CHARACTERIZATION OF LAND USE INFORMATION FOR MANGROVE FORESTS CONSERVATION AND RURAL FARMING IN DEMOCRATIC REPUBLIC OF CONGO

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Award of Master of Science Degree in Agricultural Information and Communication Management of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

DECLARATION

I declare that this is my original work and has not been submitted or published for any award of a degree or diploma in this University or any other University.

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DEDICATION

To my Mother, Josephine Luyula and my Dad, Falasi Bal' A Mpum for their sacrifice in sending me to school.

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ABSTRACT

Despite mapping and monitoring of mangrove forest decline, future land-use and land-cover change goals include quantifying linkages and feedbacks between land-use and land-cover change and other related human and environmental components. This study characterized information flow to aid land use planning and decision making for conservation and management of mangrove forests for improved livelihoods of rural communities in Moanda Territory of the Democratic Republic of Congo. A multistage purposeful random sampling was used to select 200 farmers. A fixed quota of 80% of households was attributed to villages and 20 % of households' survey to city of Moanda. Nine villages in Moanda territory were selected based use of mangrove as source of marine or forest product and where the mangrove is being converted to agriculture and/or settlement. Data from questionnaire were analysed with SPSS using descriptive statistical tools such as mean, percentage, ranking, standard deviation, and inference statistical tools such as Spearman Correlation. Logit model was used to determine factors influencing the use of different sources of information for conservation and management of mangrove forest. Global Positioning System (GPS), IDRISI KILIMANJARO and ArcView 3.2 served to detect the changes in farming and mangroves forest area over the last 22 years from landstat TM of July 1988 and landstat ETM of April 2002 and March 2010 (Path/Row scene: 180–064). Results indicated that there have not been dramatic changes in mangrove forest cover for the last 22 years (0.1%). However, tropical forest around mangrove forest decreases by 17.2 %. Farming area increased by 112 % from 1988 to 2010. Also, in all study sites, mangroves were indicated as sources of food and medicine, charcoal, firewood, and timber. The predominant ecological value for mangrove forests was indicated as conservation area. Radio, Barazas and face-to-face communication remain the most sources of information used by farmers. The adoption of emerging sources of information was found to be positively influenced by farmers' years of schooling, the number of times per month farmers received land use information through radio and leaflets/literature. Age of respondent was also an important influence, but its effect was negative. This study yielded information that will ensure the long-term quality of the land for human use, the prevention or resolution of social conflicts related to land use, and the conservation of ecosystems. Summarizing, more emphasis should be put on long-term land use planning and the conservational issues so that the benefit of mangrove forests to the local community can be sustained.

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LIST OF ABBREVIATIONS AND ACRONYMS

AGED	Agricultural Extension and Education
FAO	Food and Agricultural Organization
GIS	Geographic Information System
GPS	Global Positioning System
ICCN	*Institut Congolais pour la Conservation de la Nature.*
ICT	Information Communication Technology
IUCN	International Union for the Conservation of Nature
MDG	Millennium Development Goals
MEA	Millenium Ecosystem Assessment
MPA	Management Protected Area
MIGIS	Mobil Interactive Geographic Information System
MINAFENV	*Ministère des Affaires Foncières, Environnement, Conservation de la*
NARE	Natural Resources
	Nature, Pêche et Forêt
NGO	Non-Governmental Organization
PMM	*Parc Marin de Mangroves*
RRA	Rapid Rural Appraisal
SPSS	Statistical Package for the Social Sciences
SSRS	Simple Systematic Random Sampling
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WB	World Bank
WRI	World Resource Institute
WWF	World Wide Fund for Nature

CHAPTER ONE
INTRODUCTION

1.1 Background information

Mangroves are tidal forests of tropical and sub-tropical shores which thrive in sheltered coastal areas with relatively calm waters such as estuaries, accreting shores, bays and lagoons (Duke, 2006). Most of the people living in or adjacent to mangrove areas derive their livelihood from forestry and fisheries. According to FAO's mangrove assessment study, entitled, "The world's mangroves 1980-2005." the total mangrove area has declined from 18.8 million hectares in 1980 to 15.2 million hectares in 2005. From the results of the current assessment, it seems that Africa has lost about 500 000 ha of mangroves over the last 25 years (or about 13.8 percent), with the major losses occurring in Gabon, Sierra Leone, Guinea-Bissau, Senegal and the Democratic Republic of the Congo where annual change forest is about –0.2 % (FAO,2007).

Mapping and monitoring of mangrove forest decline has become an urgent need (Proisy et al., 2000, Kovacs *et al.*, 2001, 2005, and Li *et al.*, 2002). However, in West African countries, land administration is by government agencies and the process is mostly manual. The use of technology to automate and make the process more efficient and provide timely and less expensive service delivery to stakeholders is essential for the improvement and development of land administration and rural development as a whole. Future land-use and land-cover change mapping goals include quantifying linkages and feedbacks between land-use and land-cover change and other related human and environmental components. In the Democratic Republic of Congo, the mangroves are declining due to conversion to other land uses and forest degradation (MINAFENV, 2001). Accurate and reliable information on their present distribution, causes of their degradation and the need to sustain local livelihoods are limited. This reinforces the need of a land use plan and the development of information flow mechanisms to help reverse the decline of mangrove ecosystems for positive impact on community livelihoods.

Also, information can be a huge boon in peace-building operations, by strengthening the ties between individuals and communities and improving their ability to interact with one another. The use of Geographic Information System can make easy the process of land use planning by means of an integral analysis of the area; a visualization of the biophysical and socio-economic characteristics of the area; and an interactive use and updating of the information. In addition, the GIS can support in the formulation of legal instruments such the Land Use Plan and a Land Allocation Plan. This study used spatial analytical methods and information processes at the local level for characterized livelihoods, mangroves conservation, decision making and policy recommendations.

1.2 Statement of the Problem

Communities adjacent to mangrove forest areas depend on subsistence farming systems characterized by insufficient use of improved knowledge and technology, and low levels of productivity. According to recent Government and NGOs reports the Democratic Republic of Congo's Mangrove forests are disappearing at a rapid rate due to conversion of land to industrial and human activities including agricultural and residential development. The information necessary for planning land use and conservation of mangrove ecosystem forest is still sectoral, outdated, and gathered by different institution and traditional groups without effective coordination. Information often does not reflect the knowledge and information needs of the actual resource users .Utilization of such information thus demands the use of technology to automate, to integrate traditional knowledge and streamline the process and provide timely and less expensive service delivery to stakeholders.

1.3 Objectives

1.3.1 Broad objective

This study contribute to characterize information flow to aid land use planning and decision making for conservation and management of mangrove forests for improved livelihoods of rural communities adjacent to the mangrove forest.

1.3.2 Specific objectives

i. To assess the temporal variability of mangrove forests cover and rural farming in the study sites.
ii. To identify mangrove socio-economic and ecological values among the study sites.
iii. To determine sources of information used by farmers in conservation and management of mangrove forests.
iv. To determine factors that influences the use of different sources of information for conservation and management of mangrove forests.

1.4 Research Questions

i. What is the temporal variability of mangrove forests cover and rural farming in the study sites?

ii. What are the socio-economic and ecological values of mangrove among the study sites?

iii. What are sources of information used by farmers in conservation and management of mangrove forests?

iv. What are factors that influence the use of different sources of information for conservation and management of mangrove forests?

1.5 Significance of the Study

Communities who live in Congo's mangrove forests are interested mainly in resource exploitation such as fish, firewood, and wood for daily household consumption and sell in the local market for incomes. However, there is widespread over-exploitation of resources, which, if continued, will make it impossible to reverse the loss of environmental resources. Local institutions do not have sufficient capabilities to understand and use the available information for decision making.

A better visualization of the spatial diversity of resources, thereby improving the transparency of decisions regarding alternative uses of natural resource and the allocation of scarce funds to areas most in need is crucial. In addition, information communication between farmers and environmental experts is important in bridging the gap for sustainable land use environmental management. The result is information that will serve rural communities, local governments and state and federal governments in their efforts to more proactively address conservation of rural landscapes.

This study contributes to the achievement of the Millennium Development Goal 1, 2 and 7 by providing information regarding Congo's mangrove forest in the improvement of the livelihoods of communities.

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1.6 Assumptions of the Study

During the study the following assumptions were made.

i. The respondents gave honest responses to questions raised during the data collection.
ii. Farmers have knowledge of the importance of land use and mangrove forests.
iii. Land use information has no value unless it changes management decisions.

1.7 Definition of Terms

a) **Adoption:** Process in which farmers acquire and use new technologies.
b) **Conventional sources:** These are "not unusual or extreme; ordinary." Sources of information.
c) **Cropping zones:** Specific areas where a specific crop can perform best.
d) **Ecological values:** Mangrove productivity, ability to provide habitats for its dependent species and the diversity of species and organization it supports.
e) **Economic values:** The contribution of mangroves good or service to user-specified goals, objectives and conditions.
f) **Emerging sources:** These are " not ordinary." Sources of information.
g) **Extension**: Process through which technologies are disseminated to farmers.
h) **Forested**: Areas where two-thirds or more of the total canopy cover is composed of predominantly woody deciduous and species and areas of regenerated or young forest.
i) **GIS:** Is an information system that is designed to work with data referenced by spatial or geographic coordinates.
j) **Household:** A group of individuals, who live on the same farm, work together on at least one parcel of land and recognize the authority of a single head of household in major decisions relating to the farm enterprise.
k) **Livelihood:** A livelihood comprises the capabilities, assets (including both material and social resources) and activities that one engages in for survival.
l) **Mangroves:** Tropical trees, shrubs, palms or ground ferns that grow in a tightly knit thicket or forest along tidal estuaries of Moanda territory
m) **Non adoption:** the non-use of technologies considered in this study.
n) **Rural farming land:** Areas under activities such, fishing, forestry, wood cutting, livestock or cropping or rotation, including fallow fields and fields seeded for forage or cover crops.
o) **Socio-cultural values:** These are materials, energy or information used to contribute to human welfare.

CHAPTER TWO
LITERATURE REVIEW

2.1 Livelihood Option for Mangroves

If mangrove resources are to be conserved, sustainable management realistically must operate on the basis of economics (Turner *et al.,* 1993). It is human nature to protect and conserve a resource that is a source of income. Economic self-interest must play a role in management if mangroves are to persist and thrive in the face of human encroachment. A few case studies indicate that the idea of conserving mangroves as economic investment is realistic (Ronnback, 1999).

