrient cycle through organic materials through ecosystems have enhanced species diversity. The findings in southern Ghana reflect the sustainability of agroforestry practices in other developing countries. As Atta-krah *et al.* (2004) noted, agroforestry is a diversity-enhancing land-use system, especially in the context of interspecies diversity as it brings together, crops, shrubs, trees and in some cases, livestock on the same piece of land. Other studies (Kweiga et al. 1999) have shown that most agroforestry technologies have tended to focus primarily on selection of particular tree and crop species.

The combination of tree and crop species (agroforestry) has led to marked improvement in soil productivity and increased yield for farmers associated with the TBI, Capacity 21 and PLEC projects. The findings of this study give credence to the fact that farmers have adapted agro-ecological knowledge of crops and tree species over the years.

It offers farmers diverse sources of income and provides security against low-yields and drought-stricken seasons. Institutional capacity building, individual training (workshops and demonstrations activities) knowledge and information sharing has helped to enhance agro-forestry practices in southern Ghana. This study reflects similar studies conducted in Sidama, southern Ethiopia. Zebene and Agren (2007) used Rapid Rural Appraisal (RRA) and Group Discussions to elicit information from farmers about tree generation and management on farms. The traditional agroforestry systems in Sidama are highly developed and complex and the crop productions at these sites include: (i) mainly staple food, enset and maize; (ii) Chata edulis (chata) and *Coffee arabica* (coffee) as the principal perennial bushes. Major fruit trees cultivated are papaya, banana, avocado and mango whereas Cordia and Eucalyptus are the main timber species. In addition, vegetables for both cash generation and domestic food include Ethiopian kale, potato, carrot, pumpkins and green pepper. Unlike the case of Ehtiopia, carrot, pumpkins and coffee were not predominant choice of crops planted by farmers, in southern Ghana. Cash crops (fruit) such as cashew, mango, oil palm, orange, avocado and pawpaw (among others) were preferred by farmers in Southern Ghana. Kenyan and Zambian farmers demonstrated interest in cash crops such as fruit, timber and coffee (Bezuneh et al. 1995). Other farmers in these countries preferred improved fodder grasses and legumes. The resulting diversification of enterprises helped to increase and stabilize income. The diversification together with conservation farming practices, demonstrated that upland farming sytems could be both sustainable and profitable (Franzel et al., 2007).

There are parallels between Ghanaian farmers and farmers in Ethiopia with regards to preferences and reasons for cultivating certain crops and trees. Ghana farmers cited

Owateku *(Cola gigantean)* as bad for crops because its leaves do not decompose fast. Also, farmers do not like mixing cocoyam *(Xanthosoma saggitifolium)* with trees. Farmers noted that cassava that is planted close to acacia tends to be very bitter and people fall sick after eating them. Ethiopian farmers do not allow Eucalyptus in crop fields or enset fields due to the perceived negative effect it has on crops and soils. Farmers cite excessive water and nutrient uptake and soil toxicity as reasons for limiting Eucalyptus growth on their farms. Nevertheless, other studies (Soni and Vasistha 1991) have shown that except in few cases where it showed ellelopathy, Eucalyptus is capable of supporting dense and diverse undergrowth and a number of economic species. Similar sentiment was expressed by Ethiopian farmers who observed that differences exist in the average decomposition time for different tree leaves and pods. Leaves, pods and inflorescence of Millettia and Cordia decompose within one season and enset residues decompose more slowly within one season. In southern Ghana, animal droppings from the homestead are used to fertilize soils in home gardens. This type of animal manure is applied on small scale home gardens and not extensively on farms. Ethiopian farmers maintained soil fertility predominantly by animal dung. In addition to animal dung, organic matter input to the soil consists of leaves of native trees. In this study a cross section of Ethiopian farmers noted that insufficient application of manure both from animal dung and plants is the major cause of declining soil fertility.

Farmers who practice agroforestry in southern Ghana collect unique assemblages of seeds, seedlings and rare plants in nurseries. This serves as germplasm bank and botanic gardens for farmers who exchange these seedlings with other farmers. This is parallel to the findings of a study conducted by Atta-Krah et al (2004) under the auspices of the

International Plant Genetic Resources Institute (IPGRI) in Kenya. Atta-Krah and others discovered that seed systems influence the maintenance of genetic diversity or the promotion of genetic erosion in agroforestry. In most cases, farmers obtained seeds from other farmers who may also have harvested the original seeds from a single tree on their farms (Atta-Krah et al. 2004). Other authors have observed that farmers and nursery managers frequently collect germplasm from a relatively narrow range of maternal parents (mother trees) during propagation (Weber et al. 1997; Holding and Omondi 1998). In Kenya, some agroforestry trees are obtained from established institutions such as tree seed centres. These institutions act as seed stores with the responsibilities for seed collection, processing, storage and distribution to farmers.

Another characteristic of agroforestry practices is diversification of income. Southern Ghana farmers have also learnt several ways of diversifying their income sources. They plant cash crops amidst food crops. In times of crop failure, farmers depend on economic trees as a source of charcoal production or timber for sale. All these approaches were enhanced by institutional capacity building, demonstration site activities and various workshops. This practice by Ghanaian farmers is akin to studies done in Africa and Asia. Franzel *et al* (2004) for instance, undertook case studies of agroforestry practices in Zambia, Kenya and Phillipines and found that the keys to successful spread of agroforestry innovations include farmer-centred research and extension approach, a range of technical options developed by farmers and researchers, institutional capacity at the local and knowledge and information sharing. However, lack of planting materials is repeatedly identified as one of the most seious constraints to the wider adoption of agroforestry innovations in some African countries (Simons 1997). National seed centres have been unable to deliver seed to large numbers of smallholder farmers. The seed demand-supply relationship in a large proportion of Africa's smallholder farming systems which appears to represent a situation of market failure' (De Vries and Toenniessen 2001). For instance, scaling up in Zambia was constrained by lack of seed in 1996, seven tons of sesbania seed were imported for free distribution to farmers. Some non-governmental organizations in southern Ghana supply seedlings for agroforestry management. This approach is not regular and in some cases, the seedlings do not arrive on time during the onset of the planting season.

In Ghana, institutional capacity is dominant at the district assembly level. For instance, under the Capacity 21 project, CERSGIS trains district planning officers to use environmental information systems for resource management. On the other hand, PLEC used demonstration activities and workshops to train local farmers on germplasm and agroforestry practices with assistance from expert farmers. The institutional capacity building under each of these projects has been instrumental in forstering agroforestry practices in southern Ghana. The demonstration site activities and workshops serve as fora where farmers exchange vital germplasms and share information and knowledge on agroforestry practices. Similarly, the Landcare system in the Philippines has gone further in building local institutional capacity for organizations promoting improved fallows and fodder trees. The landcare system enabled communities to share knowledge and experience, influence the agenda of researchers and local policy makers and mobilize financial resources for technical training and community development. In addition, knowledge sharing and learning are priorities at all the sites. Landcare groups have been effective vehicles for knowledge sharing in areas of conservation farming and livelihood improvement.

5.22 Political Ecology of Agroforestry Management in southern Ghana

A plethora of information (from studies) analyzes the influence that society, state, corporate and transnational powers have on resource and environmental management and how these factors shape environmental policy, knowledge and decision making processes (Blaikie and Brookfield 1987, Peluso 1983, Berkes, 1999 and Mckenzie 2005). This enhances understanding of the interplay of the complex power (political affiliations, positions, etc), social (class, gender etc.), and institutional relations (top-down or bottom-up structures) which influence access to information, knowledge and resources. These factors determine resource allocation, consumption and mamagement of the environment. Political ecology seeks to explain the dynamic ways in which political and economic power shapes ecological features and the vice versa. Elements of these complex socio-political relations play out in information and knowledge system applications in agroforesty and agrodiversity management in southern Ghana. Stronger social relations among farmers associated with the three projects have been the major force that determines the efficiency of farmer-to-farmer knowledge acquisition and information exchange and germplasm sharing. The communal spirit in terms of demonstration activities (PLEC) and joint tree nurseries and tree planting excercises (Capacity 21 and Tropenbos) have enhanced the implementation of agroforestry activities in southern Ghana. In essence, PLEC has a greater element of bottom up approach as compared to the Capacity 21 project. This is because the approach is farmer-led and it creates a conducive environment and cross-fertilization of ideas about agroforestry.

This depends on the modus operandi of these projects, existing government policies and local micro economic situations. In-depth analysis of the Capacity 21 project reflects how a new government decision can cause a complete overhaul of existing environmental programmes. Often there is staff reshuffling and transfer to different districts. The result is that new planning officers lack knowledge of existing environmental databases accumulated by planners of the previous regime which are vital for district level environmental decision making. These political dynamics have serious repercussion for conservation and forest protection efforts at the districts. Ignorance of the existence of vital environmetal data implies there is lack of knowledge about hot-spots of environmental degradation and limited management decisions for reversing the trend of degradation in the affected areas. Apart from disruption of conservation plans, changes in administrative setup and personnel create apathy and disincentive which wanes community support for such environmental initiatives. The PLEC project is a non-government project attached to the Department of Geography, university of Ghana. TBI is also run separately from government control. Hence, the changing government machinery and the attendant personnel changes perculiar to Capacity 21 is absent in the PLEC and TBI projects which ensures continuity and sustainability of the programmes. The existing top-down nature and institutional arrangement in which the Ministry of Environment Science and Technology in Accra oversees the allocation of Capacity 21 project funds to the districts places local communities in a financially disadvantaged position. The bulk of the project money is spent at the national level and sometimes logistics like computers procured for the project are channeled for administrative uses. Such institutional relations tend to deny logistics and financial support for planning officers who are at the helm of affairs in community resource management.

Further, globalization in the form of the influence of multi-national corporations adds a different twist to the complexities of agroforestry management in southern Ghana. This phenomenon is peculiar to experiences of farmers associated with the TBI, Capacity 21 and PLEC projects. Concessions are granted to logging companies by the government. Most of these companies wield strong economic power and usually take advantage of loose environmental standards to log indiscriminately. These companies are able to 'grease the palm' of influential governmental officials to obtain logging concessions. Although the forest harvesting techniques removes old trees on farms, the process of conveying the logs from their in-situ locations to the main road for onward transportation to their various destinations cause the most obnoxious damage to crops and trees which have been nurtured over the years and maintained by the 'toil and sweat' of ordinary farmers. As a result of these unfortunate experiences, communities are often at a loss as to whether it is worthwhile to support government-led, donor-funded resource management programmes.

In view of these problems, this report outlined a number of recommendations for addressing the challenges of agroforestry management. It is envisioned that these remedies will go a long way to promote sustainable EIS and LKS application in agroforestry management and biodiversity conservation in southern Ghana.

CHAPTER 6: RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

This chapter provides a summary and synthesis of the research findings highlighting unique characteristics of project implementation and the key parallels and divergences in the strategies for implementing the UNDP Capacity 21, PLEC and TBI projects. It offers key findings from the cross-case comparison and analysis of the three projects vis-à-vis agro-forestry management. The relative effectiveness and efficiency of the mechanisms and strategies adopted under each of these projects is also discussed. The final section discusses the strengths and challenges of this study, draws conclusions and provides recommendations for addressing the challenges that farmers raised during the field interviews and focus group discussions which either are common to the three projects or unique to each individual project. This section also offers leads for future research to promote effective integration of LKS into GIS for agro-forestry management and agro-diversity conservation in southern Ghana.

6.2 Successes of EIS and LKS Application in Agroforestry Management

After 6 years of work on implementing the Capacity 21 (launched in 1998), PLEC (set up in 1992), and TBI (began in 2000) projects, there have been some minimal progress in achieving the ideals of incorporating EIS and LKS into resource management in Southern Ghana among all the three projects. These projects have been successful in collecting data and information about agro-ecological conditions, agro-forestry practices and the effects of land tenure and ownership regimes.

The key research questions that informed this research are (1) Does EIS and LKS application enhance access to data/knowledge and participation of district planners, resource managers and farmers in agro-forestry management, and (2) Does EIS and LKS application promote sustainable agro-forestry management in southern Ghana? Major components of these questions were investigated as modeled in the conceptual frameworks (Figures 3.1 and 3.2) that guided this study. The impact of EIS on agro-forestry management which was examined during the field study entails both LKS and GIS. The components of EIS application such as quality of data products and services, training and skill development, participation decion making, access to information, knowledge exchange and information sharing (Figure 3.2) were examined.

Comparative analysis of the three projects revealed that there is commonality between TBI and Capacity 21 on the type of information used for resource management. Both projects relied to a great degree on satellite images and digital land cover maps which were used by service providers to assess resource conditions. This accounted for 41 and 25% of all sources of data for the TBI and PLEC respectively. In contrast, the PLEC projects relied heavily on ground-truthing and transect walks as means of data collection (they accounted for 61% of all sources of information). Service providers associated with the TBI and Capacity 21 projects were able to access information through the auspices of the FC and CERSGIS respectively while PLEC farmers were supported by a network of scientists from the Botany, Crop Science and Social Sciences Departments of the University of Ghana. In all three projects, information was used as a means of assessing degraded regions for better decision-making in agricultural land management.

This is a major milestone in information systems application in Ghana has been successful collection of data and information about agro-ecological conditions. This is a feature of the TBI and Capacity 21 projects, especially during the initial feasibility studies and project implementation stages. Under the TBI project, the Forest Services Commission used satellite images as part of their ecological assessment of Off-Forest Reserve Areas. This has enhanced understanding of the socio-economic factors which account for the depletion of trees in the Offinso and Goaso districts. In addition, similar progress has been made in identifying patches of environmental degradation in the Assin Fosu and Sekyere West Districts of the Capacity 21 project. This has been a major stride in the decision making process. It has also enhanced efforts at reforestation in the affected areas.

Another major achievement is strengthening the capacities of district assemblies for effective environmental management through procurement of vital logistical supplies such as computers and laser printers for 8 focal districts of the capacity 21 project and training of personnel. In some of the district assemblies, these gadgets are partially integrated into the district assembly environmental resource management information system for addressing environmental problems. TBI has successfully set up information and communication training centre at Kumasi where students and resource managers are educated and equipped with knowledge and skills for application of environmental information systems for management of trees off-forest reserve areas. There is congruence between the TBI and Capacity 21 projects was computer-based training in EIS acquisition and application, especially for those well-educated planners and resource managers. Under Capacity 21, CERSGIS trained personnel in the area of knowledge application, while the Forestry Commission (FC) and the TBI Information Centre also offer training programmes on EIS application in the areas of ecological and socio-economic data collection in off-forest reserve areas of Goaso district. The training sessions enabled the service providers and resource managers to acquire skills and information needed for agro-forestry management and agro-diversity conservation. In all three projects, training of farmers in knowledge acquisition and application was conducted through workshops and demonstration activities, mainly in local languages. Diagrams and photos were used predominantly to enhance farmers' understanding of the issues of forest degradation and the best management options for redressing the problem.

Since the training programmes are free, it has increased community participation. Also, farmers and resource managers have been trained to use information to manage their resources effectively. This has been accomplished through workshops and demonstration activities which are major vehicles for knowledge acquisition and information exchange among EIS practitioners, resource managers and farmers. The workshops and field demonstration activities provide hands-on practical learning experience for people in the communities most of whom are semi-literate. With the help of tailor-made information systems and visual aids, people are able to identify environmental problems and take the initiative to reverse the trend of degradation. The workshops and skill development programmes have been instrumental in creating environmental consciousness and sensitizing community members for action. This communal spirit, as manifested in the PLEC, TBI and Capacity 21 workshops and field demonstration activities makes it easy for information dissemination from resource managers to farmers and the vise versa.