The study of (Larsson *et al.,* 1994) is a prime example of the type of critical economic and ecological analysis necessary for sustainable management as legislated in Colombia. In their model, (Larsson *et al.,*1994) first estimated the ecosystem area that is required to produce the food, clean water and nursery areas to support the shrimp farms and to assimilate their wastes. To maximize use and to minimize impact, Colombia's aquaculture operations should retain natural tidal flows, locate new farms to marginal saltpans, maximize distance between farms, use vegetable instead of animal feeds, use filter feeders to naturally clarify pond waters, and improve artificial rearing methods (Larsson *et al.,* 1994).

In the Bintuni Bay area of Indonesia where mangroves are heavily exploited for woodchips, and artisanal and commercial fisheries, strong economic arguments exist for limited clearing (Ruitenbeek, 1994). Cost-benefit analysis of forest management options incorporating links among fishery production, mangrove use and clearance rates, erosion control and biodiversity (Ruitenbeek, 1994) indicate that clear-felling of mangroves is a viable management option only when all the linkages are ignored.

Assuming that clear linkages exist between mangroves and environmental functions and fisheries, a ban on cutting is optimal; if the linkages incorporate time lags on the order of years; selective cutting of 25% of total harvestable mangroves is the optimal strategy (Ruitenbeek, 1994).

2.2 GIS and Information Communication Processes

Communication has become a key feature of sustainable development. Indeed, "communication for development" has become a recognized field among many development decision-makers (Fraser, 1994). "In sustainable development, everyone is a user and provider of information considered in the broad sense. That includes data, information, appropriately packaged experience and knowledge. The need for information arises at all levels, from that of senior decision makers at the national and international levels to the grass-roots and individual levels" (UNCED, 1992). Thus, at UNCED it was acknowledged that there is a need for information exchange among the multiple players, all of whom generate information and exchange it. The most appropriate facility for achieving this in land use management is perhaps a geographical information system (GIS), which is able to read, process, analyze, and present spatially-related data for effective interpretation and use for a variety of environmental and resource management purposes.

2.3 GIS issues for Natural Resources Management

More recently GIS software packages have been seen as a tool to also assist land managers in monitoring and improving catchment condition. This is made possible if farm action plans created by farmers can be uploaded into a central data repository and collated with other farm action plans. (Ramasubramanian, 1995 and 1999), whose identification of criteria for the successful adoption and use of spatial technologies in nonprofit organizations prove to be applicable to the communication between (local) government agencies and nonprofits as well. Ultimate test of the value of the innovations, and the effectiveness of the diffusion strategies, is how deeply and widely the system becomes embedded in the community.

Organizations like the IUCN (IUCN, 1980) and the WCDE (WCDE, 1987) also stress that the sustainable management of Natural Resources can only be achieved by developing a science based on the priorities of local people, and creating a technical base that includes both traditional and modern approaches to problem-solving (Johnson, 1992). Incorporating indigenous and scientific Knowledge means integrating information collected from farmers with scientific information and techniques. This means that we must find a way to process indigenous information in the same way as scientific information (Lawas and Luning, 1996). Many researchers have integrated indigenous knowledge into GIS for various purpose. The tools include systems to store, manage, and analyze geographically referenced data (geographic Information Systems, Or GIS. Though almost all approaches are participatory in nature, the application has differed according to the need and objectives of the project or the community where such an approach is used. (Gonzalez, 1995) used participatory approaches for integrating Indigenous knowledge into GIS for natural Resources Management.

Mari and Bitter, (1996) have used GIS and Rapid Rural Appraisal (RRA) in local level land use planning in Sri Lanka. While Participatory GIS exists, there is a new technique called Mobil Interactive Geographic Information System (MIGIS), developed by (McConchie and Mckinnon, 2002) have pioneered this methodology for integrating Indigenous Knowledge into GIS to produce Community-based maps for collaborative Natural Resources Management. It is shows that there is an increasing interest in using GIS in a participatory context. Participatory GIS is a spatial decision-making tool designed to utilize GIS technology in context of the needs and capabilities of communities that are involved with, and affected by development projects and programs. The major advantages and disadvantages of Participatory GIS, as described by (Jordan and Shrestha, 1999), are in Table1.

Table 1. Participatory GIS: Advantages and Disadvantages

Advantages	Disadvantages
Viewed as participatory process it can empower the community by involving them in the decision-making process.	If the participatory process is not well structured the community does not feel to be a part of the decision making
It can be used to effectively combine quantitative approaches to community development.	There is a potential risk of the focus getting shifted mainly towards extractive data collection.
Spatial data in the form of maps and other resource information can be utilized by the community in their decision making process rather than having access to GIs	There is a likelihood of sensitive spatial information like cadastral maps being subject to unintended misuse of held centrally
Natural Resources information can easily put together, analyzed and returned to the community for use	Excluding disadvantages groups from the" mapping "process can have a disempowering effect on them.
Useful information can be easily put together, analyzed and returned to the community for use	Availability and knowledge of the technology itself encourages a centralized approach.

Source: Jordan and Shrestha, (1999)

2.4 Used of GIS and RS in Mangrove Management

Land use and land cover maps are regarded to be fundamental for the purpose of coastal management planning (Cicin-Sain and Knecht 1998; Mumby et al. 1999; Stevens and Connolly 2004). For this reason periodic mapping of land use, land cover, coastal habitats, and land resources were performed to observe trends and changes (Cicin-Sain and Knecht 1998; Treitz and Rogan 2004). Accurate and up-to-date information on the status of mangrove vegetation, continually over time, is pre-requisite for a sustainable management of mangrove forest. Traditional field survey inside the mangrove swamps is extremely difficult. Remote Sensing (RS) and Geographic Information System (GIS) provides valuable aids for the purpose because RS and GIS is a fast, efficient and accurate mean of information retrieval to detect such changes continually over time.

The information gained can be utilized for effective planning and management of mangrove forest. Mapping using remote sensing and geographic information systems (GIS) has proven to be effective to address problems inherent in the analysis of spatial data. GIS can be used to effectively collect, archive, display, analyze, and model spatial and temporal data (Stanbury and Starr 1999). It may also be used to combine scientific and cultural data to assess and manage marine and coastal habitats (Cicin-Sain and Knecht 1998). Satellite data are now available that can be used to map and monitor changes from continental to local scales and over temporal scales (Treitz 2004). Landstat images are adequate for mapping marine and intertidal habitats (Mumby et al. 1999; Donoghue and Mironnet 2002), as well as mapping land and mangrove cover changes (Long and Skewes 1996 and Weiers et al. 2004).

Many environmental and ecological properties can be determined using remote sensing (Mumby et al. 2004). Accurate maps of their distribution and abundance are essential for monitoring changes over time, for assessing habitat condition, and for investigating their links with other ecological system components that rely directly or indirectly on them (Long and Skewes 1996).

2.5 Strategies to increase Mangrove Resilience

While there is little that protected area managers can do to control large-scale threats like sea-level rise, there are at least ten strategies managers can apply that collectively hold promise to increase the viability of mangroves by enhancing their resilience (McLeod *et al.*, 2006).

2.5.1 Spread risk by identifying and protecting representative mangrove habitats

To effectively spread the risk of losing mangroves to sea-level rise, managers should identify and protect representative species and habitats, replicates of these, and sources of seed to ensure replenishment following disasters. A range of mangrove habitats should be protected to capture different community types. These mangrove habitats may include mangrove fringe forests, over wash mangrove islands, riverine mangrove forests, and basin mangrove forests in areas with varying salinity, tidal fluctuation, and sea level maintaining biodiversity can enhance resilience if sufficient functional redundancy exists to compensate for species/habitat loss (Bellwood *et al.*, 2004).

2.5.2 Identify and protect mangrove "refuge" areas

Managers also should identify and fully protect mangrove communities that have landward migration potential. Coastal land loss and human infrastructure and topography can limit the landward migration of mangroves. For example, population densities of more than 10 inhabitants per square km typically prevent wetland migration (Nicholls *et al.*, 1999). Mangrove forests with abundant mature trees producing a healthy supply of seeds and propagules should be protected as sources for colonizing new areas and repopulating areas damaged or destroyed by a disturbance.

2.5.3 Effective management

To encourage resilience to global climate change, mangroves need to be protected from anthropogenic threats, because mangroves that are healthy will also be better able to adapt to global changes. Over half of mangrove areas are located within 25 km of urban centers inhabited by 100,000 or more people (Millennium Ecosystem Assessment, 2005). Close proximity to urban areas poses threats like pollution, dying, channelization, unregulated felling, conversion to aquaculture or agriculture, and other forms of coastal development.

2.5.4 Establish greenbelts and buffer zones

Mangrove greenbelts can provide significant coastal protection from erosion and should be established along erosion-prone coastlines and riverbanks and in areas which experience significant damage from typhoons, tidal surges, cyclones, and geomorphic erosion (Macintosh and Ashton, 2004). Greenbelts should be a minimum of 100 m, but preferably up to 500 m or 1 km (advocated in Mekong Delta which is subject to typhoons) at the open coast and 30-50 m along riverbanks and lagoons, and >10 m on islands, creeks, and channels (Macintosh and Ashton 2002; Macintosh and Ashton 2004).

2.5.5 Restore degraded critical areas that have high survival prospects

Costs for restoring both vegetative cover and ecological functions of a mangrove area range from US$225/ha to US$216,000/ha (Lewis, 2003). Hydrological restoration has been recognized as the most successful and cost-effective restoration approach (Lewis and Streever, 2000). There are two main types of hydrological restoration: 1) restoring tidal hydrology through excavation or backfilling, and 2) reconnecting blocked areas to normal tidal influences (Lewis and Streever, 2000). In Tanga, northern Tanzania, mangroves have been replanted since 1997, with 107.4 ha of mangroves actively rehabilitated by 2004 (IUCN, 2004). Managing mangroves for multiple uses makes financial sense because it can yield significantly greater economic return than a mangrove forestry plantation of a similar size (Lal, 1990 and Ruitenbeek ,1994).2.5.6 Maintain connectivity between mangroves and associated systems

Connectivity between mangrove systems and upland water catchments should be maintained to ensure an adequate supply of sediment and freshwater. Healthy mangroves should be selected wherever they are connected through currents to areas that may succumb to sea-level rise or to areas that would be suitable new areas for colonization following sea-level rise. Mangroves, reefs, and fisheries often have a synergistic relationship, based on their connectivity (Mumby *et al.*, 2004). Areas where mangroves benefit adjacent ecosystems by filtering sediments and pollutants or providing nursery habitats should be granted greater protection. Mangroves also stabilize sediments and trap heavy metals and nutrient rich run-off, thus improving the water quality for seagrasses, corals, and fish communities. (Mumby *et al.*, 2004) suggest that mangroves are important intermediate nursery habitats between seagrass beds and patch reefs that increase young fish survival. Protected area managers should secure pathways of connectivity between mangroves, seagrass beds, and coral reefs to enhance resilience (Mumby et al., 2004) and fisheries.

2.5.7 Establish baseline data and monitoring plan

Because of the limited number of pristine mangrove forests and the increasing level of threat, establishing baseline data for mangroves is urgent and essential. Data should include a range of variables including: tree stand structure, tree abundance, species richness, and diversity; invertebrate abundance, richness, and diversity; primary production (biomass and litter), nutrient export; hydrologic patterns (Ellison, 2000); and rates of sedimentation and relative sea-level rise. Human threats (e.g., sedimentation, coastal development, and deforestation) and existing management (e.g., traditional ownership, zoning system, policies controlling harvest and encroachment) should also be assessed.

2.5.8 Develop adaptive management strategies

Climate changes such as sea temperature rise, sea-level rise, precipitation or salinity changes, and the frequency and intensity of storms will affect mangrove species distributions. If mangrove conservation strategies are to be successful in protecting species and habitats, they will need to adapt to the changing climate conditions. The ability to predict the location of future habitat sites, and build these potential sites into protected area design and adaptation, will be a crucial element of long-term planning to ensure sustainable protected areas in the face of global change. Flexible strategies and boundaries should be established and tracked to allow for adaptive management.

2.5.9 Develop Sustainable and Alternative Livelihoods for Mangrove Dependent Human Communities

While local stewardship and sustainable harvest of mangroves can be successful (Hussain, 1994), encouraging local communities to develop alternative livelihoods that are less destructive than over-harvesting of mangroves or conversion to fish or shrimp ponds is a crucial step to mitigate mangrove deforestation. Examples of alternative livelihoods include charcoal production from coconut shells instead of from mangroves as well as traditional honey harvesting in mangroves, which encourages agroforestry and conservation of existing mangrove forests (Nathanael, 1964 and Bandaranayake, 1998). Alternative livelihood options and diverse income opportunities allow communities to be flexible to adapt to social, political, and economic changes.

2.5.10 Build constituency and partnerships at local, regional, and global scales

The tremendous challenges of global climate change require creative solutions and collaboration. Strong leadership is necessary to help mobilize support at local, regional, and global levels. Building global, regional, and local partnerships among industries (agriculture, tourism, water resource management) and conservation and infrastructure development can help alleviate the financial burdens of responding to large-scale threats like climate change (Shea *et al.*, 2001). Conservation groups and aid organizations can form partnerships with insurance industries that cover natural disasters.

2.6 Conceptual Framework

The framework presented below shows the interactions among the various factors that will be analyzed in this study (See Figure 1).

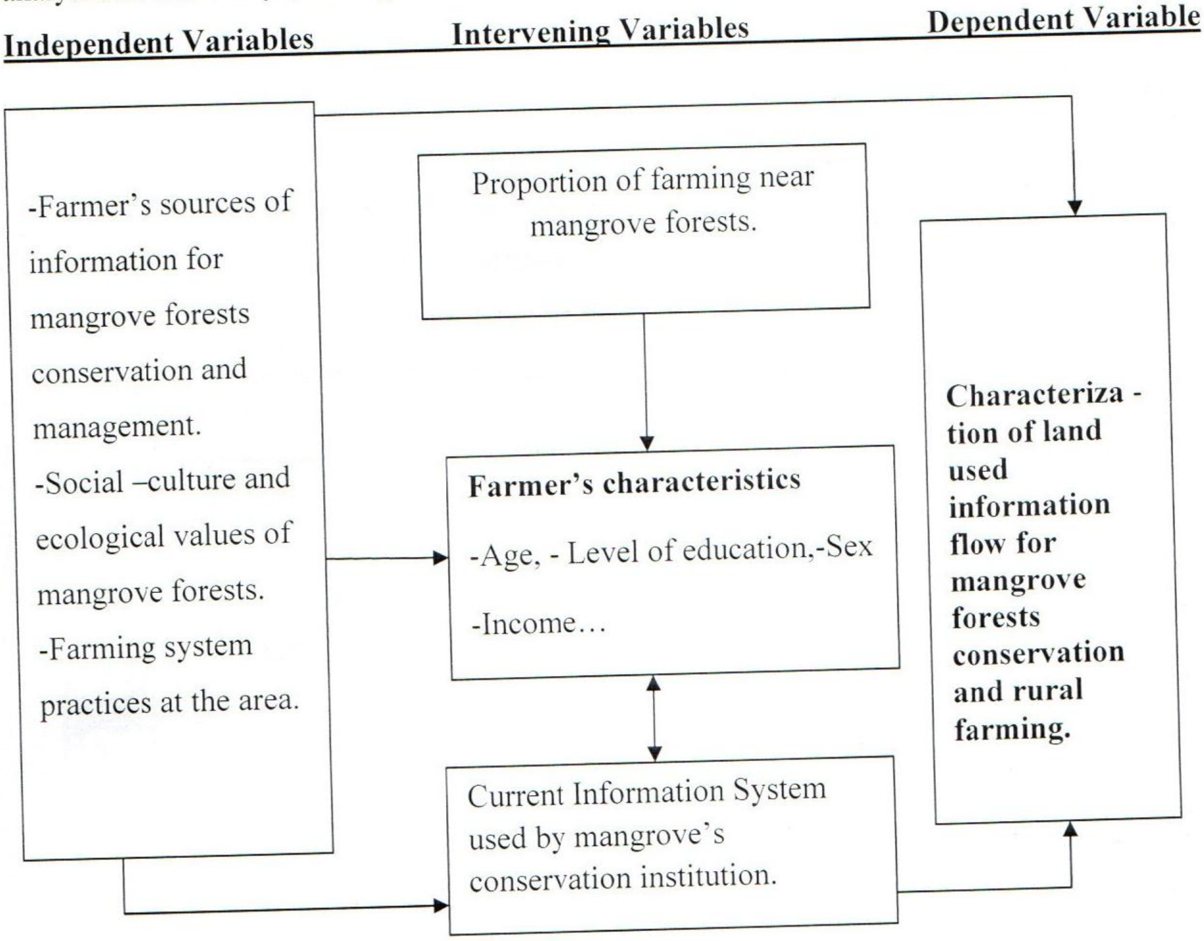


Figure 1. Conceptual framework for the characterisation of land use information flow for mangrove forests conservation and rural farming

CHAPTER THREE
METHODOLOGY

3.1 Study area

The study was conducted in Moanda territory in the Democratic Republic of Congo. Moanda Territory contents the Republic Democratic of Congo's mangrove Marine national reserve which is a multiple use reserve, class VI with regard to IUCN classification, and was created in 1992 (MINAFENV, 2001). Moanda territory is located at the Atlantic coast of the Democratic Republic of Congo, between latitudes 5° 45'– 6° 05' S and longitude 12° 45' – 13° 00 E at Congo River estuary in Bas-Congo Province.