Farmers associated with the three projects now have adequate knowledge of biotic and abiotic conditions for tree and crop growth and the best management approaches for ensuring productivity of their farms and sustainable household livelihoods. This traditional knowledge base is refined through training, demonstration and exchange of knowledge between scientists affiliated with these projects, agricultural extension officers, resource managers and social scientists attached to these projects. There are similarities among the three projects in the approaches to agro-forestry management in the communities where the projects are being implemented. Economic and timber trees (cashew, oil palm, pawpaw, mahogany, wawa, acacia, etc.) are grown on farms. Other timber species which germinate naturally on the farms (in a scattered pattern) are nurtured and used as sources of fuel wood, building materials and furniture, among others. Apart from providing shade to farmers during intermittent breaks from work, trees are used for charcoal production, erosion prevention, wind breaks, and so on. The barks and leaves of trees are used for blood tonic, treatment of hypertension, hernia and fever, among others. In all cases, women farmers have the propensity to nurture seedlings of tree species that have medicinal and cosmetic values and these species are planted close to the homestead. Mixed-cropping, multiple-cropping or inter-cropping are the predominant agricultural practices that farmers undertake. Food crops (cassava, yams, plantain, maize etc.), tubers (yam, cocoyam), and vegetables (okro, tomatoes, garden eggs etc) are planted among trees on the same piece of land. Women farmers associated with all the projects are keen on practicing in-situ (on farm) and ex-situ conservation (storing seeds of rare species of plants in the kitchen). Farm management techniques that farmers undertake in all three projects include bush fallowing, proka, composting and manure application, terracing and nurseries. Other alternative livelihood activities (e.g. bee keeping) are practiced by farmers to ease pressure on the land for farming activities. Notable among these achievements are germplasm conservation, plant propagation methods, proper charcoal burning techniques and diversified or alternative livelihood activities. There is now increased awareness among farmers about biodiversity loss (loss of genes, species and ecosystems). They have networked and formed farmers associations for annual or seasonal food crop fairs as in the case of the PLEC project. This social capital is essential for continuous acquisition, exchange and transmission of vital agro-ecological knowledge.

6.3 Problems of EIS Application in Agroforestry Management

Unfortunately, some of these projects (Capacity 21) have been conducted like pilot studies. They are run on experimental basis in the selected districts. Although it was intended that lessons learnt from the pilot districts will be replicated in other districts, this was never realized. Only selected districts benefited from the project. Hence, the initial enthusiasm for the project implementation waned with time. Some project implementations are exclusive rather than inclusive. Clearly, there is no evidence of proper feasibility studies of the districts prior to the implementation. Lack of proper feasibility studies explains why there are obstacles during the EIS implementation. Sound data, knowledge or information about the socio-economic setting would have gone a long way to reduce, if not totally eliminate the shortfalls in the project implementation.

Both TBI and Capacity 21 officials cited frequent power outages, system crashes and hardware and software configuration problems. Only Capacity 21 officials faced short-term software licensing problems. Telephone communication problems were the least of the obstacles cited by respondents associated with all three projects. A common problem with all the three projects is the divergence between the EIS designer's mental model and the context in which the system is used with respect to the skills, needs and expectations of users. This sometimes serves as a technical challenge and disincentive to use of EIS by planners.

PLEC and TBI farmers complained of a lack of logistical supplies for agro-forestry management. On the other hand, Capacity 21 farmers were grateful to have received equipment supplies for farming and afforestation activities but they expressed dissatisfaction about the lack of continuity of equipment supplies. Overall, farmers who participated in the focus group discussions under the Capacity 21 and TBI projects deemed the ad hoc nature of training programmes and farm visitations by experts as unfortunate. The computer-based information systems only served as a basis for directing farmers to degraded areas and encouraging them to use various farm management practices to halt and reverse the rate of land degradation. Overall, while computer-based information system application has been moderately successful at the district level, the extent of integration with local knowledge systems for agro-forestry management has been minimal or non-existent. The challenges of agro-forestry management require concerted and collaborative effort among all the stakeholders involved in agro-forestry management.

There is lack of proper modalities and mechanisms for integrating information obtained from these systems into laws and policies that will compel compliance to forest regulations. It will help prevent illegal logging activities and contain the incessant encroachment of agricultural activities on sensitive ecological zones. This is problem is compounded by deficient mechanisms for assessing and monitoring the progress of implementation in order to ascertain the level of achievement and challenges. Also, absence of timelines and targets make it difficult to know the impacts of these projects on agro-forestry management and agro-diversity conservation. There are no proper bench marks for assessing the impacts of thee projects on conservation. Adaptive or iterative approach of implementation would have helped to revise and improve some of the implementation strategies and processes.

In terms of financial regime, CERSGIS (Capacity 21) and FC (TBI) practiced cost-recovery to cover production cost. However, both projects initially provided funds for training officials and this was pre-arranged and paid for by the projects. This was a one-time gesture offered as part of implementation of the project and subsequent training and information is paid for by the customer. On the other hand, the PLEC project does not offer computer-based training for resource managers and farmers, but agro-ecological knowledge and information given to farmers are free.

6.4 Recommendations for Sustainable Agro-forestry Management

The recommendations offered here are aimed at promoting integration of LKS and translating environmental knowledge acquired through computer-based systems into practical agro-forestry and agro-diversity management initiatives in Ghana. Of the three environmental projects that employ EIS and LKS in agro-forestry and agro-diversity conservation in Southern Ghana, only Capacity 21 was implemented as part of the government's district assembly programme and coordinated through the Ministry of

Environment, Science and Technology in Accra. Actual implementation of this project rests on the district chief executive officers with focal persons being district planners and other administrative staff, some of whom are government appointees and tend to be answerable to the ruling party. The main obstacle to implementing such projects is their ad hoc and transient nature. Also, district appointees are often transferred to other regions as part of reshuffling programmes. The strategy of a new government is to exercise authority among the rank and file of district staff who may have deep-seated allegiance to the previous regime. Also, new governments normally discontinue or terminate on-going projects of previous governments on grounds that the electorate will not credit the current administration for success of a project that was started by a previous government or perceived as an initiative of the previous regime. A change of government and personnel often results in a lack of continuity of on-going projects in the districts. Also, newly transferred personnel at the district lack proper orientation on available data and information (district information system).

In order to address these problems, the government should institute a policy of continuity of vital socio-economic and environmental projects that will be embodied in the environmental protection policies, and guidelines of the Environmental Protection Agency (EPA) in Ghana and Ministry of Environment, Science and Technology. Embedding such a policy in the environmental protection guidelines will make it mandatory for any succeeding governments to follow through with any on-going resource management or agro-forestry conservation programmes that are deemed relevant for meeting the needs, interests and aspirations of the general public and preserving the environment for posterity in the long-term. In the interest of the public good, district personnel who are in charge of environmental resource management projects should exercise a greater degree of political will and place the interest of the nation above any private agenda and not be swayed by biased and short-term partisan interests. This will ensure a smooth transition and continuity of on-going environmental resource management programmes.

As observed in the field survey, some of the equipment (computers and printers) that were procured by the Capacity 21 project for the District Environmental Resource Information System (DERIS) has been converted into administrative tools. This denies focal district planners access to and use of databases and environmental information for resource management. As part of efforts to address this problem, the coordinator of the programme instituted a general directive to the district to set aside at least one computer and a printer for sole use by the Capacity 21 focal person in the district. The survey revealed that the fundamental reasons why the gadgets are not being used for the intended purposes are multiple problems associated with software, data availability, and diminishing computer skills and knowledge base of focal persons. When the software license expires, the onus lies on the district to renew the software. The bureaucratic process of obtaining new software and data acts as a disincentive to focal persons to continue using the DERIS systems. Consequently, a lack of application of the computers leads to slow and gradual deterioration of skills and interests in using the system. A more proactive solution to this problem would be for Capacity 21 and TBI project coordinators to provide district planners with permanent software that does not require any renewal.

In addition, regular in-service or on-the-job training and refresher courses will help to update the knowledge base and skills of EIS personnel associated with all the EIS projects and sustain interest and enthusiasm in its application. Regular technical reports on the progress of EIS implementation and constant monitoring and evaluation of programme activities will go a long way to document successes and identify challenges which will help to improve future applications of EIS. This will ensure sustainable application of EIS in natural resource management. The results of monitoring and evaluation programmes will yield valuable outcomes for the successes of training programmes, workshops and EIS applications which should serve as a model that could be replicated in other districts with similar institutions procedures, socio-economic conditions and environmental challenges.

Another challenge of information application is data availability, access and cost. Increased access to appropriate and cost-efficient data and user-friendly information systems will enable farmers and resource managers to evaluate and monitor environmental problems and prescribe solutions for these problems. A process of constant dialogue and exchange of environmental information among scientists, EIS service providers, resource managers and farmers would assist all actors to work collectively in addressing the multiple issues that confront agro-forestry practices. In addition, regular visits by scientists and experts to demonstration sites moved create a forum for farmers to learn new techniques and afford experts the opportunity to obtain feedback from farmers about the success or otherwise of knowledge applied by farmers.

The result of these reciprocal knowledge and information flows among experts and farmers depends on other contextual issues. These include physical constraints, human resource limitations, or institutional policies which constantly influence the design and application of EIS in sustainable resource management. Farmers associated with the TBI and PLEC projects cite lack of logistical supplies and resources as one of the factors militating against participation of farmers in these conservation and resource management projects. This is due to the fact that the tools were supplied once, during the initial stages of project implementation and the supplies are not sustainable. A more regular and sustainable provision of resources such as computers, digitizers, dataserts, software, wheelbarrows, tractors, plows, among others, would enable district planners and farmers to replace worn out tools, encourage other farmers to participate in the project and motivate regularly participating farmers to work harder to ensure success of the implementation.

The focus group discussion revealed that farmers have knowledge of propagation of indigenous crop varieties and medicinal plants and this will ensure that genetic stocks and knowledge on biological resource management and conservation are preserved. The survey helped to understand the role of local knowledge in (1) reversing the top-down approaches to development and (2) assisting the capacity of institutions to engage in local communities and ameliorate the effects of technical fixes. The widespread acceptance of the role of local knowledge would help to reduce the demand for costly on-station experiments and increase the likelihood that new technology will be socially-acceptable as well as ecologically sustainable.

Farmers should also practice other activities such as those that enhance ecological values, especially habitats of particular ecological value and operating composting facilities which will help farmers to convert waste crops, tree residues as well as animal wastes into organic manure to enhance and sustain soil fertility and productivity. This will enhance agro-forestry management, improve biophysical conditions and increase returns from investment in farming activities. Seedlings and other supplies should arrive in time before the onset of the rains or during the rainy season to ensure that that enough moisture is available to facilitate nurturing and growth of transplanted seedlings.

Tree crops such as cashew and kola have both economic and ecological benefits. Making these types of trees available for planting will raise the income level of farmers and at the same time enhance the productivity and functions of the farm lands. In addition, pruning trees provides fuelwood, improves yield and quality of the fruits. A financial incentive package needs to be instituted to provide financial rewards to farmers who play active roles in raising various tree seedlings for woodlot cultivation. This will serve as an incentive to other farmers within the communities to join the programme and provide an economic reason for farmers to take valuable time off their regular farming activites to invest in equally productive tree-seedling nursing and planting excerces.

There should be open negotiation between donor agencies and respective governments or affiliated agencies to set up long-term financial and administrative mechanisms to ensure sustainability of EIS implementation. Logistical supplies can be enhanced through a dedicated financial support system akin to the type offered by the World Bank Global Environment Facility (GEF). A low-interest loan from cooperative banks and small grants from international agencies or NGOs will encourage other farmers who are not associated with any of the projects to acquire requisite environmental information from service providers to improve agro-forestry practices and diversify their farm activities which will include on-site income generating activities such as bee-keeping, gari-processing and oil-palm processing. Also, the projects support off-farm alternative livelihoods and income-generating activities such as fruit and food processing, soap making and craftsmanship (basket and furniture weaving), among others. Such non-farm activities provide farmers with alternative livelihoods, additional sources of income and reduce pressure on the environment for farming activities.

While significant successes have been achieved by EIS service providers such as the Forestry Commission (FC), CERSGIS University of Ghana, Botany and Soil Science Departments with regards to providing computer-based information systems, an effective and sustainable resource management system requires a systematic approach which relies on the strengths of diverse indigenous knowledge systems with a view to incorporating these locally-based knowledge systems into computer-based information systems. The philosophy of traditional knowledge and culture expresses the relevance of maintaining a unique and inter-twined relationship between an individual, society and the environment. This fosters a bottom-up approach to national policy formulation and action programmes for agro-forestry management and conservation. The positive outcome will be a context-specific and user-friendly information system that accommodates, integrates, builds upon and strengthens local techniques of assessing environmental resource conditions and inappropriate farming and logging practices, and prescribing the right solutions to minimize and reverse the trend of degradation.

A characteristic feature of the TBI, PLEC and Capacity 21 projects is that they are being implemented in selected pilot districts. For instance, the PLEC is being implemented in the Southern and Northern parts of Ghana. The TBI initiative is being implemented at Asunafo Goaso, and the Sekyere West Districts of Ghana. In addition, there is a cluster of communities in Ghana where the Capacity 21 initiatives are predominant. It is the contention of this study that pilot EIS initiatives are pilot projects, not sustainable because they are not geared towards wider farming communities in the long-term. We must integrate indicators of success of EIS application into wider resource management initiatives by formulating policies and pragmatic activities to implement these initiatives. Methodological advantages associated with the pioneering PLEC, TBI and Capacity 21 projects should serve as a model that can be replicated in other village communities in Ghana with similar institutional, socio-economic and environmental conditions. Successes from pilot projects and experiments with agro-diversity should be further adapted and barriers lifted to benefit a wider community of farmers in degraded and economically impoverished agricultural areas. This will promote the adoption of practices that are demonstrated, and will allow infusion of guidance from policy frameworks.

Officials and experts from PLEC, TBI and Tropenbos need to conduct regular and routine visits to demonstration farms, and learn at first hand some of the problems that farmers go through and provide relevant technical advice to enable them to address problems with poor soil conditions, soil erosion, irregularity of rainfall, weeds, pests and diseases which affect farm crops and the biophyical environment. Agricultural extension officers, expert farmers, natural and social scientists associated with these projects must draw up a timeline and regular programme of activities that will enlighten farmers about particular agricultural practices. New knowledge about agro-forestry practices developed by scientists and resource managers associated with these projects should be integrated into local knowledge systems.

Farmers who participated in the focus group discussion at Adwenso, for instance, argue that there is a need for constant visits from PLEC scientists and extension officers.

PLEC farmers cite the lack of continuity of EIS training programmes as a problem that hampers effectiveness of EIS application in natural resource management. Farmers desired that the PLEC project continue to assist them materially and financially. However, some analysts argue that a two-way cooperative approach, in the 'spirit of reciprocity', is needed to enhance agro-forestry initiatives. Scientists, development planners and managers, must develop 'new' knowledge for farmers, their households and neighbours. They would need to first consider what the farmers are doing, how they are doing it, and understand the reasons for the techniques they employ, and this would need to make sense in this context. Farmers need more meaningful options from a bottom-up perspective and not top-down prescriptions. Such options can best be developed with their participation and through knowledge sharing as real partners.

6.5 Strengths and Limitations of this Research

This study investigated and analyzed the impact of knowledge systems on agro-forestry management in southern Ghana. A key feature of the study is that it devised a conceptual framework (Figure 3.2) for assessing the various factors that influence EIS application in agro-forestry and agro-diversity conservation from the perspectives of EIS service providers, resource managers and local farmers. Most of these structured components were successfully explored through the interviews and focus group discussions. This helped to bring forth the underlying contextual issues that influence EIS (the computer-based aspect and local knowledge components of EIS) application in natural resource management especially at the community level. The survey instruments were able to capture the elements of EIS (types and sources of information) and the context of project implementation (participation, information sharing, financial regime and community initiatives) and the environmental outcomes (productivity of the biophysical environment and quality of resources). These aspects of the contextual issues are vital indicators that revealed how and why the projects work and determine their sustainability.

The case-study approach and comparative analysis of the EIS projects brought out unique characteristics of each of the projects and highlighted the situation-specific factors that influence EIS implementation in agro-forestry management. The survey methods provided in-depth, diverse perceptions and rich responses from farmers and resource managers about the contextual and community-based issues that influence EIS project. The narratives reflect first hand daily chores and experiential knowledge of farmers and resource managers who are at the helm of affairs in regards to agro-forestry management in southern Ghana. This helped to understand the underlying forces that shape the success or otherwise of EIS projects in Ghana.

A major challenge of this study was that it was difficult to properly ascertain the direct community involvement in the application of GIS and other sophisticated computer-based knowledge systems. These sophisticated systems were used by service providers and resource managers. It was not very clear from the survey how farmers are trained to interpret and use topographical maps, satellite images and climatic information and such vital information which is necessary for management of their farms, cultivation, harvesting activities, among others. This is because farmers do not have access to such information and even if they do, they are handicapped to use them effectively unless they are trained. The sources of information are interpreted and used by service providers at CERSGIS, FC, TBI Information Centre at Kumasi, district planners and resource managers who normally have the prerogative to provide the information. At best, the results of these expert interpretations of satellite images and topographical maps are packaged in the form of pictures and illustrations (used profusely in the TBI and the PLEC projects) as tailor-made information to enable farmers separate environmentally harmful practices from non-harmful practices in the course of their daily decision making process and chores.