Map of Moanda Territory

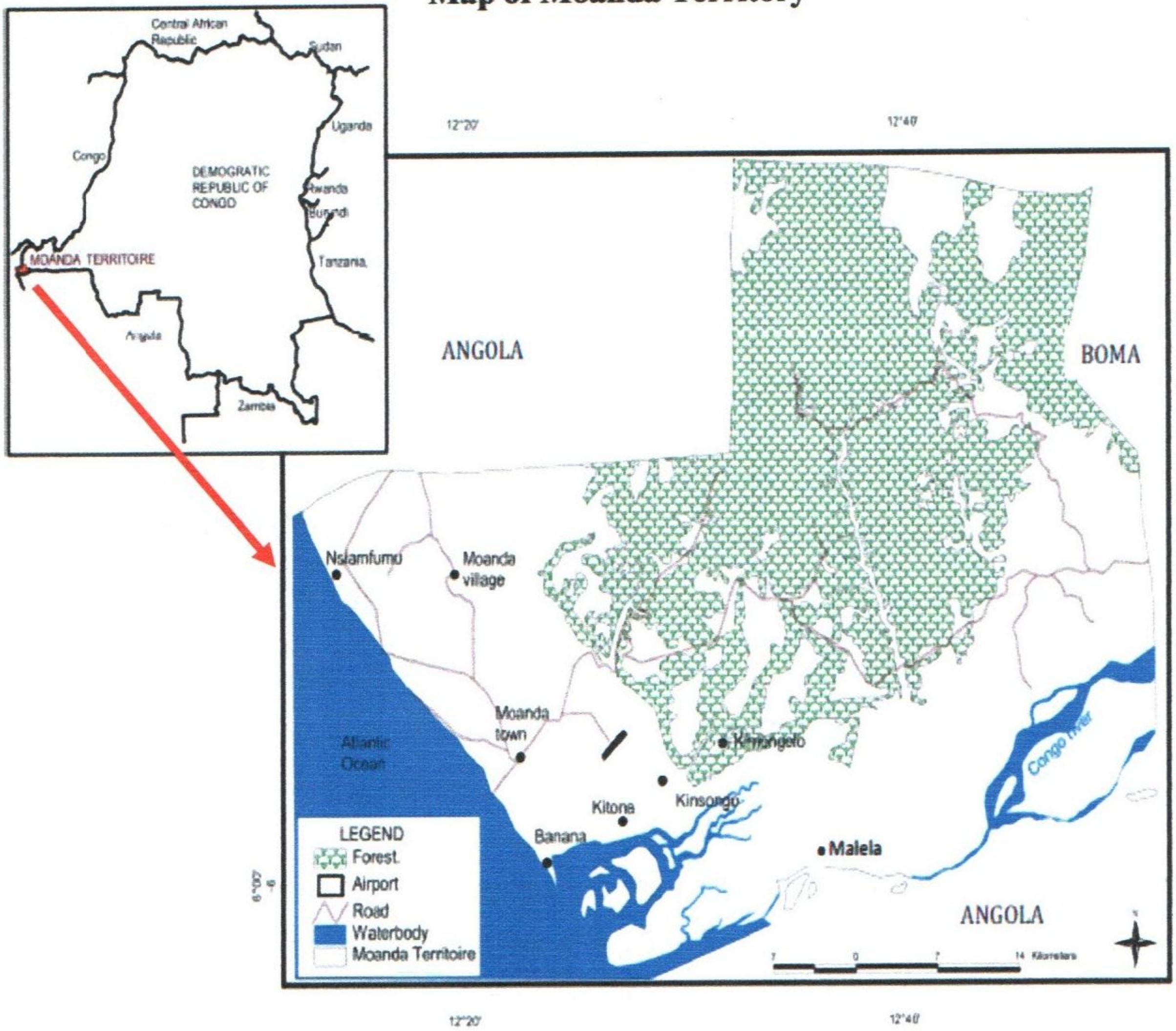


Figure 2. Map of Moanda Territory,

3.2 Climate and Topography

The Democratic Republic of Congo's coastline enjoys a humid tropical climate of the AW4 type according to the Koppen classification. It is characterized by a strong contrast between two distinct seasons: the rainy season from October to May and the dry season from June to September (MINAFENV, 2001). Humidity is high throughout the year, and varies between 77 and 81 %. The average annual precipitation is between 1 750 and 2 100 mm (Evrard, 1968). The District is divided into three topographical zones. The first zone covers the Plateau of Senze-Kitona area lying between 110 and 130 m above sea level. The second zone covers the Plateau of Kilau-Kindofula-Moanda area lying between 24 and 45 m above sea level while the third zone covers some small plateau of mangroves area lying between 10 and 14 m above sea level. The District has streams and rivers that drain into the Congo River and the Atlantic Ocean.

3.3 Soil and Vegetation

The soils of the mangrove areas are predominantly sandy unconsolidated collarine, with poor water holding capacity and extreme alkalinity (Branan, 1978). Congo's mangrove forests are dominated by halophytic plants from *Rhizophoraceae and Avicenniaceae* families' .In some areas these families are associated with plants from *Combretaceae and Malvaceae* families. *Fabaceae and Amarentaceae* family are also present. Major observed species *are Rhizophora racemoza, Laguncularia racemoza, Avicennia nitida, Avicennia. germinans ,Acrostichum aureum, Sisirium postucatrum, Paspalum veiginatum, Sporobolus virginius* ,and *Ipomea pesprae* (FAO, 2001).

3.4 Socio-Economic Profile

Moanda locality has a population of 74, 397 (Wikipedia, 2009) and reflects the striking characteristics of Democratic Republic of Congo's population: these populations are extremely young, with 58.9 percent of the people under 20 years with a significant rural migration due to difficult living conditions poverty and unemployment as a results of mismanagement and conflicts. Communities along the *Parc Marain de Mangrove* (PMM) live mainly from fishing, livestock, agriculture and carbonization. All activities (fishing, agriculture, charcoal production, and livestock) are for the most illegal in the PMM, and present threats to the conservation of Biodiversity in the Park (Bingana, 2003).

3.5 Sample Size and Sampling Procedure

A sample of 200 household units was used in the study. The sample size was obtained using the following formula as provided by Mugenda and Mugenda (2003).

$$n = \frac{Z^2 pq}{d^2} \quad \text{--}(1)$$

Where:

n = desired sample size (if the target population is >10,000. The study area / Moanda district has a population of 74,397) in which about 80 percent are farmer (MINAFENV, 2001); **Z=** standard normal deviation at the required confidence level;

p = proportion in population estimated to have characteristics being measured;

q= 1-p;

d= level of statistical significance test.

Mugenda and Mugenda (2003) suggests that if there is no estimate available of the proportion in the target population which is assumed to have the characteristics of interest, then 50% of the population is recommended. If the proportion of target population with desired characteristic is 0.5 (50%) the z-statistic is 1.96 and desired accuracy (Level of significance) at 0.05, then the sample size (n) is: **384**. SPSS (2003) recommends 200 sample units are sufficient for an accurate study.

A multistage purposeful random sampling was used to select household units. Nine villages in Moanda territory where selected based on predominantly use of mangrove as source of marine or forest product and where the mangrove is being converted to agriculture and/or settlement. This was used as the criterion for purposeful random sampling. The selected villages were Moanda village, Nsiamfumu, Mbanza malela, Kimuabi, Banana, Kimongowolo, Kinsongo, Kindofula, and city of Moanda. Villages where grouped geographically in three categories: 0-1 km to mangrove forest (Kimongowolo, Mbanza malela, Kimuabi), 1-5 km (Banana, Nsiamfumu) and 5-10 km (Kinsongo, Kindofula, Moanda village, and City of Moanda). A fixed quota of 80% of households was attributed to villages and 20 % of households' survey to city of Moanda. All household units in the three categories were used to enable random selection of households to be included in the study. The household units surveyed were proportionately calculated from the household units in the study area as shown in Table 2.

Table 2. Data on study sites and number of household units interviewed

Geographical groups	Total number of Households	% of number of households surveyed
5-10km	669	93
1-5km	575	77
0-1km	218	30
TOTAL	1462	200

Source: NGO ACODES, 2010

3.6 Research Design

The study involved socio-ecological survey design in GIS environment, the research made use of structured questionnaires, focus group discussions and secondary data to establish constraints and gaps in land use information service delivery. A multistage purposeful sampling was used, 200 household units were surveyed proportionately to the household units in the study area. Data collected from the questionnaires was complimented by personal contact with respondent and focus group discussion so that more information from the survey was realised. The items on the questionnaire were developed on the basis of the objectives of the study and scores were made on likert summative scale which is ordered and one-dimensional from respondents choose one option that best aligned with their views as shown in appendices. The instruments were administered to the household respondents by the researcher himself in order to facilitate elaboration of any aspects that may not have been easily understood by the respondents. Global Positioning System (GPS) Garmine, Idrisi Kilmanjaro and ArcView GIS 3.2 served to detect the changes in farming and mangroves forest area over the last 22 years from landstat TM of July 1988 and landstat ETM of April 2002 and March 2010 (Path/Row scene: 180–064).

3.7 Data Collection

Information was gathered using a variety of social and natural science methods. A pre-test to determine the reliability and validity of the research instruments was done in Moanda territory. Pre-testing of the survey instrument with 23 respondents from the nine villages and 4 respondents for the extension service and local NGO was done. Any necessary corrections were made before the instruments were applied to the study populations.

The study focused mainly on household heads for interviewing to ensure uniformity of data collection process. In the event that the household head was absent, the most responsible household member was interviewed. This was a member who had been entrusted with the responsibility of overseeing the running of household in the absence of the household. The questionnaires were designed to capture information at two levels: one focusing on key informants (Appendix 2) and the other targeting individual households (Appendix 1) involved in direct utilization of the mangroves in the study sites. The questionnaire for the extension personnel and NGOs leaders (Appendix 2) was personally deliver to the concerned personnel and collect them immediately after they were filed. The questionnaire survey was supplemented by group discussion (appendix 3). Global Positioning System (GPS), Idrisi Kilmanjaro and ArcView GIS 3.2 served to detect the changes in farming and mangroves forest area over the last 22 years from landstat TM of July 1988 and landstat ETM of April 2002 and March 2010 (Path/Row scene: 180–064). Ocular methods were used to confirm and compare the reported information with the actual occurrence in the study area.

3.8 Data Analysis

- **Objective 1: To map the temporal variability of mangroves forest and rural farming among the study sites.**

Preliminary image analysis was performed to extract meaningful information from the acquired Landsat TM of images of the years 1988, 2002, and 2010 to investigate the Spatio-temporal change of the areas of Moanda Territory. These three temporal dates of satellite images were used to assess the temporal variability of mangrove forest and the land covered by rural farming. For recognition of vegetation reflectance, layer stacking of band 4, 3 and 2 (false color composite) for TM and ETM+ was performed. Supervised classification was done and maximum likelihood operation was performed to generate vegetation cover maps. Afterwards, vegetation cover map of 1988 and 2002 and 2010, were overlaid to generate the map of change of vegetation cover for the respective dates and to find out the changing pattern of vegetation cover. The images were then classified into (1) Tropical forest, (2) Mangroves, (3) Marshland, (4) Farming area, (5) Open grassland, (6) Settlement, (7) Swamp, (8) Disturbed Forest, (9) Shrub land and (10) Water body. Land cover change was determined by comparing multi-date images. GCP were taken with a GPS device in strategic locations of the study area; this was to establish ground information on vegetation cover.

- ❖ **Objective 2:To identify mangroves socio-economic and ecological values among the study sites**

Socio-economic values - refers to status and value attachment to mangroves forest in terms of consumption and was measured by the following indicators: Food and medicinal herbs, source of charcoal, timber and wood, research activities, heritage site, tourism and settlement. Ecological values-refers to conserve forest and animals; water for farming and livestock grazing reserves. The scores were made on a likert summative scale which is ordered and one-dimensional scale from which respondents chose one option that best aligns with their view. Descriptive statistics enabled a meaningful description of scores within the use of frequencies, percentages and means. The statistical Package for Social sciences (SPSS), was used for analyse.

- ❖ **Objective 3: To identify sources of information used by farmers in conservation and management of mangrove forest.**

Information used by farmers in conservation and management of mangrove forest was identified using mean and percentage. Sources of information for conservation and management of mangrove forest were grouped as conventional and emerging. Descriptive statistics was enabling a meaningful description of scores within the use of frequencies, percentages, and means. The Statistical Package for Social sciences (SPSS), was used for analyse.

- ❖ **Objective 4: To determine factors that influences the choice of information sources for conservation and management of mangrove forest.**

Inferential statistics was applied to analyze data. The Logit model was used in this study as it integrates bio-economic, socio-economic and biophysical databases. In addition, the statistical significance of the estimated coefficients can also be interpreted directly. However, linear probability is theoretically simple but its prediction may lie outside the limiting intervals (0-1) of probability laws (Pindyck and Rubinfeld, 1981; Mukras, 1983).