Another problem encountered during the field survey was that frequent change of government and transfers of government personnel made it extremely difficulty to track down those district personnel who were associated with the implementation of the Capacity 21 project. This posed a challenge during the initial sampling of the respondents for the interview. This problem was circumvented by obtaining contacts from the districts that personnel where the personnel worked before they were transferred. Though some of the employees were located, others could not he found for the interview. Hence, annual quarterly reports of the projects, memoranda of understanding, minutes of meetings, agreements and budget statements had to be relied upon to obtain insight into how the projects were implemented in those jurisdictions.

6.6 Suggestions for Future Research

One of the key aspects of EIS implementation is the nature of institutional changes which are orchestrated by the political dispensation of the day. This determines the continuity or suspension of environmental initiatives in Ghana. A promising area for future research would be to investigate governmental machinations and their influence on the donor-funded EIS projects in Ghana. This is a crucial determinant of sustainability of

EIS application in agro-forestry management. Such research should focus on sector-specific and district-specific policies and programmes that require new governments to take up the responsibilities of a previous government in matters of administration and implementation of on-going donor-funded EIS projects. In addition, studies that explore the inherent capacity of incumbent governments to take on the mantle of responsibility of continuous implementation and expansion of projects once the donor funds are exhausted or the pilot phase is completed will be worthwhile. This will help to understand the sustainability of such projects vis-à-vis the intended objectives.

Information in itself is a source of awareness but not potent until it can be channeled into practical measures for reversing the trend of degradation and designing action programmes that can help local people to effectively use GIS. Research that can explore other avenues or opportunities for translating knowledge and data collected on the environment into national policy frameworks and action programmes on the environment will go a long way to help streamline current approaches to EIS implementation

6.7 Conclusion

It is the contention of this study that EIS application under the UNDP/Ghana Capacity 21, PLEC and TBI projects is fundamentally problematic because apart from demarcating areas undergoing degradation and raising awareness of the communities and districts about these problems, there are no clearly identified policies, pathways and procedures for incorporating local knowledge systems into the broader information systems. Secondly, in some cases, the needs, skills and expectations of the communities do not match the level of expertise and resources required to implement these projects. At best, individual farmers and groups, based on the sensitization, knowledge, skills and information acquired through these project training sessions, have taken the initiative to address problems of deforestation, soil nutrient depletion, low moisture, low farm yield, income insecurity, crop failure, pests and diseases, bush fires, fuelwood shortages, illegal logging, agro-diversity and biodiversity loss, among others. These economic, ecological and socio-cultural problems are complex, intricately interwoven and mutually reinforcing. Hence, any approach for addressing these issues must be holistic, integrative and proactive. Understanding the causes and dynamics of these environmental outcomes certainly requires reliable and accurate data, information and knowledge about resource conditions and rate of depletion and the actual remedies for these problems lie in the policies, institutional context, behavioural tendencies, group dynamics and resource support systems which will enable local communities to realize their ideals and goals. Initiatives that are inclusive, enhanced by expert advice and demonstration activities will go a long way of promoting effective resource management.

The study further asserts that an alternative approach which uses IKS (transect walks, social data) as supplementary to computer-based information systems (satellite images, aerial photographs and GPS) is ideal for context-specific understanding of environmental problems, enhances community participation and effective decision making in agro-forestry management. This type of knowledge is both dynamic and diverse in any community and tends to maintain ecological integrity. Given their strengths and weaknesses, a synthesis of indigenous agro-ecological knowledge and information technologies may be the best approach for effective community-based resource management. EIS application in natural resource management in southern Ghana should evolve from a short-term, donor-funded project into a more sustainable long-term project that will involve the wider farming communities of Ghana. The indicators of effective EIS application in natural resource management should reflect the contextual issues that influence EIS application and long-term implementation. Considering the huge amount of resources and dollars spent on EIS initiatives, it is envisioned that the findings of this study will encourage effective use of human, institutional, technical and financial resources to support the long-term routine production and integration of EIS and LKS into community-based resource management.

To participate effectively in community-based resource management, local resource managers and farmers in Ghana must have; (1) quality information pertinent to resource management, (2) the skill and knowledge to use the information effectively, and (3) access in terms of affordability and technical support. These enabling factors will help to build a sound information society and information management culture. Due to these critical issues, projects which integrate IKS with EIS have been touted as potentially people-centred, cost-effective and sustainable. Indigenous knowledge builds on years of local forms of resource use where community-level rules and spiritual beliefs regulate behaviour. This type of knowledge is both dynamic and diverse in any community and tends to maintain ecological integrity of the environment. Since local knowledge is seldom documented or appreciated, it is underutilized in EIS project development.

References

Abagele F. K., Addo J., Adisenu-Doe R., Mensah A. K. Apana S. Agyei B. E. Nyarko A. O. and Minu P. 2003. The Potential and Constraints of Agroforestry in Forest Fringe Communities of the Asunafo District-Ghana. *Tropenbos International,* Ghana.

Abaidoo D.Y.1997. Legal Tools for Effective Environmental Management. In E. K. Boon and Hens L. (eds.), *Proceedings of the Seminar on Key Economic and Legal Instruments for Environmental Management in West Africa.* Human Ecology Department, Brussels, Belgium.

Abdulai A. S., Gyasi E. A. and Kuforgbe S. K. 1999. With Assistance of P. K. Adraki F. Asante M., Asumah A., Gandaa B. Z. Ofori B. D. and Sumani A. S. Mapping of Settlements in an Evolving PLEC demonstration Site in Northern Ghana. *PLEC News and Reviews.* Accra Ghana.

Abura-Asebu-Kwamankese District Assembly,1999. *Annual Report.* Assin Fosu Ghana.

Adhikari M. 2004. A Non-destructive Approach for Quantitative Assessment of Tree Resources Outside the Forest. Unpublished MSc Thesis Submitted to the International Institute for Geo-information Science and Earth Observatory. International Institute of Geo-Information Science. Enschede, Netherlands.

Adu-Gyamfi S. 2005. Can Off-Forest Reserve (OFR) Timber Tree Resources be Certified?—A Situation Analysis of the Goaso Forest District of Ghana Using Remotely Sensed Data and GIS Techniques. Unpublished MA Thesis Submitted to the International Institute of Geo-Information Science and Earth Observatory. in Degree of Master of Science in Geo-information. Enschede, Netherlands.

Agrawal A. 1995. Dismantling the Divide between Indigenous and Scientific Knowledge. *Development and Change.* 26 (3): 413-439.

Agyepong G T. 1997. *Land degradation in Ghana.* University of Ghana. Legon, Ghana.

Allen T.F. and Starr T.B. 1982. *Hierarchy: Perspectives for Ecological Complexity.* University of Chicago Press, Chicago: 310.

Allotey J. Baidoo A. and Martensson U. 1999. *Best Practices of Environmental Information Systems the case of Ghana.* DUMECO, Sweden.

Altieri M. and Yurjevic A. 1995. "The Latin American Consortium on Agro-ecology and Development (CLADES) – Fostering Rural Development based on Indigenous Knowledge" Chapter 40 in: *Cultural Dimension of Development: Indigenous Knowledge Systems.* D. M. Warren L.J. Slikkerveer and D Brokensha, eds. London: Intermediate Technology Pub. Ltd. 458-461.

Amamoo-Otchere E. 2002. Capacity Building for Space-based Resources Information Management Systems for Poverty-reduction Planning at Grass-roots Level: Possibilities at CERSGIS, Legon, Ghana. *Paper presented at the United Nations Regional Workshop on the use of Space Technology for Disaster Management for Africa.* Addis Ababa, Ethiopia. 1-5 July.

Amanor K. S. 1994. *The New Frontier: Farmers response to land degradation: A West African Study.* Zed Books, London.

Andrew F. 2002. *Transforming Technology: A Critical Theory Revisited.* Oxford University Press, UK.

Antenucci, John C, Kay Brown, Peter L, Croswell and Michael J. Kevanny 1991. *Geographic Information Systems: A Guide to the Technology.* New York: Van Nostrand Reinhold.

Ardayfio-Schandorf 2005. Off-Reserve Tree Management in the Goaso Forest District. *University of Ghana Tropenbos Project in Collaboration with the Resource Management Support Centre (RMSC), Forestry Commission*, Kumasi and Rural Youth Association (RUDEYA), Accra, Ghana.

Arksey H. and Knight P. 1999. *Interviewing for Social Scientists. An Introductory Resource with Examples.* Sage Publications, London.

Arvello-Jiminez N., and Keith C. 1995.The Yekuana Self-demarcation Process. *Cultural Survival Quarterly,* 18 (4): 40-43.

Asenso-Okyere K. Faber C. D. and Meijerink G. 1998. Natural Resources Management Oriented Agricultural Research and Policy Change: Comparing Two Ghanaian Research Experiences. *Closing the Loop: From Research and Natural Resources to Policy Change. Policy Management Report. No 8.* Maastricht: European Centre for Development Policy Management: 34-51.

Ashley, C. and Carney, D. 1999. *Sustainable Livelihoods: Lessons From Early Experience*, DFID, London.

Atta-Krah K, Kindt R, Skilton J. N and Amaral W. 2004. Managing biological and genetic diversity in tropical agroforestry. *Agroforestry Systems* 61: 183–194.

Azad B. 1998. *Management of Enterprise-wide GIS Implementation: Lessons from Exploration of Five Case Studies*. PhD thesis, Department of Urban and Planning, MIT Cambridge.

Azad B and Wiggins L. 1995. Dynamics of Inter-organizational Data Sharing: a Conceptual Framework for Research. In: *Sharing Geographic Information* Eds. H. J. Onsrud, G. Rushton. Centre for Urban Policy Research, New Brunswick: 22-43.

Babbie E. 2001. *The Practice of Social Research.* 9th Ed. Wadsworth Publishing, CA, USA.

Barnaby J. 2002. 'Recognizing traditional ecological knowledge' in: J. Bird, L. Land and M. MacAdam (eds.) *Nation to Nation: Aboriginal Sovereignty and the Future of Canada Toronto*. Irwin Publishing, pp. 85-91.

Barndt M. 1998. Public Participation GIS: Barriers to implementation. *Cartography and Geographic Information Systems*. 25: 105-111.

Barr R. 1998a. The Price of Freedom. *GIS Europe*. 7 (3), 14-15.

Barrett C. 2001. Community-Based Natural Resource Management. *BioScience.* (51): 497-502.

Bassole A., Brunner J. and Tunstall D. 2001. Supporting Environmental Planning and Management in West Africa. *A Report of the Joint USAID/World Resources Institute Information Working Group for Africa*. USA..

Batterbury S.T., Forsyth T. and Thomson K. 1997. Environmental Transformations in Developing Countries: Hybrid Research and Democratic Policy. *The Geographical Journal* 163 2: 126-132.

Becker R. 2001. From Data to Information. Proceedings of the 5th *AfricaGIS Conference & Exhibition. Nairobi Kenya*, 5-9 November 2001.

Bell S. and Wood-Harper, T. 1992. *Rapid Information Systems Development: A Non-Specialist's Guide to Analysis and Design in an Imperfect World.* London: McGraw-Hill Book Co.

Bellamy J., Walker J., McDonald G. T. and Syme G. J. 2001. A Systems Approach to Evaluation of Natural Resource Management Initiatives. *Journal of Environmental Management* 63: 407–423.

Bellamy, J. A., McDonald, G. T., Syme, G. J. and Butterworth, J. E. 1999a. Evaluating Integrated resource management. *Society and Natural Resources* 12, 337–353.

Bellamy, J. A.,McDonald, G. T., Syme, G. J.,Cottrell,A., Johnson, A. K. L., McCreddin, J. A., Robinson, J. and Walker, D. H. 1999b. The Herbert River Integrated Catchments Management Process: Longitudinal Study. In: *Evaluation of Integrated Catchment Management in a Wet Tropical Environment: Collected Papers of LWRRDC R&D Project CTC7 (J. A. Bellamy, compiled*), 1: 67–200. Brisbane: CSIRO Tropical Agriculture.

Benbasat I., Goldstein D. K. and Mead M. 1987. The Case Study Research Strategy in Studies of Information Systems. *MIS Quarterly*, September, 369-386.

Benneh G.1997. Indigenous African Farming Systems: Their Significance for Sustainable Environmental Use (Keynote Address). In: *Environment Biodiversity & Agricultural Change in West Africa.* Perspectives from Ghana. Eds. Edwin Gyasi and Uitto J. I. United Nations University Press, Tokyo.

Benneh G. 1995. Towards Sustainable Development: An African Perspective. *Geografisk Tidsskrift* 90:1-4.

Benneh, George. 1987. "Land Tenure and Agroforestry Land Use Systems in Ghana," In: John Raintree (ed.) *Land, Trees, and Tenure.* Madison: University of Wisconsin Press, 163-168.

Benneh G. and Agyepong G. T. *Land Degradation in Ghana.* Commonwealth Secretariat, Marlborough House, Pall Mall, London, Department of Geography and Resource Development, University of Ghana, Legon, Ghana. 126-127.

Benneh G. and W. Ahadzie 2004. Poverty Reduction Efforts In: *Ghana; The Skill Development Option*, Accra.

Berg, B.L. 1998. *Qualitative Research Methods for the Social Sciences.* Needham Heights, Allyn and Bacon.

Berger, T. 2001. Agent-based spatial models applied to agriculture: a simulation tool for technology diffusion, resource use changes and policy analysis. *Agricultural Economics* 25 (2/3): 245-260.

Berkes F., 1999. *Sacred Ecology: Traditional Ecological Knowledge and Resource Management.* Philadelphia, Taylor and Francis.

Bernhardsen T. 1999. *Geographic Information Systems: An Introduction.* 2nd Edition. John Wiley and Sons, Inc. New York.

Besley T. and A Case, 1994. "Diffusion as a Learning Process: Evidence from HYV Cotton" *Working Paper, Department of Economics, Princeton University*, USA.

Bhaskar V., and Jeffery R., (eds) 2001. *Introdution: Analytical Issues in Participatory Natural Resource Management.* Palgrove Publishers Ltd., New York.

Blaikie, P. and H. Brookfield 1987. *Land degradation and society.* London: Methuen
Brookfield, H., H. Parsons and M. Brookfield eds 2003. *Agrodiversity: learning from farmers across the world.* Tokyo: United Nations University Press.

Blaikie P. 1989. Environment and Access to Resources in Africa. *Africa* 59 (1):18-40.

Blaikie, P.K., P. Brown, P. Dixon, M. Sillitoe, Stocking, and L. Tang, 1996. "Knowledge in Action: Local Knowledge as a Development Resource and Barriers to Its Incorporation in Natural Resource Research and Development," *Agricultural Systems.* 55:217–37.

Blankson E. J. 1989. A Case for a Vegetation Survey of the Afram Plains Basin of Ghana. In: Agyepong G. T. Gyamfi-Aidoo J, Allotey J. A. and Yankson PWK (eds) Remote Sensing in Ghana. *Proceedings of the National Seminar/Workshop on Remote Sensing and Geographic Information Systems.* P. 63-66 Accra.

Blaut J. M., Stea D. Spencer C. and Blades M. 2003. Mapping as a Cultural and Cognitive Universal. *Annals of Association of American Geographers.* 93 (1):165.

Boon E. K.1998. Monitoring, Evaluation and Control of Environmental Policy and Programmes in Developing Countries: Lessons from Ghana. L Hens, R. Borden, S. Susuki and G Caravallo (eds.), *Case Studies in Applied Human Ecology-An International Overview.* VUB-Press, Brussels.

Boon K. and Hens L. 1999. Institutional, Legal and Economic Instruments in Ghana's Environmental Policy. *Environmental Management.*24 (3): 337-351.

Boon E. K. 1998. Monitoring, Evaluation and Control of Environmental Policy and Programmes in Developing Countries: Lessons from Ghana. In: L Hens, R. Borden, S. Susuki and G Caravallo (eds.), *Case Studies in Applied Human Ecology-An International Overview.* VUB-Press, Brussels.

Boon K. E. and Hens L. 1999. Institutional, Legal, and Economic Intruments in Ghana's Environment Policy. *Environmental Management.* 24 (3): 337-351.

Borley S. F. H. 1991. *A Review of Literature on the Use of Geographical Information Systems in Developing Countries.* Department of Shield, UK.

Bozeman B. and Klein H. 1998. *The Case Study as Research Heuristic: Lessons from the R&D Value Mapping Project.* June 24, 1998.

Bradshaw, B. 2 003. Questioning the credibility and capacity of community-based resource management. *The Canadian Geographer* 47(2): 137-150.

Brinkerhoff D. W. 1996a. Coordination Issues in Implementation Networks: An Illustration from Madagascar's Environmental Action Plant. *World Development* 24 (9): 1497-1510.

Brinkerhoff D.W. Gage J. D. and Yeager J. A. 1992. Implementing Natural Resources Management Policy in Africa. *A Document and Literature Review. Prepared for USAID/AFR/ARTS/FARA by Management Systems International, the International Development Management Centre,* University of Maryland, Washington D. C.

Brokensha H. C. and Brown P. 1980. *Indigenous Knowledge Systems and Development. Washington DC.* University Press of America.

Brookfield H. and Padoch C. 1994. Appreciating Agrodiversity: A Look at the Dynamics and Diversity of Indigenous Farming Systems. *Environment*, 36 (5): 6-11.

Brookfield H. and Stocking M. and Brookfield M. 1999. Guidelines on Agrodiversity Assessment in Demonstration Site Areas. Revised to form a Companion Paper to the BAG guidelines). *PLEC News and Views* 13: 17-31.

Brookfield H. eds 2003. *Agrodiversity: Learning From Farmers across the World.* Tokyo: United Nations University Press.

Brookfield H. 2002. PLEC News and Views. A Periodical of the United Nations University Project of Collaborative Research on People, *Land Management and Environmental Change* (PLEC). No 10-May.

Brookfield H. 2001. *Exploring Agro-diversity.* New York Columbia, University Press.

Brookfield H. 1987. Land Degradation and Society: London: Metheun.

Brush S. B. and Stabinsky D. 1996. *Valuing Local Knowledge*. Washington DC., Island Press.

Bryant R. 1998. "The Rise and Fall of Taunga Forestry: Social Forestry in Defense of the Empire. *The Ecologist* 24 (1): 21-26.

Bryant L. 1995. The Rise and Fall of Taunga Forestry: Social Forestry in Defense of the Empire. *The Ecologist* 24 (1): 21-26.

Bryant R. and Wilson, G. 1998. Rethinking Environmental Management. *Progress in Human Geography.* 22: 321-43.

Budic-Nedovic Z and Pinto K. J. 1999. Understanding Interorganisational Context: Interaction and Adaptation, NGIA/GISDATA. *International Young Scholars Institute Maine.* US. 1-17.

Budic Z. D. 1994. Effectiveness of Geographic Information Systems in Local Planning. *APA Journal*. Spring, 1994.

Buttenfield P. 2004 Formalizing Semantic Spaces for Information Access Sara Irina Fabrikant, Barbara. *Annals of American Geographers*. 5-Nov-2004.

Caldwell W., Bowers S., Greening H., B., S. and Williams O. A., 1999. *Community Development Approach to Environmental Management*. Environments 27 (27): 2.

Calestous Juma, 2002. Technological change and sustainable development: Developing Country Perspective. *Proceedings of the American Association for the Advancement of Science, Annual Meeting and Science Development Exposition.* February 14-19, 2002. Boston, USA.

Calkins H.W.and Obermeyer N.J.1991. Taxonomy for Surveying the Use and Value of Geographical Information. *International Journal of Geographical Information Systems* 5 (3):341-51.

Campbell M. 1993. *Implementing the Environmental Action Plan of the Environmental Protection Council in Accra: Problems and Prospects.* Unpublished MPA Dissertation, University of Ghana, Accra.

Campbell H. and Masser I. 1995. *GIS and Organizations.* Taylor & Francis, London.

Campbell H. 1991. *Impact of Geographic Information Systems on Local Government,* TRP 101, Sheffield UK: The University of Sheffield.

Chambers, R. and Conway, G.R. 1992. Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. *IDS Discussion Paper No.296.*: IDS, Brighton.

Carter J. R. 1989. On Defining the Geographic Information Systems. In: *Fundamentals of Geographic Information Systems*: A Compendium, W. T. Ripple (ed.) Falls Church: VA, ASPRS/ACSM).

Cashman K. 1992. Systems of Knowledge as Systems of Domination: the Limitations of established Meeting. Agriculture and Human Values 8 (1): 49-58.

Castells M. 1989. *The Informational City: Information Technology, Economic Restructuring and the Urban-regional Process* Blackwell, Oxford.

Cavaye, A.L.M. 1996. "Case study research: a multi-faceted research approach for IS," *Information Systems Journal* 6 (3): 227-242.

CDEP 2004. *Adoption and Impact of Livelihood Activities in the Kumasi Peri-Urban Interface*, Unpublished Report Number One, Accra.

Chambers R., 1998. Behaviour and Attitudes: A Missing Link in Agricultural Science" In: V. L. Chopra R. B. Singh and A. Varma, eds. *Crop Productivity and Sustainability Proceedings of 2nd International Crop Science Congress*, New Delhi: Oxford University Press and IBH Publishing.

Chambers R. A. 1993. *Rural Development: Putting the Last First.* Scientific and Technical. Essex: Longman.

Christoffersen L.., Denisov N., Folgen K., Heberlein C., Hislop L., Holt H., Simonett O., Tveitdal S., 2000. *Impact of Information on Decision Making Processes. GRID Adrenal Issues Paper.* Adrenal May 11, 2000.

Ciborra C. 1993. *Teams, Markets and Systems.* Cambridge University Press, United Kingdom.

Clark T. 2002. The *Policy Process: A Practical Guide for Natural Resource Professionals.* Yale University, USA.

Coakes S. J. 2001. *SPSS Analysis Without Anguish: Version 10.0 for Windows* Milton, Qld: J. Wiley and Sons Australia.

Coorperazione R. 2005. *Forest Resources Creation Project (FRCP) 2001-2004, European Union* and RC Unpublished Report. UK.

Costanza R., Segura O. and Martinez-Alier J. 1996. *Getting Down to Earth: Practical Applications of Ecological Economics* Washington DC Island Press, USA.

Crehan K. 1997. *The Fractured Community: Landscapes of Power and Gender in Rural Zambia.* Berkeley: University of California Press, USA.

Curry M. 1997. The Digital Individual and the Private Realm. *Annals of the Association of American Geographers.* 87 (4): 681-699.

Curry M. 1995. Rethinking Rights and Responsibilities in Geographic Information Systems: Beyond the Power of the Image. *Cartography and Geographic Information Systems.* 22 (1): 58-69.

Curtis A., Robertson A. and Race D. 1998. Lessons from recent evaluations of natural Resource management programs in Australia. *Australian Journal of Environmental Management.* 5 (2): 109–119.

Darke P., Shanks, G. and Broadbent M. 1998. Successfully Completing Case Study Research: combining rigour, relevance and pragmatism. *Information Systems Journal.* 8 (4): 273-289.

Davies L., Newman M. and Kaplan B. 1993. A Workshop on Two Techniques for Qualitative Analysis: Interviewing and Evaluation. *Proceedings of the Fourteenth International Conference on Information Systems.* 399.

DeLone W. H. and McLean E. R. 1992. Information Systems Success: The Quest for the Dependent Variable. *Information Systems Research.* 3 (1):60-95.

den Biggelaar C. 1995. Mainstreaming Gender Concensus: Aspects of Compliance, Resistance and Negotiation. In: A. M. Goetz (ed) *Getting Institutions Right for Women in Development*. London: Zed Books p. 77-89.

De Man, W.H.Erik, 2000. Institutionalization of Geographic Information Technologies: Unifying Concept. *Cartography and Geographic Information Science*. 27 (2): 139-151.

Denbach J. 2002. *Toward Sustainability*. Washington, DC: Environmental Law Institute, 593-605.

Denzin, N. K., & Lincoln, Y. S. (eds). 1994. *Handbook of Qualitative Research.* Thousand Oaks, CA: Sage.

DeVries J and Toenniessen G. 2001. *Securing the harvest: Biotechnology, breeding, and seed systems for Africa's crops*. CABI Publishing, Wallingford U.K.

Doss and Morris, 2001. "How Gender Affect the Adoption of Agricultural Innovations? The Case of Improved Maize Technology in Ghana" *Agricultural Economics*. 25: 27-39.

Drijver C. A. and Sajise P. E. 1993. Community-based Resource Management and Environmental Action. *Community-based Resource Management: Perspectives, Experiences and Policy Issues*. Halifax, Nova Scotia/Laguana, Phillippines: Environmental and Resource Management Project, ERMP Report 6: 29-50.

Duadze S. E. K., Adu-Prah S., Annor J. and Donyuo S. S. 1999. National Land Use and Land Cover Mapping of Ghana Using Satellite Imagery. *Proceedings of a Seminar on Remote Sensing and Geographic Information Systems (GIS) in Ghana. Research Applications and Collaborations, Organised by the Remote Sensing Applications Unit, University of Ghana, Legon.*

Dube L and Pare G. 2003. Rigor in Information Systems Positivist Case Research: Current Practices, Trends and Recommendations. *MIS Quarterly*. Minneapolis. 27 (4): 597.

Duncan, S.L. 2004. *Technology and Meaning in Natural Resource Management: The Story-making Potential of GIS in the CLAMS Project*. Ph.D. Thesis, Environmental Sciences, Oregon State University.

Dzidonu C. 2003. *An Integrated ICT-led Socio-Economic Development Policy and Plan Development Framework for Ghana.* The Ghana ICT for Accelerated Development (ICT4AD) Process. United Nations Economic Commission for Africa. Valley View University, Ghana.

Earl, M.J. 1993. "Experiences in Strategic Information Systems Planning," *MIS Quarterly* 17 (1): 1-24.

Eason, K. 1988. *Information Technology and Organizational Change*. Taylor and Francis, London.

Eastman J. R. 1993. Decision Theory and GIS. *Proceedings of the Africa GIS '93 Conference*. June, Tunisia: 12-33.EIS-SSA, 2001. About the Programme on Environmental Information Systems in Sub-Saharan Africa. *Http://www.grida.no/eis-ssa/about/about.htm, (Accessed 27/10/2001).*

Edmunds D. 1997. Green Imperialism? Conservation Refugees and Kibale Forest National Park. *Paper Presented at the Association of American Geographers Annual meeting*, Charlotte, NC 5-9 March.

EIS-Africa 2001. Environmental Information System-Africa. In: *Environmental Information Systems Development in Sub-Saharan Africa: Approaches, Lessons, and Challenges.* Gavin E. and J. Gyamfi-Aidoo (eds). EIS-Africa.

EIS-Zimbabwe, 2002. Best Practices of EIS: the Case of Zimbabwe. *http://www.grida.no/eis-ssa/products/zimbabwe/zimca008.htm* (Accessed 08/10/02).

EIS Africa, 2002. *Geo-Information Decision Support in Africa. http://www.eis-africa.org/DOCS/A5-Engv7.pdf* (Accessed 08/10/02).

EIS News, 1999. Ghana – Country at a Glance. http://www.grida.no/eis-ssa/eisnews/1_99/cag.htm (Accessed 23/01/2002).

Elliott J. A. and Campbell M. 2002. The Environmental Imprints and Complexes of Social Dynamics in Rural Africa: Cases from Zimbabwe and Ghana. *Geoforum. (*33): 221-237.

EPA, 2001. *National Framework for Geo-spatial Information Management: Harnessing Spatial Information for Development. http://www.epa.gov.gh/Nafgim/NAFGIM.htm* (Accessed 08/10/02).

EPA 1997. *Annual Report*. Environmental Protection Agency, Accra.

EPA 1999. Updating of National Land Use in 2000. National Resource Management Project. *Ministry of Lands and Forestry and Environmental Protection Agency Project*. Government of Ghana, Accra, Ghana. 127.

Environmental Protection Agency (EPA) 1996. *Environmental Action Plan.* Vol 1 EPC, Accra, Ghana, p. 106.

Escobar A. 1996. Constructing Nature: Elements for a Post-structural Political

Ecology. In: *Liberation Ecologies*, eds Peet R. and Watts M. 46-68. Routledge, London.

Est D. and Person G., 2001. Constructing the Future: Dynamics of Local and External Views Regarding Community-based Resource Management. In: *Analytical Issues in Participatory Natural Resource Management. E*ds. Bhaskar Vira and Jeffery R. Palgrave Publishers Ltd. New York.

Evangelatos T. V. 1999. Minutes from the February 8, 9 and 10 1999. Inter-Agency Committee on Geomatics, Canadian Council on Geomatics National Coordination Meeting on Canadian Geospatial Data Infrastructure. *http://cgdi.gc.ca/english/.* (Accessed 25/08/01).

Fabricant S. I., Buttenfield P. B. 2001. Formalizing Semantic Spaces for Information Access. *Annals of Association of American Geographers.* 91(2): 263-280.

Falloux F. 1989. Land Information and Remote Sensing for *Renewable Resource Management in Sub-Saharan Africa.* Washington DC, World Bank.

FAO, 2003. Country Deforestation Data: The State of the World's Forests. *Food and Agriculture Organization* FAO, Accra Ghana.

FAO 1999. *Food and Agriculture Organization: A Gender Perspective*. FAO United Nations.

Feenberg A., 2002 Technology in a Global World. In: *Science and Other Cultures: Issues in Philosophies of Science and Technology*, R. Figueroa and S. Harding eds. Routledge, *forthcoming*. Technology in a Global World. Japanese Version in *Shisaku,* Journal of the Philosophy Department of Tohoku University.

Feenberg A., 2002. *Transforming Technology: A Critical Theory Revisited.* Oxford University Press.

Feenberg A. 1999. *Questioning Technology*. Routledge, New York.

Fellizar F. P. 1993. Synthesis and Recommendations. In: *Community-based Resource Management: Perspectives, Experiences and Policy Issues*. Halifax, Nova Scotia/Laguana, Philippines: ERMP Reports 6, 141-148.

Firestone, W. 1993. Alternative arguments for generalizing from data as applied to qualitative research. *Educational Researcher* 22 (4): 16-23.

Flora C. B., Restructuring Agriculture: the Case for Local Knowledge. *Rural Sociology*, 57 (1): 92-97.

Flyvbjerg B. 2004. Five Misunderstandings about Case Stuy Research. In: Seale C, Gobo G. Gubrium J. F. and Silverman (eds.). *Qualitative Research Pracitice*. London and Thousand Oaks, CA: Sage. 420-434.

Fontana, A. and Frey, J. H. 1994. Interviewing: The Art of Science In: Denzin, N. K. and Lincoln, Y. S. eds. *Handbook of Qualitative Research*, p. 236-247, SAGE Publications, Thousand Oaks, California.

Foody G. M. and Hill R. A. 1996. Classification of Tropical Forest Classes From Landsat TMdata. *International Journal of Remote Sensing*. 17: 2353-2367.

Forbes A. A. 1995. Heirs to the land: Mapping the Future of the Makula-Barun. *Cultural Survival Quarterly.* 18 (4): 69-71.

Forestry Commission, 2001. *An Information Management Strategy for Ghana's Forest Sector.* Devised by MIS Developers Group Under the NRMP Consolidated by Forestry Commission Research and Information Management Unit. Accra.

Furlong D. 1996. *The Conceptualization of Trust in Economic Thought. Working Paper* 35. Brighton, UK.: Institute of Development Studies, University of Sussex.

Found W.C. 1991. Implementing Environment-Management Programmes: A general Framework for Analysis. In: *Programme and Policy Implementation- Proceedings of Workshop at the Bandung Institute of Technology*, (ed.) F.Carden, W. Found and R. Amir. Research Paper No 42: 229-293. Bandung: University Consortium on the Environment.

Fox J. 1998. Mapping the Commons: The Social Context of Spatial Information Technologies. *The Common Property Resource Digest* 45:1-4.

Fox J. 1992. The Problem of scale in Community Resource Management. *Environmental Management.* 16:289-297.

Gable G. 1994. Integrating Case Study and Survey Research Methods: An Example in Information Systems. *European Journal of Information Systems*.3 (2):112-126.