In this study, sources are grouped as conventional only and emerging. The choice model is described as follows:

$$P_i / 1\text{-}P_i = \sum (\alpha_i X I + \beta_i Z_i + \varepsilon) \quad (2)$$

Lineared into:

$$Y = \alpha + X_1\beta_1 + X_2\beta_2 + \ldots + X_n\beta_n + \varepsilon \quad (3)$$

Where;

P_i is the probability of use of different sources of information for conservation and management of mangrove forests (Y_c=conventional only; Y_e=emerging) and

1-P_i is the probability of non-use.

X_1...Xn are factors that influence use of information such as (age, education, gender, institution (NGOs), members of groups , distance to the forest, distance to the river, access to the extension services, income from the farming , size of the land…); α is the Constance, and β1..n were the parameters to be estimated. Running the model started with its evaluation and check of goodness-of-fit. The X_1 to X_n are variables of interest and their descriptions are given in Table 3 below.

3.9 Data and Hypothesized Effects

The study presumed that use of different sources of information for conservation and management of mangrove forests was influenced by farm and farmer characteristics, institutional support factors. Therefore, education, age, gender, access to credit, extension, training, region and distance to the forest were used as explanatory variables.

Educational level of farmers was used as a representative of human capital. It was captured by calculating the average years of completed schooling for all farmers. Production decision making can be influenced by the level of education of household members. Farmers with a higher level of education were expected to be more likely to use emerging sources of information for conservation and management of mangrove forests. This is because generally literacy improves the ability to conceptualize information and make economically viable decisions.

Age and the number of years the farmer has been keeping farming reflect his experience, hence, might influence the use of emerging sources of information for conservation and management of mangrove forests. The older farmers are expected to have more experience in farming production. We assume that, as people grow old they tend to be more conservative hence involved in free range production systems where limited interventions are used. On the other hand younger farmers were expected to adopt more emerging sources of information as they are actively involved in production activities. Age of the farmer was expected to positively or negatively influence the use of emerging sources of information for conservation and management of mangrove forests.

Farmers accessing credit, training, Leaflets/literature, information communication tools, such as, TV, radio, radio call and mobile phone, and extension from NGOs and government were expected to adopt more emerging sources of information for conservation and management of mangrove forests. The Table 3 below shows variables included in Logit Model and their hypothesized effects.

Table 3. Hypothesized effects of explanatory variables on adoption of interventions

Variables	Code	Description	Expected Sign
Sources of information	Y	Categorical	
Education	Ed	Number of years of schooling	+
Group Membership	Gm	Dummy scoring 1= for member 0 = Otherwise	+
Access to credit	Cd	Dummy scoring 1=Yes and 0= Otherwise	+ or –
Gender	Gd	Dummy variable 1=female gender and 0= Otherwise	+ or -
Age	Age	Age measured in years	+ or -
Access to extension	Ext	Dummy variable 1=Yes 0=otherwise	+
Income	Inf	Farm income in dollar / year	+
Leaflets/literature	Lit	Dummy variable 1=Yes 0=otherwise	+ or -
Distance to the forest	Disf	Distance captured in kilometres	+ or -
Size of land owned	Sland	Dummy scoring 1=Yes, 0= otherwise	+
TV	Tv	Number of time received information through TV/ month	+
Radio	Radio	Number of time received information through radio/ month	+
Radio call	Rcall	Number of time received information through radio/ month	+

CHAPTER FOUR
RESULTS

4.1 Household Characteristics

Results indicate that 60% and 40% of the households that were interviewed were female and male headed respectively (Figure 3).

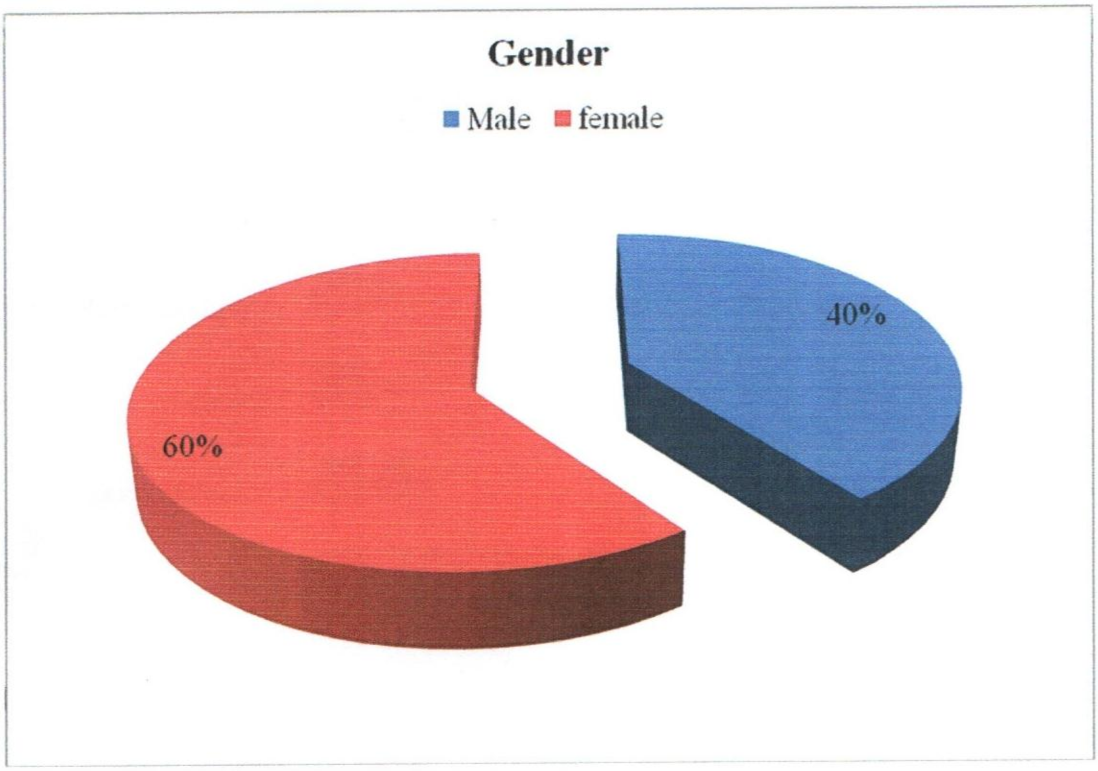


Figure 3. Gender repartition at the study sites

Fifty eight percent of the total respondents were farmers while 48 % engaged in forestry activities (Figure 4).

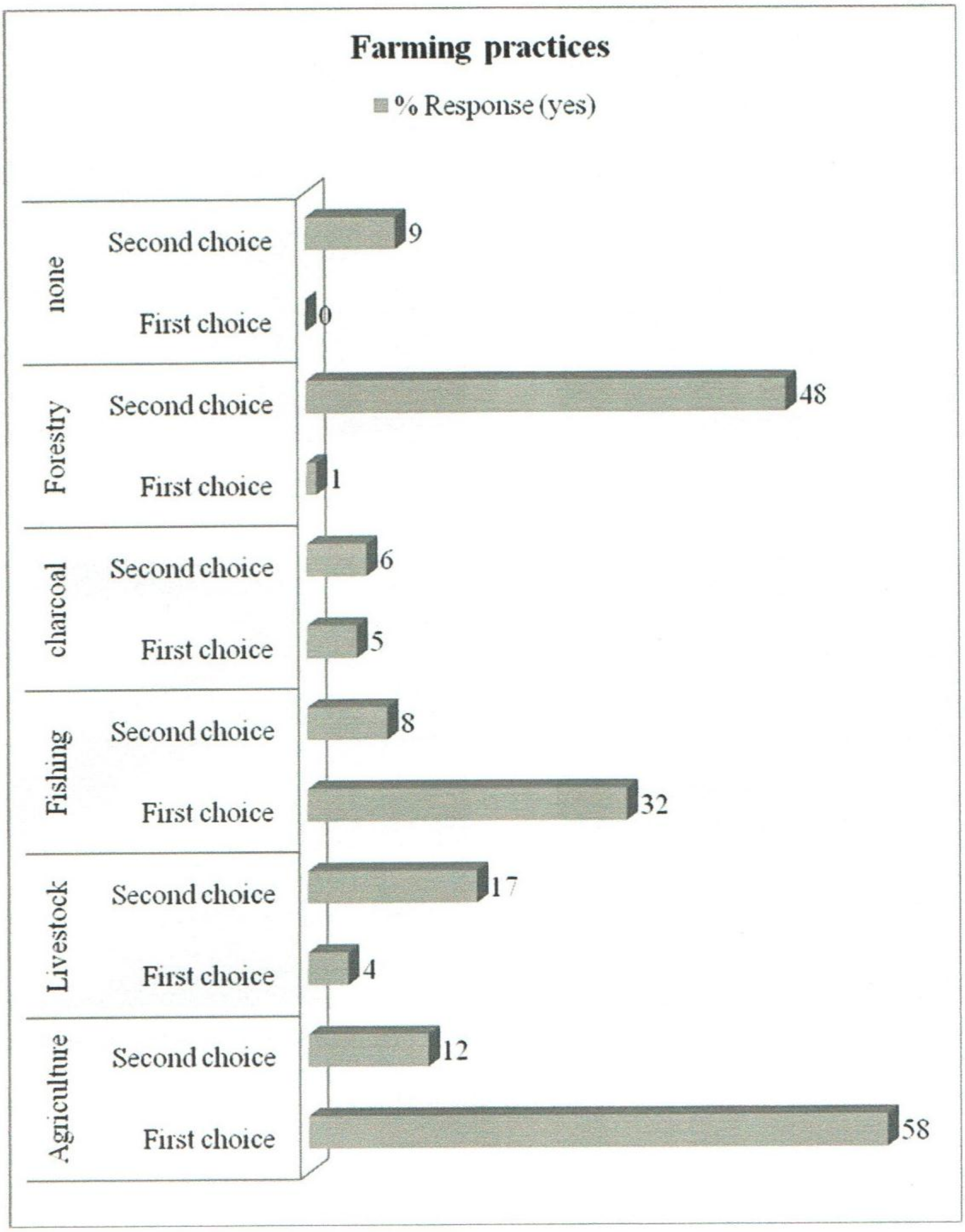


Figure 4. Farming practices at the study sites

(a) Forestry activity near Kimongowolo

(b) Livestock at Mbanza malela village

(c) Agricultural activities at Kimuabi village

(d) Fishing village of Nsiamfumu near the Atlantic Ocean

Plate 1. Farming activities in the Moanda territory

In Moanda territory, agriculture is still the dominant key component of the rural economy. Principal food crops include cassava, banana, taro, yams, maize and sweet potatoes. Fishing is also an important economic activity in Moanda. Shrimp, crab, and shark are among the principal catches. Most of Moanda's native animals were hunted to extinction long ago. Also, the degree of deforestation already present seems to preclude the reestablishment of wildlife, although the climate would be hospitable to any tropical plants or animals.