Gadgil, M., F. Berkes, and C. Folke. 1993. Indigenous Knowledge for Biodiversity Conservation. *Ambio* 22:151-156.

Gavin E. and Gymfi-Aidoo J. 2000. *Environmental Information Systems in Sub-Saharan Approaches, Lessons and Challenges*. EIS Africa, Kenya.

Gene M. Y 1991. *Environmental Databases Design, Implementation and Maintenance.* Lewis Publishers Inc. Michigan USA.

Gerster R. and Zimmermann S. 2003. *Information and Communication Technologies (ICTs) for Poverty Reduction*? SDC Discussion Paper, Bern.

Gilruth P. and Prevost Y. 1997. *Environmental Information Systems in Sub-Saharan Africa: From Innovation to Management.* The World Bank Group. No. 128 February, 1999.

Gilruth P. and Prevost Y. 1999. Environmental Information Systems in Sub-Saharan Africa: From Innovation to Management. In: *The World Bank Group.* No. 128 February, 1999.

Gogo J. O 1997. The Role of Technology in Environmental Management. In Boon E. K. and Hens L. *Proceedings of the Seminar on Key Economic and Legal Instruments for Environmental Management in West Africa. Human Ecology Department,* VUB, Brussels, Belgium.

Goodchild M., Egenhofer M, Kemp K., Mark D. and Sheppard E. 1999. 'Introduction to the Varenius Project. *International Journal of Geographical Information Science* 13 (8): 731-745.

Goodchild M., Longley P., Maguire D. and Rhind D. W. 2001. *Geographic Information Systems and Science.* John Wiley and Sons Ltd, Sussex, England.

Gordon C. 1997. *Environmental Health Risk Analysis.* In: E. K. Boon and L. Hens (eds.) Proceedings of Seminar on Key Economic and Legal Instruments for Environmental Management in West Africa. Human Ecology Department, VUB, Brussels, Belgium.

Gore, A., 1993. *Earth in Balance*, Plume, New York.

Gore J. 2000. IPM/ICM for Vegetable and other Crops in Antigua and Barbuda: Status, potential and problems. Presented at the *Workshop on Farmer Participatory Methods for Ecological Crop Management.* September 11-15, Trinidad and Tobago.

Goss J. 1995. We Know Who You are and We Know Where You Live: The Instrumental Rationality of Geodemographic Information Systems. *Economic Geography.* (71): 171-98.

Gouveiaa C., Fonsecaa, Caˆmarab, A., Ferreirab F. 2004. Promoting the Use of Environmental Data Collected by Concerned Citizens through Information and Communication Technologies. *Journal of Environmental Management.* (71): 135–154.

Government of Ghana, 1997. *Ghana Poverty Reduction Strategy: An Agenda for Growth and Prosperity.* Ghana Publishing Corporation, Accra.

Government of Ghana 2002. *Ministry of Communications, Speech by Minister F. K. Owusu-Adjapong on Ghana's Effort*. To Become the ICT Hub and Destination of Choice for ICT Foreign Direct Investment.

Government of Ghana, 2002. *Framework for the Development of a National Policy for Information Technology*. Draft Version 1, Accra, Ghana.

Government of Ghana 2002. *Ministry of Communications, Speech by Minister F. K. Owusu-Adjapong on Ghana's Effort*. To Become the ICT Hub and Destination of Choice for ICT Foreign Direct Investment.

Grant, W.E., Pedersen, E.K., Marın, S.L., 1998. *Ecology and Natural Resource* Management: Systems Analysis and Simulation. Wiley, New York, 373 pp.

Grant, W.E., 1986. Systems Analysis and Simulation in Wildlife and Fisheries Sciences. Wiley, New York, 338.

Greenberg J. B. and Park K T. 1994. Political Ecology. *Journal of Political Ecology* 1 (1):12.

Grimble R. and Laidlaw M. 2002. Biological Resource Management: Integrating Biodiversity Concerns in Rural Development Project and Programme. In: Towards Environmentally and Socially Sustainable Development. Paper No 85. Prepared by the Natural Resources Institute (NRI) for the Environment and Rural Departments of the World Bank, with Funding from the Department for International Development (DFID), United Kingdom.

Grindle M. S. 1996. Challenging the State: Crisis and Innovation in Latin America and Africa. Cambridge University Press.

Grindle M. S. 1980. Politics and Policy Implementation in the Third World. Princeton: University Press.

Guha, R. 1989. *The Unquiet Woods: Ecological Change and Peasant Resistance inthe Himalaya*. Berkeley: University of California Press.

Guijt I. et van Veldhuizen L. 1998, *Quels Outils pour l'agriculture Durable ? Analyse Compare des Méthodes Participatives,* Programme Zones Arides, Dossier 79, Londres, IIED, 36.

Gyamfi-Aidoo, J. 1999, EIS News - October 1999, *http://www.grida.no/eis-sa/eisnews/1-00/01.htm*, (Accessed 29/12/05).

Gyamfi-Aidoo J. 1994. Environmental Information System Workshop in the Gambia. Legon: *Remote Sensing Applications Unit,* University of Ghana.

Gyasi, E.A., G. Kranjac-Berisavljevic, E.T. Blay and W. Oduro, eds, 2005. *Managing Agrodiversity in the Traditional way: Lessons from West Africa in sustainable use of Biodiversity and Related Natural Resources.* Tokyo: United Nations University Press.

Gyasi E. A. Kranjac-Berisavljevic G., Blay E. T. and Oduro W. 2004. *Managing Agro-diversity the Traditional Way.* Lessons from West Africa in Sustainable Use of Biodiversity and Related Natural Resources.

Gyasi 2004. Demonstration Sites and Expert Farmers in Conservation of Biodiversity. In: Managing Agrodiversity the Traditional Way: Lessons from West Africa. In: *Sustainable Use of Biodiversity and Related Natural Resources* (ed) Gyasi E, Blay E, Gordana K and Oduro W. United Nations University Press. New York.

Gyasi, E.A., Oduro W., Kranjac-Berisavljevic G, Dittoh S. and Asante W. 2003. In H. Brookfield, H. Parsons and M. Brookfield, eds, *Agrodiversity: Learning from Farmers Across the World.* Tokyo: United Nations University Press.79-109.

Gyasi E. A. 2004. UNU/PLEC Place Emphasis on the Study of Agro-diversity Among Small Farming Communities in the Tropics. *PLEC News and Views,* Accra.

Gyasi E. A. 2002. Traditional Forms of Conserving Biodiversity within Agriculture: Their Changing Character in Ghana. In: Brookfield H. Padoch C., Parson H., *Agrodiversity* United Nations University Press. 79-109.

Stocking M. 1996. *Cultivating Biodiversity: Understanding, Analyzing and Using Agricultural Diversity.* London: ITDG Publishing.

Gyasi, E. A. 2001. Development of Demonstration Sites in Ghana. *PLEC News and Views, Accra.* 18: 20-28.

Gyasi E. A. 1998. PLEC (People Land Management and Environmental Change) Experiences with Participatory Approach to Bio-physical Resources Management in Ghana. *PLEC News and Views.* No 10, May.

Gyasi, E. A. and J. I. Uitto eds. 1997. Environment, Biodiversity and Agricultural Change in West Africa: Perspectives from Ghana Tokyo United Nations University Press.

Hall B. 1999. GIS Education and Infrastructure: Challenges and Problems in Emerging Countries. *Transactions in GIS.* 3(4): 311-317.

Hambly H. V. 1999. *The Implementation and Institutionalization of Agro-forestry in Western Kenya*: A Gender and Agency Analysis.Doctorial Disssertation. York University, North York, Ontario, Canada.

Hammersley, M. 1992. *What's Wrong with Ethnography? Methodological Explorations*, Routledge, London.

Harris T. M. D. and Levin R. 1995. Pursuing Social Goals Through Participatory GIS: Redressing South Africa's Historical Political Ecology. In: *Ground Truth: The Social Implications of Geographic Information Systems*. J. Pickles eds. New York.

Harris T. M. and Weiner D. 1998b. Empowerment, Marginalization and Community-Integrated GIS. *Cartography and Geographic Information Systems*. 25 (2): 67-76.

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

Haverkort B., van't Hooft K. and Hiemstra W (eds), 2003. *Ancient Roots, New Shoots: Endogenous Development in Practice*, Leusden: ETC/Compas.

Haverkort, Bertus; Hooft, Katrien van at; Hiemstra, Wim (eds.) 2002. Ancient Roots, New Shoots Endogenous development in practice. Zed Books, London, GB; New York, NY, USA. P. 264.

Hawken, P. 1996. A Teasing Irony. In: R. Welford and R. Starkey (eds.) *Business and the Environment*, London: Earthscan pp. 5-16.

Hawthorne, W.D. 1994. Fire Damage and Forest Regeneration in Ghana: Forestry Inventory and Management Project of the Ghana Forestry Department. Overseas Development Administration, London.

Heidegger M. 1977. *The Question Concerning Technology*, W. Lovitt, New York: Harper and Row. 17.

Hoeschele W. 2000. Geographic Information Engineering and Social Ground Truth in Attappadi Kerala State, India. *Annals Association of the American Geographers*. 90 (2): 293-321

Holden M. 2000. GIS in Land Use Planning: Lessons from Critical Theory and the Gulf Islands. *Journal of Planning Education and Research*. 19:287-296.

Holding C. and Omondi W. (eds) 1998. Evolution of Provision of Tree Seed in Extension Programmes: Case Studies from Kenya and Uganda. SIDA Technical Report No. 19. Regional Land Management Unit, Swedish International Development Cooperation Agency, Nairobi, Kenya. http://www.rbgkew.org.uk/peopleplants/handbook/handbook5/interviews.htm

Holling C. and Meffe, G. K. 1996. Command and Control and the Pathology of Natural Resource Management. *Conservation Biology* 10:328-337.

Horsburgh R. 2003. *Shift from Single to Multi-Purpose Land Use. Summit to Sea Conference*: The Values of Scotland's Mountains and Water in the 21st Century, Battleby, Scotland.

Hountondji, P.J. (ed.) (1997) *Endogenous Knowledge: Research Trails*. Dakar: CODESIRA.

Hugo G. 2001. Addressing Social and Community Planning Issues with Spatial Information. *Australian Geographer.* 32 (3): 269-293.

Huijun G. D. Zhiling and Brookfield H. 1996. Agrodiversity and Biodiversity on the Ground and Among the People: Methodology from Yunnan. *PLEC News and Views*, 6:15.

Hukkinen J. 1999. Expert Thinking and Environmental Institutions. *Biodiversity and Conservation.* 8: 17-27.

Hutchison C. F. and Toledano J. 1993. Guidelines for Demonstrating Geographic Information Systems Based on Participant Development. *International Journal of Geographical Information Systems.* 7 (5):453-461.

Ingold T. 2000. *The Perception of the Environment: Essays in Livelihood, Dwelling and Skill*. London: Routledge.

Ingold T. and Kurthila T. 1999. *Perceiving the Environment in Finnish Lapland. Manchester, England*: University of Manchester, Department of Anthropology. Unpublished Paper.

Jensen M. 2003. The Current Status of Information and Communications Technologies in Africa. In: *Information and Communications Technologies for African Development*. United Nations.

Job D. 1994. Global Climate Change, Natural Resource Management and Biodiversity Conservation in the Congo Basin: *A Preliminary Literature Review. For the Central African Regional Programme for the Environment* (CARPE).

Johnson J. P. 1996. Case Studies of Dissemination Policy in Local Government GIS Agencies. *Computer, Environment and Urban Systems*, 19 (5/6): 373-389.

Jones B. 1990. *Neighbourhood Planning: A Guide for Citizens and Planners*, Chicago and Washington DC: Planners Press, American Planning Association.

Jordan G. 1998. Public Participation GIS for Community Forestry User Groups in Nepal: Putting People Before Technology. Department of Agriculture and Forestry Newton Rigg College University of Central Lancashire, Penrith Carlisle.

Jordan, G H and Shrestha, B, 1998, *Integrating Geomatics and Participatory Techniques for Community Forest Management: Case Studies From the Yarsha Khola Watershed,* Dolakha District, Kathmandu, Nepal.

Kalenski Z. D. and Latham J. S. 1998. The Establishment of Environmental Information Systems in Developing Countries. *Proceedings of the Tenth International Geomatics Conference*, Ottawa, Canada. 8-11 June 1998. MAPSAT Ltd. Durbin Court Kanata, Ontario. *http://cgdi.gc.ca/sdi98/geomatica_papers/kalensky.pdf* (Accessed 14/10/02).

Kannae L. and Appiah S. K. 2001. UNDP/Ghana Capacity 21 Programme. *Training Manual on Environmental Management and Development Planning for Sustainable Development*. Ministry of Environment Science and Technology. Accra, Ghana.

Karikari I and Stillwell J. 2004. *The Implementation of Geographical Information Systems for Land Administration in Ghana*. IDPR, 26 (2): 209-229.

Karikari I., Stillwell J. and Carver S. 2004. Land Administration and GIS: the Case of Ghana. *Progress in Development Studies*. 3 (3): 223-242.

Kay J. and Foster J. 1999. About Teaching Systems Thinking. In: Sage G. and Roy P (eds). *Proceedings of the HKK Conference*. 14-16 June, Waterloo Ontario.165-172.

Kellert, S., Mehta, J., Ebbin, S. and Lichtenfeld, L. 2000. Community Natural Resource Management: Promise, Rhetoric, and Reality. Society and Natural Resources Bradshaw, B. 2003 eds. In: Questioning the Credibility and Capacity of Community-Based Resource Management. *The Canadian Geographer* 47(2): 137-150.

Kellogg W. 1999. From the field: Observation Using GIS to Develop a Neighourhood Environmental Information System for Community-based Organizations, *URISA Journal* 11 (1): 15-32.

Kitchin R. and Frendchuh S. 2000. Cognitive Mapping. In: *Cognitive Mapping: Past, Present and Future*. (Eds). Kitchin R and Frenschuh S. Routledge London.

Klinkenberg B. 2003. The True Cost of Spatial Data in Canada. *The Canadian Geographer*. 47 (1): 37-49.

Klooster D. J. 2005. Towards Adaptive Forest Management: Integrating Local Forest Management with Scientific Forestry. *Economic Geography*. 78 (1): 43-70.

Knauer P. 1997. Environmental information systems for area- and ecological planning. A critical appraisal. In: *Colloquium-Geographicum*. 23: 111-131.

Knopman, D., Susman, M. and Landy, M. 1999. Civic Environmentalism: Tackling Tough Landuse Problems with Innovative Governance. *Environment* 41(10):24-32.

Kotey N. A., Owusu F., Yeboah K. S., Amanor M, and Antwi L. 1998. Falling into Place, Ghana International Institute for Environment and Development, Accra Ghana.

Kothari A. 2004. *Environmental and Social Management Framework. Draft Report.* Government of Ghana. 1: E928.

Krueger R. 1988. *Focus Groups*. Newbury Park, Sage, Califonia.

Kufogbe and Amatekphor, 1997. Remote Sensing Evaluation of Urban Encroachment on the Sakumo Coastal Wetland in the Accra-Tema Metropolitan Area in Ghana. *Bulletin of the Ghana Geographical Association*. 20, July.

Kull C. 2002. Empowering Pyromaniacs in Madagascar. Ideology and Legitimacy in Community-Based Natural Resource Management. *Development and Change*, 33 (1): 57-78.

Kwesiga F.R., Franzel S., Place F., Phiri D. and Simwana C.P. 1999. *Sesbania sesban* improved fallows in eastern Zambia: their inception, development and farmer enthusiasm. *Agroforestry Systems* 47: 49–66.

Kyburz-Graber R. 2004. Does Case-study Methodology Lack Rigour? The need for quality Criteria for Sound Case-study Research, as Illustrated by a Recent Case in Secondary and Higher Education. *Environmental Education Research.* 10 (1): 53-65.

Kyem K. P. 2004. Of Intractable Conflicts and Participatory GIS Applications: The Search for Consensus Amidst Competing Claims and Institutional Demands. *Annals of Association of American Geographers*, 94 (1): 37-57.

Kyem K. P. 2004. Power, Participation and Inflexible Institutions: An Examination of the Challenges to Community Empowerment in Participatory GIS Applications. *Cartographica.* 38 (3): 4.

Kyem K. P 2001a. Embedding GIS Applications in Resource Management and Planning Activities of Local and Indigenous Communities: A Desirable Innovation or a Destabilizing Enterprise? *Journal of Planning Education and Research.* 20:176-186.

Kyem K. P. 2000. A Choice Heuristic Algorithm for Managing Land Resource Allocation Problems Involving Multiple Parties and Conflicting Interests. *Transactions in GIS* 5 (2): 113-132.

Kyem K. P. 1999. Promoting Local Community Participation in Forest Management through the Applications of Geographic Information System: a PPGIS experience from Southern Ghana. *Report of a Specialist Meeting, Varenius National Center for Geographic Information and Analysis's Project to advance Geographic Information Science*, Santa Barbara, Oct. 14-17.

Lachman B. E., Wong A., Knopman D. and Gavin K. 2002. *Lesson for the Global Spatial Data Infrastructure: International Case Study Analysis.* Ramd Santa Monica, California USA.

Laituri M. 2002. Ensuring Access to GIS for Marginal Societies. In: *Community Participation and Geographic Information Systems.* Ed (Craig W. J. Harris M. T. and Weiner D.) Taylor and Francis, London.

Lake R. W. 1993. Planning and Applied Geography: Positivism, Ethics and Geographic Information Systems. *Progress in Human Geography.* 17 (3): 404-413.

Leakey R. 1996. Definition of Agro-forestry Revisited. *Agro-forestry Today.* 1(8):5-6.

Lee, T. W. 1999. *Using qualitative Methods in Organizational Research.* SAGE Publications, California.

Leeuwen L. and Martien G. 2004. Geo-Information Application for Off-Reserve tree Management in Ghana. In: *ITC NEWS is Published Quarterly*, by ITC, Enschede, the Netherlands, Number 2.

Levine, H.G. and Rossmore, D. 1993 "Diagnosing the Human Threats to Information Technology Implementation: A Missing Factor in Systems Analysis Illustrated in a Case Study," *Journal of Management Information Systems*, 10 (2): 55-73.

Ljesevic M. and Filipovic D. 1995. Environmental Information System as the Basis of Environmental Protection in Serbia. *Computer, Environment and Urban Systems.* 19 (2): 123-130.

Ludwig, D., Hilborn, R. and Walters, C. 1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History. *Science* 260:17-36.

Luger G. F. and Stubblefield W. D. 1993. *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*. Redwood City CA: Benjamin/Cummings Publishing Company.

Lye T. P., Jong W., and Ken-ichi, 2003. The Political Ecology of Tropical Forests in Southeast Asia Historical Perspectives. Kyoto University Press. Japan.

Lye T. P. 2000. Forest, Bateks and Degradation: Environmental Representations in a Changing World. Tonan Ajia Kenkyu South-east Asia Studies. 38:165-184.

Lykke A. M. 2000. Local Perceptions of Vegetation Change and Priorities for Conservation of Woody-savanna Vegetation in Senegal." Journal of Environmental *Management* 59 (2): 107-120.

Lyman, M. and Child, B. 2005 'Introduction' in: M. Lyman and B. Child (eds.) *Natural Resources as Community Assets, Sand County Foundation and The Aspen Institute*, 1-15.

Lyytinen K. 1991. Penetration of Information Technology in Organizations. *Http://www.iris.informatik.gu.se/sjis/vol3/kale.shtml (Accessed* 07/02/04).

MacDevette, D.R. 1993. The status of advanced information technology applications for Natural Resource Management in Southern Africa. In: C. Heatwole (Ed.) *Application of Advanced Information Technologies: Effective Management of Natural Resources*. Addison-Wesley Longman Publishing, USA.

MacDevette, D. R. 1991. Institutional concerns and opportunities in LIS/GIS-some experiences from South Africa. In De Goodwin, W. Olthof and K Philip (eds.) Institutional concerns and opportunities in LIS/GIS. *Proceedings of the Third Seminar on Land and Geogrphic Information Systems in Zimbabwe, Hahare*, 4-5 March.

MacDevette, D. R. 1991b. Introducing GIS: Implications in terms of Organizational strategy, structure and culture. *Proceedings of the Earth data Information Systems / South African Geographical Information System Conference*. Pretoria 16-18 July.

Machionini G. 1995. *Information Seeking in Electronic Environments.* Cambridge Series on *Human-Environment Interaction*, no 9. Cambridge UK, Cambridge University Press.

Mackenzie F. 2005. Land Tenure and Biodiversity: *An Exploration in the Political Ecology of Murang'a Districts, Kenya.*

Mammo T., 1999. The Paradox of Africa's Poverty: *The Role of Indigenous Knowledge, Traditional Practices and Local Institutions;* The Case of Ethiopia, Lawerenceville and Asmara: Red Sea Press.

Manchur W. 1997. From Thirsty Soils to Spirit Hills: *A Case Study of Indigenous Natural Resource Management for Sustainable Agriculture in Malawi*. Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Environmental Studies, Dalbousie University, Halifax, Nova Scotia, 20 October.

Marchand E. M. and Winchell R., 1994. Tribal Implementation of GIS. *Cultural Survival Quarterly*. 17 (4): 49-51.

Markus, M.L. 1989. Case Selection in a Disconfirmatory Case Study. In: *The Information Systems Research Challenge*, Harvard Business School Research Colloquium, Boston: Harvard Business School. 20- 26.

Martensson U., Eklundh L., Gyamfi-Aidoo J. and Tetteh E. 1999. Ghana: *Country at a Glance.* The Environmental Protection Agency. Ghana.

Mayher R. and Law M, 1994. Cultural Shift: GIS Training as an Agent of Change. In: Decision Making with GIS the Fourth Dimension. *Proceedings of GIS' 94 Symposium*. Vol 1. Ministry of Supplies and Services Canada. Vancouver, British Columbia.

Mbile P., DeGrande A., and Okon D. 2003. *Integrating Participatory Resource Mapping and Geographic Information Systems in Forest Conservation and Natural Resources Management in Cameroon:* A Methodological Guide. *EJISDC*, 14 (2): 1-11.

McKenna, B. 1995. *Community Participation in Local government – A Research Report And Critique,* Report by the Australian Centre for Regional and Local Government Studies for the Office of Local Government, University of Canberra, Canberra, Australia.

Meredith C. T. 1997. Information Limitations in Participatory Impact Assessment. In: John Sinclair ed. *Environmental Impact Assessment in Canada*. University of Waterloo Press.125-154.

Meredith T. C. 1997. Making Knowledge Powerful." *Alternatives Journal.* 23 (4): 28-35.

Merwe J. V. D. 2002. Sawu Bona: Systems Theory in Design. In: *Systems Theory and Practice in the Knowledge Age* (Eds. Ragsnall G. West D. and Wilby J.). Kluwer Academic/Plenum Publishers, New York.

Messerschmidt D. A. 1995. *Rapid appraisal for community forestry* IIED, London Simonett, O, 1992, Geographic Information Systems for Environment and Development. Summary paper, UNEP/GRID, Carouge, Switzerland.

Miles, M. B. and Huberman, A. M. 1994. Qualitative Data Analysis*: An Expanded Sourcebook.* 2nd Ed. SAGE Publications, Thousand Oaks, California.

Miller R. 1995. Beyond method, beyond ethics: Integrating social theory into GIS and GIS into social theory. *Cartography and Geographic Information Systems* 22 (1): 98-103.

Ministry of Food and Agriculture (MOFA), 2000. *Strategic Environmental Assessment of Agricultural Services Sector Investment Programme* (AgSSIP). Prepared under the auspices of EPA, March, 2000.

Ministry of Land and Forestry 1998. *Forest and Wildlife Policy*, Ministry of Land and Forestry, Accra.

Mitchell B. 1997. *Resource and Environmental Management*. Essex: Longman.

Mooneyhan W. D. 1998. International Applications of GIS. In: *The History of Geographic Information Systems*: Perspectives from the Pioneers, edited by Timothy Frosman,. 349-66. Upper Saddle River NMJ: Prentice Hall.

More H. L. and Voughan M. 1994. Cutting Down Trees: *Gender, Nutrition and Agricultural Change in Northern Province of Zambia,* 1890-1900. Portsmouth NH: Heinemann.

Munshi, K. 1999. Learning From Your Neighbours: *Why Do Some Innovations Spread Faster than Others?* Working Paper, Department of Economics, University of Pennsylvania.

NACIA, 21 32. Government of Ghana /MEST; *Evaluation of Ghana Capacity 21 Programme* /Final Report1, October 2001.

NAFGIM, 1993. National Framework for Geo-spatial Information Management in Ghana *http://www.epa.gov.gh/Nafgim/Role%20of%20the%20working%20groups-Policy.html* (Accessed 08/10/02).

Najim A. 1995. *Learning From the Literature On Policy Implementation*" A Synthesis Perspective. Lexenburg, Austria: International Institute for Applied Systems Analysis.

National Academy of Sciences, 2002. Down to Earth: *Geographic Information for Sustainable Development in Africa.* National Academy of Science Press, Constitution Avenue, Washington DC.

National Development Planning Commission 2004. *Ghana Poverty Reduction Strategy*: Annual Progress Report.

National Research Council (NRC), 1997. Commission on Geosciences, Environment and Resources. *Rediscovering Geography*: New Relevance for Science and Society. Washington DC: National Academy Press.

National Research Council (NRC), 1995. Commission on Behavioural and Societal Sciences and Education. 1995. *Emerging Needs and Opportunities for Human Factors Research.* Washington DC: National Academy Press.

Ndione, E, Philippe deLeener, M Ndiaye, Pierre Jacolin, J-P Perier. 1995. The Future of Community Lands: Human Resources. London: *Intermediate Technology*. Reviewed in Local Environment, 1(2): 238-240.

Nedovic-Budic P., 1999. *Understanding Inter-organizational GIS Activities*: A Conceptual Framework" Journal of the Urban and Regional Information Systems Association 11 (1): 53-64.

Nedovic-Budic, Z. and Pinto J. K. 2000. Information sharing in an inter-organizational GIS environment. *Environment and Planning B.* 27 (3): 455-474.

Nkwae B. and Nichols S. 2002. *Spatial Data Infrastructure*: African Experiences. FIG XXII International Congress, Washington D. C. April 19-26 2002.

Nolan, R.L 1979. *Managing the Crisis in Data Processing*, HBR. March-April, 57 (2): 115-126.

Nolan, R. L. 1984. Managing the Advanced Stages of Computer Technology: Key Research issues. In: *The Information Systems Research Challenge*, F. W. McFarlan, Ed. Harvard University Press, Boston, Mass., p. 195-215.

Norgaard R. 1984. "Traditional Agricultural Knowledge: Past Performance, Future Prospects and Institutional Implications" *American Journal of Agricultural Economics*, December, 874-878.

Norusis M. J. and Marija J. 1998. *SPSS 8.0 Guide to Data Analysis Upper Saddle River,* N.J. Prentice Hall.

Nsiah-Gyaboah K. 1994. *Environmental Degradation and Desertification in Ghana*: Ashgate Publishing, London.

NTIA 1996. Falling through the net: *Defining the Digital Divide*. US Department of Commerce. National Telecommunications and Information Administration United States (NTIA). *http://www.ntia.gov.doc* (Accessed 21/03/05).

Nune Hailemariam S. N., 2004. *Assessment of Tree Outside Forest Using Object-Oriented Classification and Medium Resolution Satellite Imager y.* (A Case Study in Brong Ahafo Region of Ghana). Masters Degree Thesis. Geo-Information Science and Earth Observatory with Specialization in Forestry for Sustainable Development.

Obermeyer and Pinto, 1994. *Managing Geographic Information Systems*. New York: The Guilford Press.

Oduro-Afriyie, K. 1996. *Rainfall Erosivity Map for Ghana. Geoderma*. 74 (1-2): 161-166.

Okyeman Environmental Foundation, 2003 Community-based Integrated Natural Resources Management Project in Okyeman. Medium Size Project Brief Global Environment Facility.

Olson G. 1987. The Social Space of Silence. *Environment and Planning A.* Society and Space 5 (3): 249-262.

Olsson, P., and C. Folke. 2001. Local Ecological Knowledge and Institutional Dynamics for Ecosystem Management: a Case Study of Lake Racken Watershed, Sweden. *Ecosystems* 4:85–104.

'O' Neill R. D. L. DeAngelis J. B. Weide and T. F. Allen. 1986. *A Hierarchical Concept of Ecosystems*. Princeton University Press, Princeton, New Jersey.

R.G. Woodmansee and P.G. Risser. New York, John Wiley and Sons. Scope 35: 29-45.

Onsrud H. and Pinto N., 1993. Evaluating Correlates of GIS Adoption Success and the Decision Process of GIS Acquisition. *URISA Journal*. 5 (1):18-39.

Openshaw S. 1991. A view on the GIS Crises in Geography, or, Using GIS to put Humpty Dumpty back Together Again. *Environment and Planning A*, 23, 621-628.

Ostrom, E., 1996. Crossing the Great Divide: Corporation, Synergy and Development. *World Development Report*. 24 (6): 1073-87.

Owubah C. E. 2001. Forest Tenure Systems and Sustainable Forest Management: The Case of Ghana. *Forest Ecology Management* 149 (1-3): 253-264.

Padoch, C. and M. Pinedo-Vasquez. 1998. Demonstrating PLEC: A diversity of approaches. *PLEC News and Views.*11: 7-10.

Paehlke, R. 2001. 'Spatial Proportionality: Right-sizing Environmental Decision-making' In: E. Parson (ed.) *Governing the Environment: Persistent Challenges, Uncertain Innovations* Toronto: University of Toronto Press, 73-83.

Pagiola S. & Kellenberg 1997. Mainstreaming Biodiversity in Agricultural Devlopment: Toward Good Practice. *World Bank Environmental Paper 15*. World Bank, Washington DC.

Pagiola, S., Kellenberg, J., Vidaeus, L. 1998. Mainstreaming biodiversity in agricultural development. *Finance and Development,* 35 (1): 38-41.

Paradjayi C. and Ruther H. 2002. Evolution of Environmental Information Systems in Africa. In: *The International Achieves of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. Vol XXXIV. Part 6W6.

Pare, G. and Elam, J.J. Using Case Study Research to Build Theories of IT Implementation. In: *Information Systems and Qualitative Research*, A.S. Lee, J. Liebenau and J.I. DeGross (eds.), Chapman and Hall, London. p. 542-568.

Paulson S., Gezon L. L. and Watt M., 2005. Politics, Ecologies, Genealogies. In: *Political Ecology Across Spaces, Scales, and Social Groups* (Eds). Paulson S. and Gezon L) State University of New Jersey.

Peluso N. L. 1983. *Markets and Merchants: The East Kalimantan Forest Product Trade in Historical Perspective*. Masters Thesis, Cornell University.

Peluso N. L. 1995. Whose Woods are These? Counter Mapping Forest Territories in Kilimantan Indonesia. *Antipode 27* (4): 383-388.

Pickles, J. 1991. Geography, GIS, and the Surveillant society. *Papers and Proceedings of Applied Geography Conferences.* 14: 80-91.

Pickles J. 1995. Representations in an Electronic Age: Geography, GIS and Democracy. *In Ground Truth: The Social Implications of Geographic Information Systems*, ed. J. Pickles 51-67. New York: Guilford Press.

Pickles, J. ed.1995. *Ground Truth: The Social Implications of Geographic Information Systems*. New York: Guilford.

Pinedo-Vasquez et al M. E. A., Gyasi E. A. M. and Coffey K. 2001. PLEC Demonstration Activities: *A Review of Procedures and Expectations PLEC News and Views 17*:12-30.

Pinedo-Vasquez M. E. A. Gyasi and K Coffey, 2002. "PLEC demonstration activities: A Review of Procedures and Experiences", In Brookfield, Christine Padoch, Helen Parsons, and Michael Stocking, eds. Cultivating Biodiversity: *Understanding, Analyzing and Using Agricultural Diversity*, London: ITDC Publishing.

Pinto J. K and Onsrud H. J 1993. Sharing Geographic Information Across Organizational Boundaries: A Research Framework' In: H. J. Onsrud and G Rushton (eds) *Sharing Geographic Information*. New Brunswick; NJ: Centre for Urban Policy Research (CUPR). Press. 44-64.

PLEC 1995. News and Views. *The PLEC Clusters*. No 4 March 1995.