Table 4 indicates that the average annual income from the sale of mangrove products was US$ 779. The average age of respondent among the study site was 39 years. Household heads had an average of 45 years while the mean number for household size was 5. Also, the mean number for formal education was 6 years and the mean number for number of extension visits/years was 1.

Table 4. Selected characteristics of household head in the study sites

Characteristics of household head	Mean	Std. Deviation
Age of Respondent	39.11	14.43
Education of respondent (Number of years in school)	5.45	3.86
House hold size	4.72	1.91
Income from the farming / year (in USA $)	778.80	614.89
Number of extension services visitors/years	1.12	0.36
Age of the household head	45.25	12.08

n= 200

4.2 Institutional Information at the Study Sites

Approximately 87% of total farmers interviewed were satisfied with the content and about 77% of farmers interviewed were satisfied with the impact of land use information delivered by locals NGOs and the mass media. However, a few farmers (23 %) interviewed were very satisfied with the frequency of delivery. It is also important to note that the respondents were dissatisfied with government institutions in terms of content of information, frequency of delivery and impact of information (Figure 5).

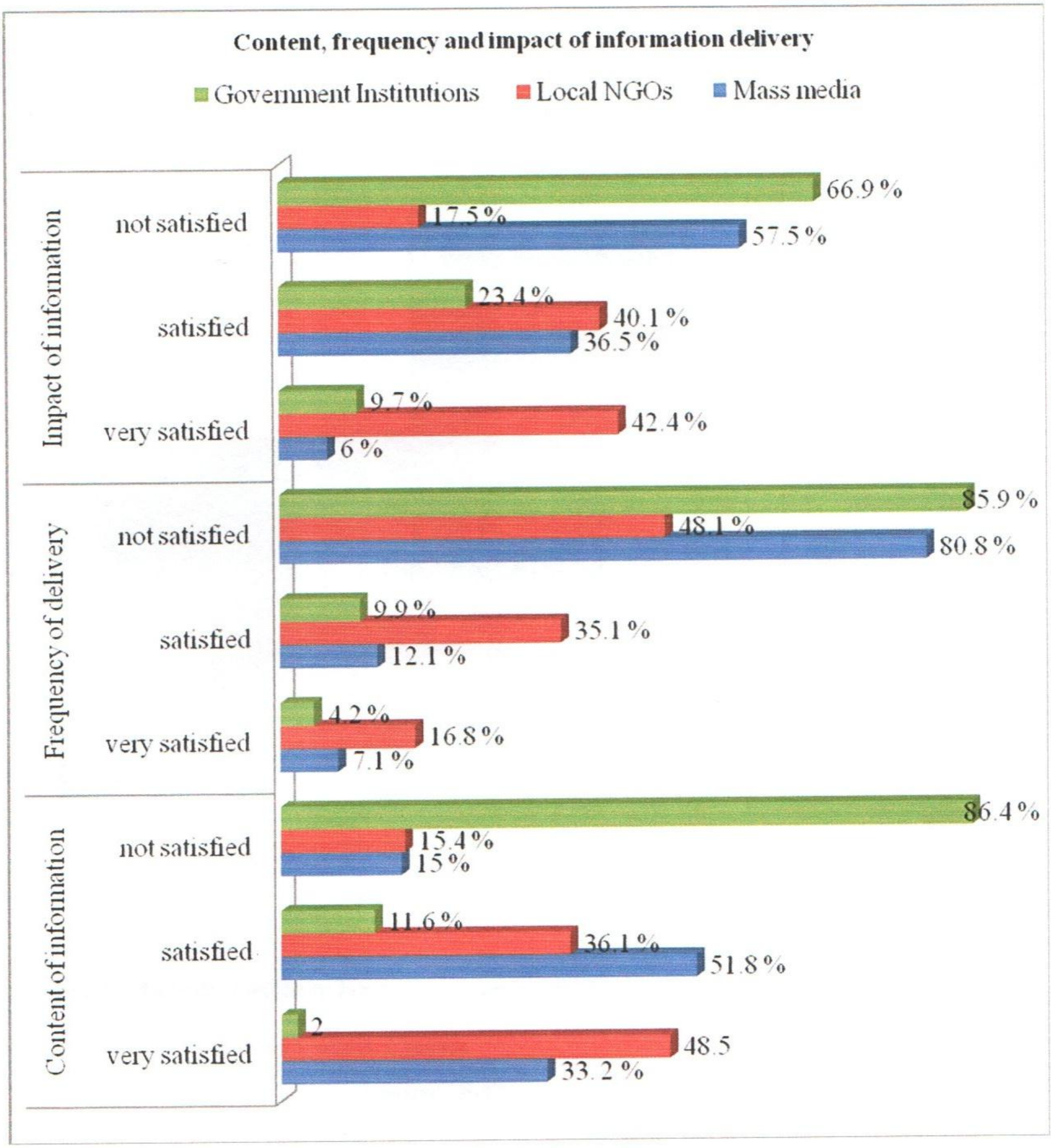


Figure 5. Content, frequency and impact of information delivery in Moanda Territory

4.3 Temporal Mangrove Land Covers Variability

Images were classified into 10 land use/cover Classes, with a overall accuracy of 78%. (1)Tropical forest, (2) mangroves, (3) Marshland, (4) Farming area, (5) open grassland, (6) settlement, (7) swamp, (8) Disturbed Forest, (9) Shrub land and (10) Water body (Figure6).

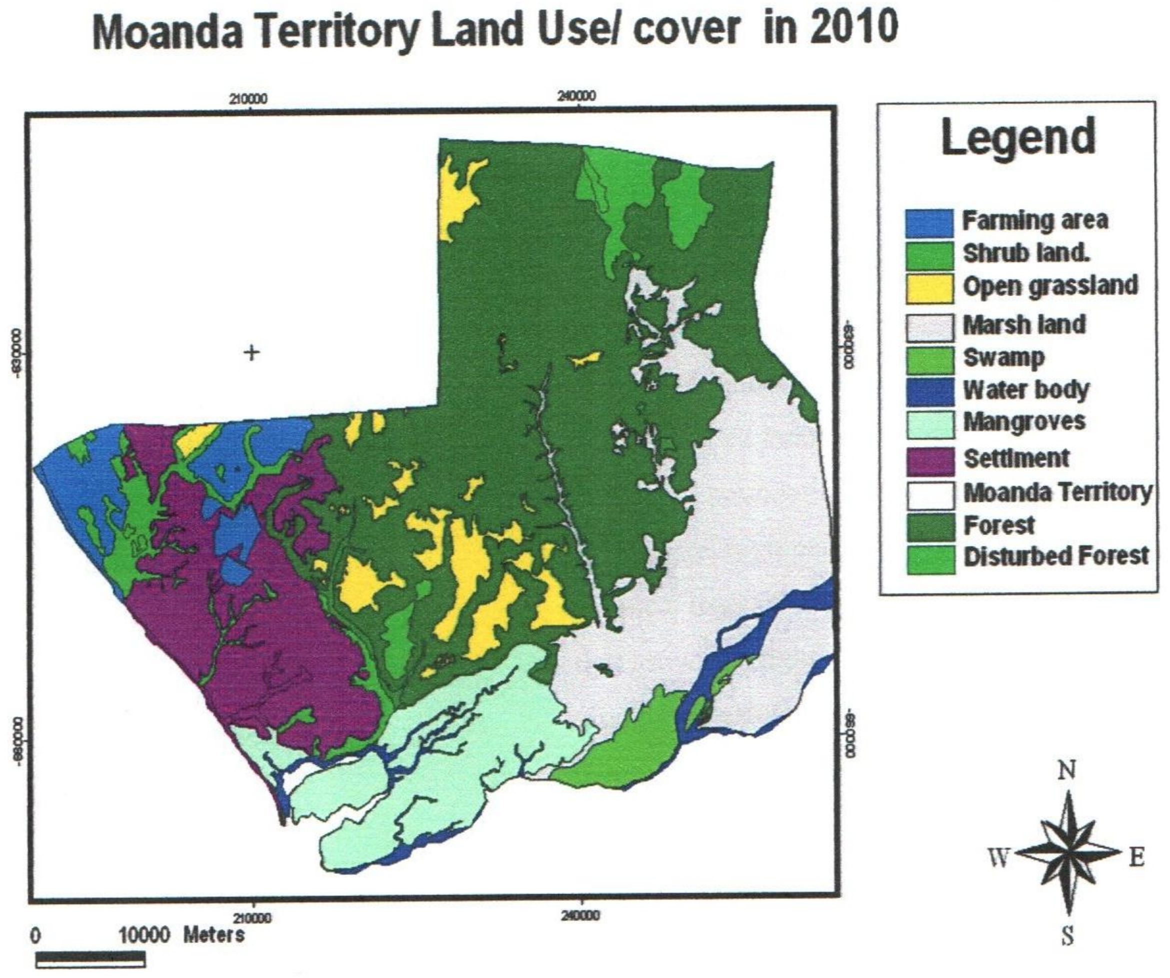


Figure 6. Moanda territory land use/cover in 2010

4.4 Description of Land Covers Classes

Table 5 shows land cover classes distinguished in the supervised Landsat imagery classification process. This classification has been only assessed by a visual interpretation.