Prevost Y. and Gilruth P. 1999. Environmental Information Systems in South Saharan Africa: From Innovation to Management. *Http:// www.worldbank.org/afr/findings/English/find128.htm* (Accessed 10/11/2001

Rabinovitz, F and Rein M. 1978. Implementation: A Theoretical Perspective. In: *American Politics and Public Policy*, edited by W.D. Burnham and M.W. Weinberg. Cambridge, MA: MIT Press.

Ramasubraminian L. 1995. Building Communities: GIS and Participatory Decision Making' *Journal of Urban Technology*. 3 (1): 67-79.

Rao M.R., Singh M. and Day R. 2000. Insect pest problems in tropical agroforestry systems: Contributory factors and management strategies. *Agroforestry Systems* 50: 243–277.

Reeve and Petch, 1999. GIS Organisation and People: A Socio-Technical Approach. Taylor and Francis Limited. Gunpowder Square, London.

Reid E. 1992. Machiavelli and data. *Association for Geographical Information Conference Proceedings*, (London: AGI).

Rhind D.1991. Data Access, Charging and Copyright and their Implications for GIS. *Proceedings of European Conference on Geographical Information Systems.* Brussels, Belgium. April 2-5 1991 Volume 2.

Robbins P. 2000. "The Practical Politics of Knowing: State Environmental Knowledge and Local Political Economy. *Economic Geography* 76 (2): 126-144.

Robson, S. 2002. *Raid Ruins Research lab Crops.* News Story, 14 January 2002. Received via the IATP Biotech Activists.

Robbins P. 2004. Political Ecology: *Critical Introductions to Geography.* Blackwell Publishing, United Kingdom.

Rocheleau D. 1999. "Commentary on 'After Nature: Steps to an Anti-Essentialist Political Ecology,' by Arturo Escobar." *Current Anthropology* 40, no. 1:22-23

Rocheleau D. 1995. Gender, Ecology and the Science of Survival: *Stories and Lessons form Kenya, Agriculture and Human Values.* 8(1-2): 156-165.

Roe, E.M. 1998. *Policy Analysis and Formulation for Sustainable Livelihoods.* New York: United Nations Development Programme.

Roling N. G. and Wagemakers M. A. E., 1998. A New Practice: Facilitating Sustainable Agriculture. In: *Facilitating Sustainable Agriculture.* Participatory Learning and Adaptive Management in Times of Environmental Uncertainty, (Eds) N. G. Roling and M. A. E. Wagemakers, Cambridge University Press. Wageningen, PP. 3-22.

Saaka S. O. 1999. *Proposed Group Planning Workshop for the Ghana Capacity 21 Programme Kumasi.*December 20-22. Ministry of Environment Science and Technology.

Saaka S. O. 2001. *Report of First Tripartite Review Meeting Held in Tamale.* December. 13-14

Santhakumar V., 2001. Analyzing Failed Participation from the Perspective of New Institutional Economics: Evidence from Kerala. In: *Analytical Issues in Participatory Natural Resource Management* (Eds Bhaskar Vira and Jeffery R.) Palgrave Publishers Ltd. New York.

Sauer, C. *Why Information Systems Fail: A Case Study Approach*, Alfred Waller Ltd. Henley-on-Thames, 1993.

Sawicki D. and Craig, W. 1996. The Democratization of Data: Bridging the Gap for Community Groups, *Journal of the American Planning Association*, 62 (4): 512-523.

Scaling up the Impact of Agroforestry: Lessons from three sites in Africa and Asia. *Agroforestry Systems*. 61: 329-344.

Schaeffer P. V. and Hopkins L. D. 1987. Behaviour of Land Developers: Planning and the Economics of Information. *Environment and Planning A*. 19 (9):1221-32.

Schank R. C. 1996. A1 and Natural Resource Management. In: *Building Knowledge-based Systems for Natural Resource Management*. Chapman and Hall, New York.

Scoones, I. 1998. *Sustainable rural livelihoods: a framework for analysis*. IDS Working paper 72, Brighton Institute of Development Studies, University of Sussex.

Scott R. W. 1995. *Institutions and Organizations*. Thousand Oaks: Sage Publications.

Sedego L. G. and Groten M. E. 2002. Integration of Local Participatory and Regional Planning: A GIS data Aggregation Procedure. *GeoJournal* 56: 69-81.

Sekhar M., 2001. Organizations for Participatory Common Property Resource Management. In: *Analytical Issues in Participatory Natural Resource Management* (Eds Bhaskar Vira and Jeffery R) Palgrave Publishers Ltd. New York.

Senge, P. M. (1992). *The Fifth Dimension: The Art and Practice of the Learning Organisation*. Milsons Point, N. S. W. Random House Australia.

Shackleton S. Campbell B. Wollenberg E. and Edmunds D. 2002. Devolution and Community-based Natural Resource Management: Creating Space For Local People to Participate and Benefit. *Natural Resource Perspective*. 76 March.

Sheldon C. and Yoxon M. 1999. Installing Environmental Management Systems: *A Step by Step Guide*. Earthscan Publications Ltd. UK.

Sieber R. E. 1997. *Computers in the Grassroots: Environmentalists, GIS, and Public Policy'* PhD Dissertation, Department of Urban Planning and Pubic Policy, Rutgers University.

Sieber R. 2000. 'Conforming (to) the opposition: the social construction of geographical information systems in social movements', *International Journal of Geographical Information Science* 14 (8): 775-793.

Sieber, Renee E. 2000. Conforming (to) the Opposition: The Social Construction of Geographical Information Systems in Social Movements. *International Journal of Geographical Information Science.* 14 (8): 775-93.

Simons A.J. 1997. Delivery of improvement for agroforestry trees. In: Dieters M.J. and Matheson C.A. (eds) *Tree Improvement for Sustainable Tropical Forestry. Queensland Forestry Research Institute*, Gympie, Australia. 261.

Smith N. 1992. Real Wars, Theory Wars. *Progress in Human Geography.* 16 (2): 257-271.

Snel A. M. 2001. *A Conceptual Framework of and Implementation Guidelines for A Sustainable Environmental Information System (SEIS): Evaluating and Guiding the Development of a Malawi SEIS.* Doctoral Dissertation, Department of Geography, Clark University, Worcester, Massachusetts.

Soni P. and Vasistha H. 1991. Understorey Vegetation in eucalyptus plantations—A review. J. Trop Forest (1):13-26.

Soyez D. 2002. Environmental Knowledge, the Power of Framing and Industrial Change. In: *Knowledge, Industry and Environment*: Institutions and Innovation in Territorial Perspective (Eds, Hayter R. and Heron R. L., 2002).Ashgate Publishing Limited. Gower House, England.

Stakes R. 1995. *The Art of Case Study Research.* Thousand Oaks, California: Sage Publishing.

Stakes, R. E. 1994. Case studies. In Denzin, N. K. and Lincoln, Y. S. eds. *Handbook of Qualitative Research.* SAGE Publications, Thousand Oaks, California. 236-247.

Stow D. A. 1999. Reducing the Effects of Misregistration on Pixel-level Change Detection. *International Journal of Remote Sensing.* 20 (12): 2477-2483.

Strauss A. and Corbin J. 1990. Basics of Qualitative Research: *Grounded Theory Procedures and Techniques.* Newbury Pack.

Subaryono 1996. *Assessment of Conditions Relative to Implementation of GIS in Local Government of Bali, Indonesia.* A Thesis Presented to the University of Waterloo in Fulfillment of the Requirement for the Degree of Doctor of Philosophy in Geography. Waterloo, Ontario, Canada.

Sui D. Z. 1994. GIS and Urban Studies: Positivism, Post-positivism and Beyond. *Urban Geography* 15: 258-78.

Sullivan, S. 2000. "Getting the Science Right, or, Introducing Science in the First Place?" In: *Political Ecology: Science, Myth and Power*, edited by P. Scott and S. Sullivan. New York Arnold: 15-44.

Taylor P. J. 1990. *GKS, Political Geography Quarterly* 3: 211-212.

Taylor 1991 and Overton Further Thoughts on Geography and GIS. *Environment and Planning A*, 23 1087-1094.

Tropenbos International-Ghana 2005. Equity in Forest Benefit Sharing Stakeholders' Views. *Workshop Proceedings* 3. Wageningen, the Netherlands.

TBI, 2005. Alternative Livelihoods and Sustainable Resource Management. *Workshop Proceedings of TBI* Ghana 4. Accra

TBI 2004. Natural Resource Management in Ghana-Challenges for Professionalism. In: Nketiah K. S., Asubonteng O. and Wieman A. (eds). *Tropenbos International*, Wegeningen, Netherlands.

TBI, 2003. *The Potential and Constraints of Agro-forestry in Forest Fringe Communities of the Asunafo District-Ghana*. October.

TBI, 2002 Innovative Financing Mechanisms for Tropical Forests. In: *Newsletter 27*, July 2002.

TBI, 2002 Sustainable livelihoods. In: *TBI Newsletter* 28, November 2002.

TBI, 2001. Programme Development in Ghana. In: *TBI Newsletter* June Accra 25 (11)

TBI, 2000 *Tropenbos Newsletter* No. 23. Ghana, September 2000.

TBI, 1998. *Newsletter* November 17/18 Ghana, December 1998.

Tengberg A. and Stocking, M. 1999. Current Issues in Land Degradation PLEC News and Reviews 7 November.

Tetteh E., Martensson U., Eklundh L. and Gyamfi-Aidoo J. 1999 Ghana: Country at a Glance (G-CAG). *Environmental Protection Agency*. Ghana.

Tritiku P. K. 1989. Updating Small Scale and Vegetation Maps of the Volta Region with the aid of LANDSAT Imagery and Aerial Photographs. In: Agyepong G. T. Gyamfi-Aidoo J. A. and Yankson PWK (eds) Remote Sensing in Ghana. *Proceedings of the National Seminar/Workshop on Remote Sensing and Geographic Information Systems.* 72-80.

Trotter, R. T., & Schensul, J. J. 1998. Methods in Applied Anthropology. Pgs 691-711 in *Handbook of Methods in Cultural Anthropology*, Bernard, H.R. (ed). Alta Mira Press. Walnut Creek, CA.

Tolbert P. and Zucker L. 1996. The Institutionalization of Institutional Theory. In *Handbook of Organization Studies*, (ed.) S. R. Clegg, C. Hardy, and W. R. Thousand Oaks CA: Sage Publications: 174-190.

Toledano, J. 1997. The Ecological Approach: *A Strategy for GIS Implementation.* PhD. Dessertation Worcester: Graduate School of Geography, Clark University.

Toulmin, C. and J. Quan (eds.) 2000. *Evolving Land Rights, Policy and Tenure in Africa, London*: International Institute for Environment and Development, and Natural Resources Institute.

Turnbull J. 2004. Explaining Complexities of Environmental Management in Developing Countries: lessons from the Fiji Islands. *The Geographical Journal.* 170 (1): 64.

Uitto,1997. Population, food and water in the 21st century. In: Rose, J. (ed.) *Population Problems – Topical Issues*. New York: Routledge.

Uitto J., 1998. The Geography of Disaster Vulnerability in Megacities: a Theoretical Framework. *Applied Geography*, 18:7–16.

Uitto J. 2000. Population, Food and Water in the 21st Century'', in Rose, J. (ed.) *Population Problems – Topical Issues*. New York: Routledge.

UNDP/*Ghana Capacity 21 2000. Annual Report* for Year 2000.

UNDP, 2000. *Capacity 21 Programme*. Progress From Fourth Quarter. Ministry of Environment, Science and Technology Accra, Ghana.

UNDP/Ghana Capacity 21 Programme 2002. Training Manual on Environmental Management and Development Planning for Sustainable Development. Ministry of Environment, Science and Technology, Accra-Ghana.

UNEP, 1995. *Integration of Environmental Information into Development Planning and Decision Making Processes*: A Zambia Case Study. Review and Recommendations. May - July 1995. Compiled by Jacob Gyamfi-Aidoo, Remote Sensing Appl Unit, University of Ghana, Legon; Michael C. Soko, National Commission for Development Planning, Zambia and Douglas Kunda, Environmental Council of Zambia. Report UNEP/EAP.MR/95/18. United Nations Environment Programme, Nairobi.

United Nations, 1992. Earth Summit, *Agenda 21*. New York.

United Nations 2002. *Europa Year Book*, UN.

United Nations Environment Programme 1997. Global Resource Information Database. Website: http://www.grida.no/ (Accessed 29/05/06).

United Nations University and Institute for Natural Resources in Africa 1999. Enhancing Natural Resource Management Capacity in Africa. Institute for Mineral Resource in Africa. Tokyo, Japan. United Nations, 2000. *The Europa World Year Book*. England.

Veregin H. 1995. Computer Innovation and Adoption in Geography: A Critique of Conventional Technological Models. In Pickles (ed) *Ground Truth: The Social Implications of Geographic Information Systems*. The Guilford Press, New York.

Vermal V.K., Sharma, P. K, Patel, L. B, Loshali D. C. and Toor G. S. 2000. Natural Resource Management for Sustainable Development Using Remote Sensing technology- a Case Study. *http://www.gisdevelopment.net/application/nrm/overview/nrm0006.htm (Accessed 12/18/04).*

Wakefield S 1998b. Computer-Assisted Qualitative Analysis. Qualitative Analysis in Process Evaluation for Heart Health Promotion. *Workshop Proceedings of Health Canada Population Health Fund.*

Walker D. H., Leitch A. M., de Lai R., Cottrell A., Johnson K. L. and Pullar D. 2002. A Community-based and collaborative GIS joint venture in rural Australia. In: *Community Participation and Geographic Information Systems.* Craig W., Harris T., M. and Weiner D. (eds.) Taylor and Francis, New Fetter Lane, London.

Walker P. and Young M. 1997. Using Integrated Economic and Ecological Information to Improve Government Policy. *International Journal of Geographical Information* Science. 2 (7): 617-632.

Wallace, M. G., Cortner, H. J. and Burke, S. 1995. Review of Policy Evaluation in Natural Resources. *Society and Natural Resources.* 8: 35–47.

Weber J.C., Labarta Chávarri R.L., Sotelo-Montes C., Brodie A.W., Cromwell E., Schreckenberg K. and Simons A.J. 1997. Farmers' use and management of tree germplasm: case studies from the Peruvian Amazon Basin. pp. 57–63. In: Simons A.J., Kindt R. and Place F. (eds), *Policy Aspects of Tree Germplasm Demand and Supply. Proceedings of an International Workshop*, held in Nairobi, Kenya, October 1997, ICRAF, Nairobi, Kenya.

Weiner D. Warner T. A., Harris T. M. and Levin M. R. 1995. Apartheid Representation in a Digital Landscape: GIS remote sensing and local knowledge in Kiepersol, South Africa. *Cartography and Geographic Information Systems,* 22 (1): 30-44.

Weiner D., Trevor M., Craig H., and Craig W., 2002. Community Participation and Geographic Information Systems. In: *Community Participation and Geographic Information Systems*. Craig W., Harris T., M. and Weiner D. (eds.) Taylor and Francis, New Fetter Lane, London.

Weiner, D., and T. Harris, 1999. *Community-Integrated GIS for Land Reform in South Africa.*' WVU Regional Research Institute Research Paper. 9907, Morgantown W.V.

Wisconsin Land Information Programme 1991. *Http://www.doa.state.wi.us/olis/wlip/(Accessed 5/3/2002).*

World Bank 1992. *Staff Appraisal Report. Republic of Ghana Environmental Resource Management Project* September, 1992. Report No. 10692-GH.

World Bank 1998. Global Environment Facility, 2004. *Ghana Sustainable Land Management for Mitigating Land Degradation, Enhancing Agricultural Biodiversity and Reducing Poverty*. Proposal for GEF Funding Medium-Size Project. Washington DC., USA

World Bank, 2002. Ghana, Northern Savanna Biodiversity Conservation Project. *Project Appraisal Document on the Proposed Grant From the Global Environmental Facility Trust Fund. For the Northern Savanna Biodiversity Conservation Project.* Rural Development, Country Department 10. Africa Regional Office.

World Bank, 2002. Natural Resource Management and Gender: A Global Source Book. Prepared by Piet Wijn. 20 September 1941-2 October.

World Bank, 2004. Geographical Targeting for Poverty Alleviation: Methodology and Application. *World Bank Regional and Sectoral Studies*. http://www- wds.

World Commission on Environment and Development (WCED), 1987. *Our Common Future.* Oxford University Press, New York.

Worster D. 1995. The shaky ground of sustainability. In G. Sessions (Ed). *Deep Ecology for the 21st Century* (p 417-427). Boston: Shambhala.

WRI/USAID Information Working Group, 1999. *Minutes of the Second Meeting*, October 14-15 Washington DC.

Yapa L. 1998. *Why GIS Needs Postmodern Cartography, ed David Ruxton Fraser Taylor*, 249-69. Oxford: Elsevier Science.

Yapa, L.S. 1991. Is GIS appropriate technology? *International Journal of Geographical Information Systems* 5: 41-58.

Yates D. Shields M, and Helmy D. 1994. *Systems Analysis and Design*. Pitman Publishing, London P5.

Yin, R. K. 1984. *Case Study Research: Design and Methods*. Sage: Berverley Hills.

Yin R K 1989. Research Design Issues in Using the Case Study Method to Study Management Information Systems.

Yin, R.K. 1993. *Applications of Case Study Research*. SAGE Publications, Newbury Park, California.

Yin, R.K. 2003. Case Study Research: Design and Methods. *Applied Social Research Methods Series,* Vol. 5. SAGE Publications, 3rd Ed Thousand Oaks, California.

Zachary G. P. 2002. Ghana's Digital Dilemma. *Technology Review.* July-August, 2002.

Zebene A. and Agren G. 2007. Farmers' local knowledge and topsoil properties of agroforestry practices in Sidama, Southern Ethiopia. *Agroforestry Systems.* 71:35–48.

Zucker L 1988. *Institutional Patterns and Organizations.* Cambridge MA: Ballinger.

Zurayk R. F., El A-awar, Hamadeh S. 2001. "Using Ingenous Knowledge in Land Use Investigations: A Participatory Study in a Semi-arid Mountainous Region of Lebanon" *Agriculture Ecosystem and Environment* 86 (3): 247-62.

APPENDIX A: QUESTIONNAIRE FOR SERVICE PROVIDERS

Demographic Information

Gender: ☐ Male ☐ Female

Level of Education: ☐ Primary ☐ Secondary ☐ Tertiary ☐ Other (Specify)

What is your age? ....

What is your occupation? ....

What capacity do you serve in this company/institution?.....................................

How long have you lived in this community? ....

What is your total annual income Cedis)?...

Section A: Survey of Existing EIS

1. Target user: Who will actually run or use the system?
   - ☐Farmers
   - ☐Forest managers
   - ☐Lecturers
   - ☐Private individuals
   - ☐Policy makers/District planners
   - ☐Chiefs
   - ☐Other, please specify ....

2. What form of data and information do you provide decision makers and farmers?
   - ☐Satellite imagery
   - ☐Aerial photography
   - ☐Topographic maps
   - ☐Digital databases
   - ☐Statistical and text data
   - ☐Other (Please specify)

3. What type of information and data do you provide to users?
   - ☐Climate data
   - ☐Land cover/landuse data
   - ☐Population/Socio-econ data
   - ☐Air quality data
   - ☐Geological/soil data
   - ☐Hydrological data
   - ☐land ownership/cadastral data
   - ☐Other (Please specify) ....

4. What forms of analysis can the EIS be used for?

....

5. Ease of Accessibility	Yes	No	Don't Know
a. Can the system be used for other purposes?			
b. Is data and information always available on demand?			
c. Do you have on-line environmental information systems?			

6. What are the main reasons for having an on-line information system?
   - ☐Time
   - ☐Reach
   - ☐Format/Use
   - Cost
   - ☐ Other (Please specify) ....

Section B: Credibility of Data/Information/Services

7. Describe your level of proficiency in the data and information that you use. beginning with 1-not efficient, 2-fairly efficient, 3-efficient, 4-very efficient, 5-most efficient. (1 is the least and 5 the highest).

☐1 ☐2 ☐3 ☐4 ☐5

8. Rate your level of confidence in the decisions you make based on the data and information that you use beginning with 1- not confident, 2-fairly confident, 3-confident, 4-very confident, 5-most confident. (1 is the least and 5 the highest).

☐1 ☐2 ☐3 ☐4 ☐5

Section C: Technical Support

9. Please rank the following contraints to EIS infrastructural support in order of Seriousnes (1 is the least and 5 the highest).

1 = Not serious 2=Least serious 3= Fairly serious 4=Very serious 5= Most serious

Infratructure Contraints	Ratings					
Power fluctuations/Power Outages						
Lack telephone						
Lack internet						
Lack software						
Lack computers						
Other please specify						

10. Please rank the following complaints from EIS users in order of seriousness. (1 is the least and 5 the highest).

1= Not serious 2=Least serious 3= Fairly serious 4=Very serious 5= Most serious

User Compliants	Ratings					
Absence of skilled representative						
Delays in mail						
Information is technical						
Lack of information requested for						
Information is not presented in local languages						
Other please specify...............						

Section D: EIS Training and Skill Development

11. Training	Yes	No	Don't Know
a. Do you offer training programmes on how to use EIS?			
b. Do you make an attempt to collect user feedback on a regular basis?			

12. What media programmes do you provide to educate users of EIS products that you provide?

☐ forum/public meetings leaflets ☐ manuals
☐ durbar of chiefs and people ☐ newsletters
☐ work book/course book ☐ Other (please specify) …………..

13. Which of the following electronic training approaches do you use

☐ telephone hotline ☐ public address system
☐ computer-based training ☐ video
☐ Training Kit (tutorial databases) ☐ Direct Internet Access
☐ Other (please specify) ……….

Please provide reasons for your answer ……………………………………………………

14. How long are training sessions?

☐ 1-3 days (Specify………..) three weeks (Specify……….)
☐ 4-7 days (Specify………..) ☐ One month (Specify………..)
☐ Two weeks (Specify ……) ☐ Other, please (Specify……...)

15. User friendliness of EIS	Yes	No	Don't Know
a. Is the user-interface designed for use by non-technical decision-makers?			
b. Does the system offer references and explanations?			
c. Is there a step-by-step description of how to retrieve, display and use the data?			

Please provide reasons for your answer ……………………………………………………

16. Technical Support	Yes	No	Don't Know
a. Are the training programmes adequate to ensure user understanding of the data and information?			
b. Do you provide technical information on the attribute of the datasets and specific details concerning the generalization of some of the datasets?			
c. Do you provide EIS users information on the technical limitations of the data and information that they use			

Please provide reasons for your answer ……………………………………………………

Section E: Economics of EIS (Commercial Contracting Versus Free Distribution)

17. Which of the following financial principles do you practice?

☐ Cost recovery ☐ Open Access
☐ Other, please specify……………

Please provide reasons for your answer………..………………………

18. Cost recovery	Yes	No	Don't Know
a. Do you charge users for data and information you provide			
b. Is the price or cost of the data and information affordable?			
c. Do the benefits of using data/information justify the cost?			

19. Which of the following reasons account for your decision to sell data and information?
    - ☐ Cover marketing
    - ☐ Production cost
    - ☐ CD-ROMs
    - ☐ Other (please specify)
    - ☐ Maintenance costs
    - Salaries of workers
    - ☐ Postage

20. Free Access	Yes	No	Don't Know
a. Does the amount you charge for the data prevent people from buying the data?			
b. Do you provide information at no cost to the public?			
c. Does any governement agency or organisational sponsor data production for free distribution to the public			

21. What copyright laws deal with digital data acquisition and ownership?

....

APPENDIX B: QUESTIONNAIRE FOR RESOURCE MANAGERS

Demographic Information

Gender: ☐ Male Female
Level of Education: ☐ Primary ☐ Secondary ☐ Tertiary ☐Other (Specify) ....
What is your age? ....
What is your occupation? ....
How long have you lived in this community? ....
What is your total annual income (in Cedis)?...

Section A: EIS Application

1. Awareness	Yes	No	Don't Know
a. Are you aware of the existence of EIS datasets/information			
b. Do you ever seek environmental information?			
c. Do you have access to data and information?			

Please explain ....

2. How do you obtain data and information for resource management?

....

3. What form of data and information do you use?

☐ Satellite imagery ☐ Digital databases
☐ Aerial photography ☐ Statistical and text data
☐ Topographic maps ☐ Other (Please specify)

4. What type of information and data do you use?

☐ Climate data ☐ Geological/soil data
☐ Land cover/landuse data ☐ Hydrological data
☐ Population/Socio-econ data ☐ Land ownership/cadastral data
☐ Air quality data ☐ Other (Please specify) ....

Please provide details about the information you use for resource management

....

5. EIS Use	Yes	No	Don't Know
a. Is data and information relevant for your task?			
b. Has EIS improved your awareness and understanding of environmental problems?			

Please explain ....

6. In what way(s) has EIS application helped to reduced pressure on land recourses?

....

7. Is EIS application sustainable? (Is EIS application an on-going process or is it done on ad-hoc basis)?

....

8. Describe your level of competence in the use of EIS for resource

management...

Section B: Credibility of Data/Information/Services

9. What are the advantages and disadvantages of the medium of information that you obtain?

....

Section C: Training, skill development and support services

10. Training	Yes	No	Don't Know
a. Do you have EIS training programmes?			
b. Are training and skills development programmes regular?			
c. Do you understand and are you able to interpret the data/system you use?			
d. Has the training improved your knowledge of how to use EIS?			
e. Do you do any self-training?			

Please provide reasons for your answers

....

11. Logistics/expert support	Yes	No	Don't Know
a. Do you attend workhops and skills development forums?			
b. Do you use manuals or documentations and course materials?			
c. Are there facilitators who come to demonstrate the use of EIS?			
d. Do you have any hotline contact for expert advise?			

Please explain your answers.

....

12. Which of the following means do you use to request for information from EIS service providers?
    - ☐ Write letters
    - ☐ Walk-in/visiting office
    - ☐ Phone calls
    - ☐ Visit website
    - ☐ E-mail
    - ☐ Other please specify ………………

13. How long does it take to get the information requested
    - ☐ 1-3 days (Please specify)………
    - ☐ 4-7 days (Please specify)………
    - ☐ 2 weeks (Please specify)………
    - ☐ 3 weeks (Please specify)…………..
    - ☐ 1 month (Please specify)…………
    - ☐ Other, (please specify) ……………

14. Supporting Information	Yes	No	Don't Know
a. Are there supplier (data providers) directions and instructions attached to data and information about how to use the system/data/information?			
b. Do data/information suppliers provide list of information about the probable limitations of the data/information?			
c. Do you receive regular updating of the data/information that you use?			
d. Is the data/information relevant for your work?			

15. How do you receive education on the use of EIS
    - ☐ Internet/Websites
    - ☐ CD ROM
    - ☐ Leaflets
    - ☐ News letters
    - ☐ Database
    - ☐ Please specify ………………..
    - Manuals

Section D: Obstacles to EIS Use

16. Rank the following obstacles to EIS implementation in order of seriousness, beginning with 1- least serious to 5-most serious problem. (1 is the least and 5 the highest).

1 = Not serious 2= Fairly serious 3= Serious 4=Very serious 5= Most serious

Infratructure Contraints	**Ratings**					
Power fluctuations/Power Outages						
Lack telephone						
Lack internet						
Lack appropriate software						
Lack computers (obsolete computers)						
Data formatting problems						
Other please specify ………..						

Please provide reasons for your ranting

………………………………………………………………………………………………

17. Rank the following constraints to acquisition of data and inforamtion from EIS service providers beginning with the least serious to the most serious problem (1 is the least and 5 the highest).

1 = Not serious 2= Fairly serious, 3= Serious, 4=Very serious 5= Most serious

Contraints	**Ratings**					
Absence of skilled representative						
Delays in mails						
Lack of policy agreement for data access, ownership & use						
Lack of information requested for						
Inadequate technical skill and knowledge						
Language of EIS makes is inaccessible						
Other (please specify)……………						

Please provide reasons for your ratings.

……………………………………………………………………………………………

18. What assistance do you offer farmers for effective use of EIS in community-based resource management?

……………………………………………………………………………………………

Section E: Social Processes

19. Participation	Yes	No	Don't Know
a. Do you assist community members in using EIS for resource management.			
b. Do you exchange data, share knowledge and information easily?			
c. Do data and information enable you to provide input in the resource decision making process?			

Please provide reasons for your anwers

……………………………………………………………………………………………

20. Is the entire community involved in EIS implementation projects? (Are some groups alienated from the implementation process?)

……………………………………………………………………………………………

21. Are individuals within the community familiar with and do they understand the language in which EIS is presented and communicated?

……………………………………………………………………………………………

22. Is there community support for the use of EIS products and services for resource management? (Do the community members dislike EIS application?)

……………………………………………………………………………………………

23. Does EIS use create understanding and cooperation among members of the community?

....

24. What traditional or ethnic customs, superstition and taboos affect EIS use and why?

....

25. Does EIS application adversely affect religious and cultural attitudes of residents in the area?

....

26. Does EIS application create conflict and misunderstanding among members of your community? (What kind of conflicts arise?)

....

Section F: Economics of EIS

27. Cost Recovery	Yes	No	Don't Know
a. Do you pay for the data and information you use?			
b. Is the price or cost of the data and information affordable?			
c. Do the benefits of using data/information justify the cost?			

28. How much do you pay for datasets, information that you obtain from the service providers (Amount in Cedis)?

....

29. Free Access	Yes	No	Don't Know
a. Does cost prevents you from buying the data/information?			
b. Do you obtain information and data free from EIS providers?			
c. Does any governement agency or any organisation sponsor data production for free distribution to the public?			

Please provide reasons for your answers.

....

30. Describe how cost or free access to EIS has affected resource management activities.

....

APPENDIX C: FOCUS GROUP DISCUSSION WITH FARMERS

Demographic Information

Total number of participants ....
Gender: ☐ Number of Males .... ☐ Number of Females ....
Level of Education:
☐ Total No: of Primary Education .... ☐ Total No of Secondary Education.........
☐ Total No: of Tertiary Education .... ☐ Other ....
Ages of participants...
Occupation of participants..
Average length of stay in the community ....
Average annual income (in Cedis)...

Section A: Needs Assessment

1. Do you need environmental information for resource management?

....

2. What kind of data or information do you use for your work?

....

Section B: Awareness and Access to Information

3. Are you aware of the existence of environmental datasets, information and services?

....

4. Have you ever sought environmental information?

....

5. Is the type of datasets and information you seek readily available upon request?

....

6. In what way(s) do you obtain environmental data and information?

....

Section C: LKS Use/Application

7. How do you use the local data and information for resource management?

....

8. Has IKS improved your awareness and understanding of environmental problems and in what way(s) does information changes your attitude, bahaviour and activities towards resource management?

....

9. In what way(s) have data and information helped you to tackle forest and land degradation problems.

....

10. In what way(s) has the project resulted in loss or damage to forests and farm lands?

....

11. How have LKS use indirectly led to practices that cause soil loss?

....

12. What are the other benefits you derive from using the LKS data and information?

....

13. Is LKS application sustainable? (Is LKS application an on-going process or is it done on ad-hoc basis)?

....

Section D: Decision Implementation and Consultation

14. Do you exchange data, share knowledge and information easily about LKS application?

....

15. Does data and information enable you to provide input in the resource decision-making processes?

....

16. How do you receive education and training on Agroforestry and how long does it take?

....

17. Who or what agencies offer such, training, workshops and seminars?

....

18. Do you have user or manuals/ documentations course materials?

....

Section F: Constraints of LKS Application in Agroforestry Practices

19. What are the problems associated with the LKS training and skill development programmes and the information you use?

....

20. Do you seek advise on the use of information from other sources? (friends, colleagues, etc.).

....

21. What directions and instructions from agencies about the effective methods of Knowledge and information application in resource management?

....

22. How do you cope with or overcome the limitations of the datasets and information that you use?

....

Section H: Social processes

23. Is the entire community involved in the implementation of the project? (Are some groups alienated from the implementation process?). Are there conflicts, and mis-understanding among members of the community.

....

24. Does the project implementation meets the needs, interests and aspirations of the community members? (How are your needs met?)

....

25. Are individuals within the community familiar with and understand the language in which training and workshops are presented?

....

26. What traditional customs affect kowledge application in agro-forestry practices and why?

....

Section I: Economics

27. Do you pay for the data and information you use? (How much do you pay?)

....

28. Are there any financial support or arrangement from any private or government agency that enables you to obtain datasets and information free?

....