Table 5. Land covers classes

Class	Description
Tropical forest	Dense growth of trees, together with other plants, dense canopy covering a large area of land with lowest disturbance level.
Disturbed forest	All forests subject to some kind of visible human interactions , plantation mixed with indigenous species
Farming area	Cultivated land of diverse characteristics, highly divided land with trees and bushes along plot boundaries, mainly subsistence agriculture, high percentage of bare ground
Mangrove	Tropical trees, shrubs, palms or ground ferns that grow in a tightly knit thicket or forest along tidal estuaries of Moanda territory
Marshland	Type of wetland which is subject to frequent or continuous flood. Typically the water is shallow and features grasses, rushes, reeds, typhas, sedges, and other herbaceous plants.
Open grassland	Open Grasslands are the flowing landscapes of open areas where grasses are the dominant vegetation and where relatively few trees or shrubs grow.
Settlement	Space cover by roads (tarmac or dirt track), rocks, village, town
Shrub land	Vegetation dominated by shrubs, often also including grasses, herbs, and geophytes. In some places may either occur naturally or be the result of human activity
Swamp	Wetland characterized by relatively deep and widespread areas of water.
Water	Water (Atlantic ocean, Congo river)

Table 6 shows land use /cover classes and changes that have occurred from 1988, 2002 and 2010 in Moanda territory. Mangrove forests covering approximately 23 491.42; 23 352.43; and 23 351.40 ha in the 1988, 2002 and 2010 time periods, respectively. Forest cover declined by 113 160 ha to 93 690.22 ha in 2002, however from 2002 to 2010, the forest loss amounted to 93 690.22 and 93 580.82 ha respectively. Open grassland declined from 33 405.42 in 1988 to 14 179.78 ha in 2010. From 3 986.74 ha in1988, farming are increased by 7 998.68 and 8 452.91 in 2002 and 2010 time periods respectively.

Table 6. Land use/cover change trend 1988-2010

Land use	1988		2002		2010		% change		
	(ha)	(%)	(ha)	(%)	(ha)	(%)	1988-2002	2002-2010	1988-2010
Disturbed Forest	14 824.2	6.1	14 219.4	5.9	14 026.11	5.8	0.20	0.10	0.3
Farming area	3 986.74	1.6	7 998.68	3.3	8 452.91	3.5	-1.7	-0.2	-1.9
Forest	113 160	46.6	93 690.22	38.6	93 580.82	38.5	8	0.1	8.1
Mangrove	23 491.42	9.7	23 352.43	9.6	23 351.40	9.6	0.1	0.0	0.1
Marshland	27 943.92	11.5	46 344.85	19.1	46 298.37	19.1	-7.6	0.0	-7.6
Open grassland	33 405.42	13.8	14 268.55	5.9	14 179.78	5.8	7.9	0.1	8.0
Settlement	11 716.16	4.9	30 669.6	12.6	30 679.7	12.6	-7.7	0.0	-7.7
Shrub land	3 049.8	1.2	1 304.91	0.5	1 279.5	0.6	0.7	-0.1	0.6
Swamp	4 968.4	2	4 697.42	1.9	4 697.42	1.9	0.1	0.0	0.1
Water body	6 343.74	2.6	6 343.74	2.6	6 343.74	2.6	0.0	0.0	0.0
Total	242 889.8	100	242 889.8	100	242 889.8	100	0.0	0.0	0.0

Figure 7 shows that farming area increased by 100.63 % and 112.02 % from 1988 to 2002 and 1988-2010 time periods respectively. Tropical forest loss amounted 17.20 % between 1988 and 2002. However, there was no dramatic changes in mangrove forest cover for the last 22 years; -0.59 % from 1988 to 2002 and – 0.60 % from 1988 to 2010.

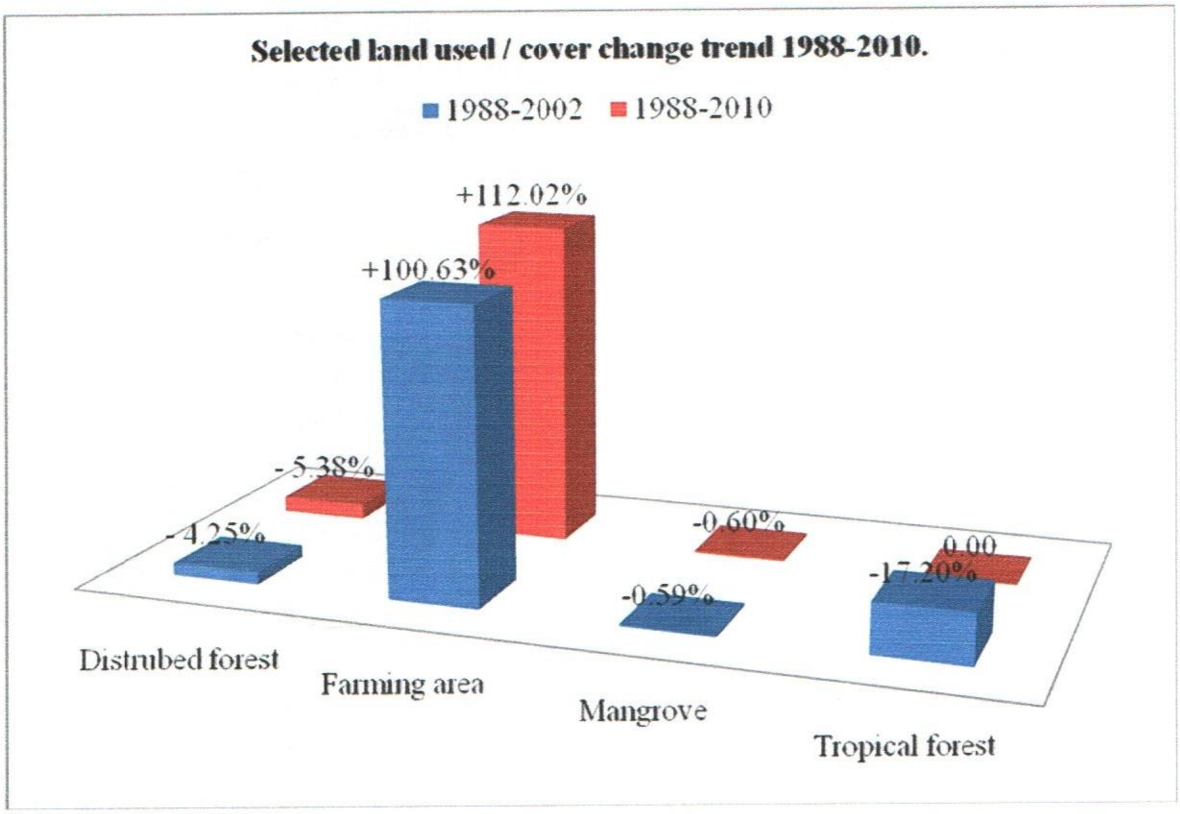


Figure 7 Selected land use / cover change trends 1988-2010

Figure 8 shows forest cover changes from 1988 to 2010. This includes tropical forest, mangroves, shrub land, and disturbed forest.

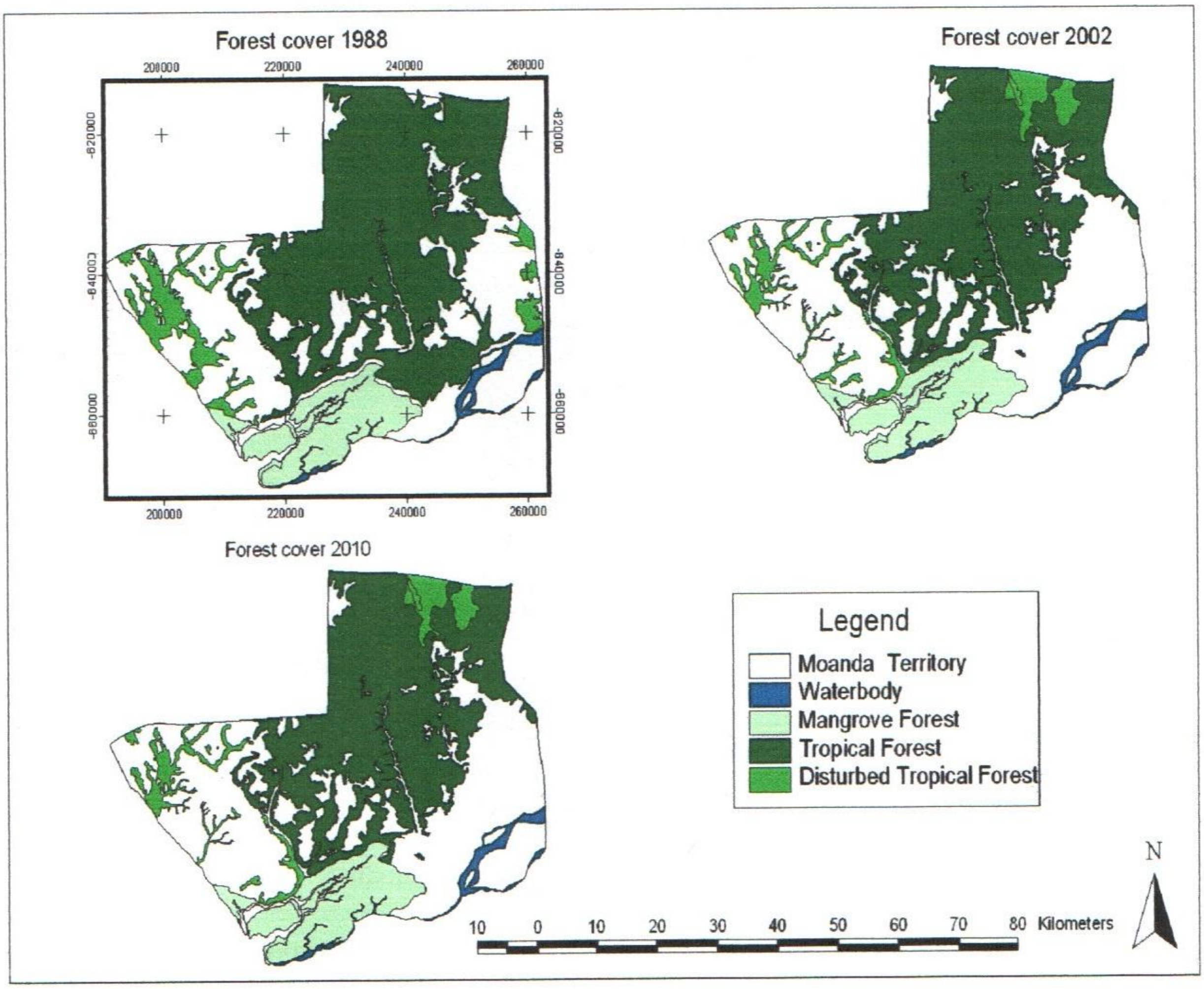


Figure 8. Forest cover changes 1988 to 2010

4.5 Socio-economic Values of Mangroves Forests in Moanda Territory

Among the study sites, 70 % of respondents indicated that mangrove had greatest value in term of food and herbal. Thirty one % of the respondent interviewed designated mangroves have greatest value for provision of charcoal, timber and wood. Only 25 % of respondent indicated mangroves have a greatest value in settlementnn. A few (15 %) of respondent indicated mangrove site for touristic values (Figure 9).

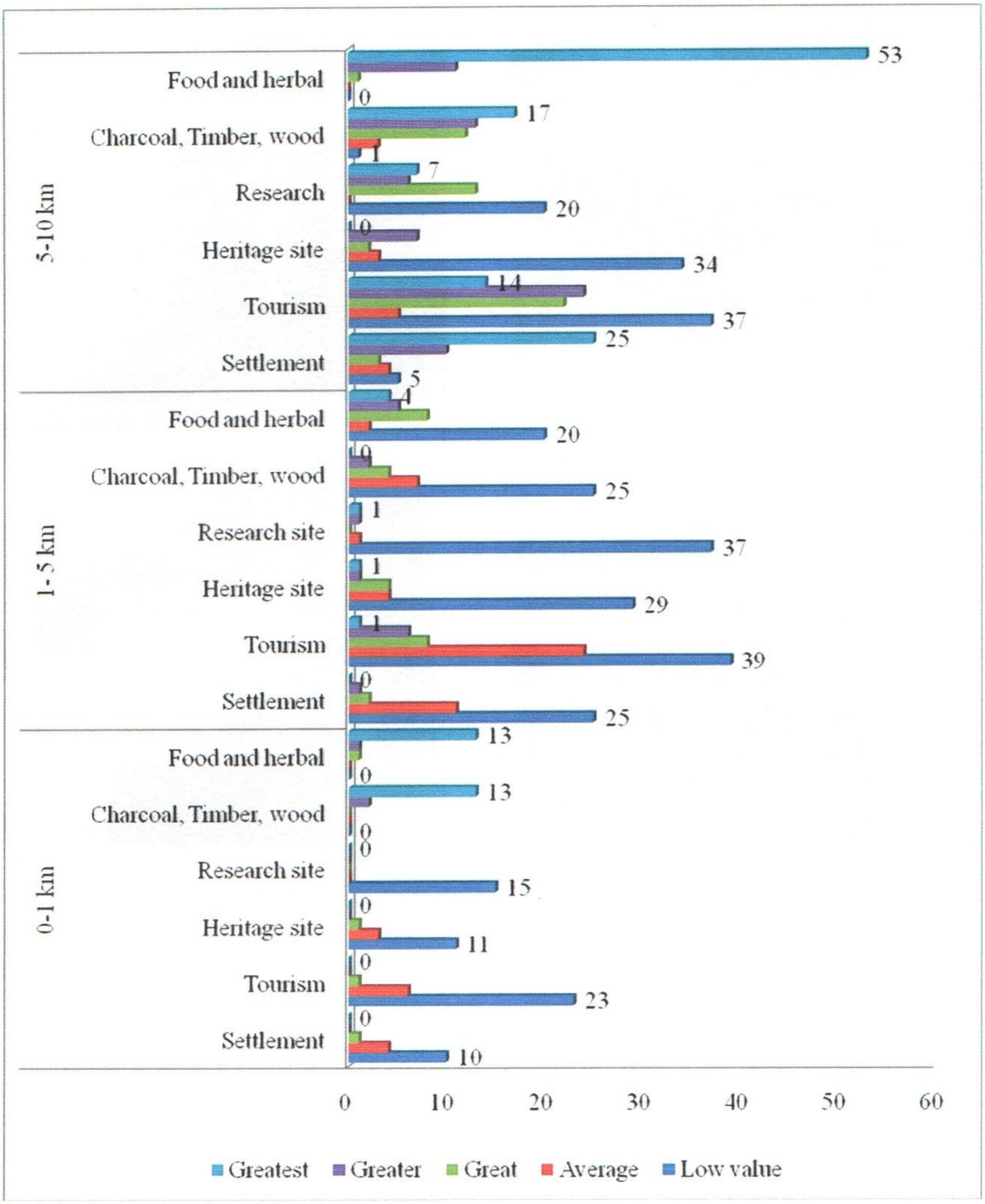
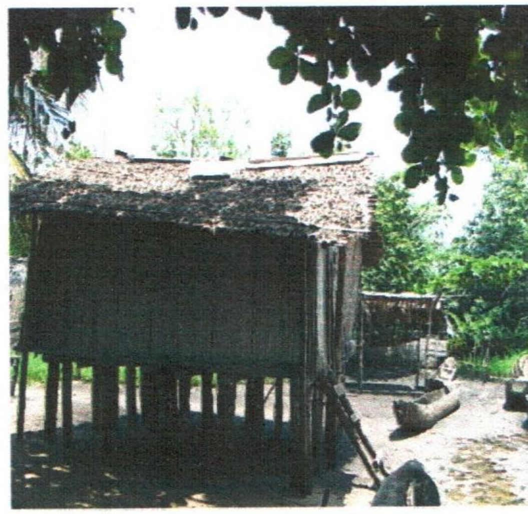


Figure 9. Socio-economic values of mangrove forests

(e) Fuelwood production near Congo River



(f) Fisherman house contraction from Mangroves' trees near Congo River

(g) Shrimp fisherman at Banana

(h) Charcoal production at Kimongolo village

Plate 2. Socio-economic activities at the study sites

4.7 Sources of Information used by Farmers in Conservation and Management of Mangrove Forest

The majority of respondent (88 %) consider the frequency of information from face to face high, and about 83 % of respondent consider the frequency of information from barazas as high. A few, only 18 % regard the frequency of information from opinion leader high. Frequency of information from drama and Leaflets/ literature was very low (Figure 11).

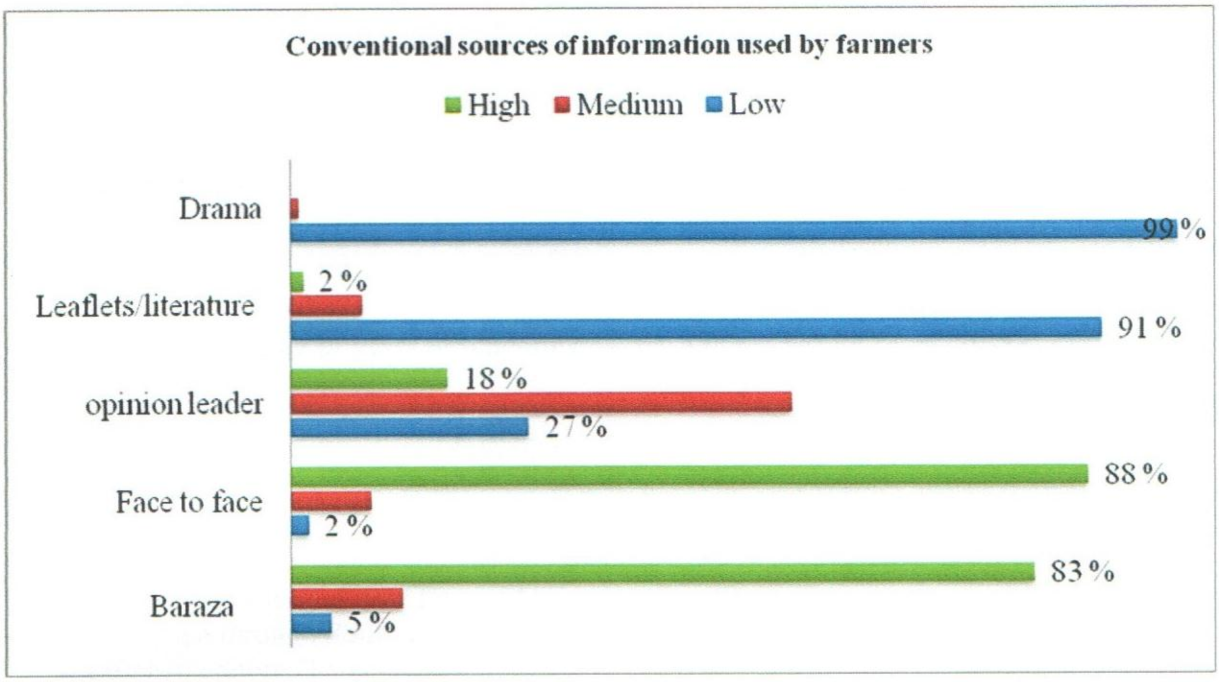


Figure 11.Indigenous sources of information used by farmers in conservation

Figure 12 shows that 64% of respondent consider the frequency of information from Radio high while a very few (5%) of respondent consider information from mobile phone and radio call high. In the most of cases the frequency of information from modern sources was very low.

4.8 Factors that Influences the Choice of Information Sources for Conservation and Management of Mangrove Forest

Farmers' years of schooling, the number of time per month farmers received land use information through radio, the number of time per month farmers received land use information through Leaflets/literature and farmers' years of education influenced farmer's decision to use modern sources of information. Age of respondent was also an important influence, but its influence was negative. Several variables had no significant influence on giving out of influences on the choice of information sources for conservation and management of mangrove forest (Table 7).

Table 7. Logit estimates for farmers' use of modern sources of information

Factors	Coefficient	Standard error	
Age (years)	-0.147*	0.062	
Education (Number of years of schooling)	0.441*	0.199	
Credit (1=received credit, 0= Not received credit)	23.924	1.304	
TV (Number of time received information through TV/ month)	25.211	1.568	
Radio (Number of time received information through radio/ month)	5.784**	1.604	
Radio call(Number of time received information through Radio call/ month)	27.308	1.012	
Leaflets/literature (1=received information through leaflets , 0=Not received)	7.196**	2.563	
Constant	-4.562	1.990	
-2Log likelihood			161.985
Model chi-square			134.489
Correctly predicted of use of conventional source of information only			98.8%
Correctly predicted of use of emerging sources of information			82.1%
Overall cases correctly predicted			96.5%
Sample size			200.0
R2			0.490

*and ** Significant at 5% and 1% levels respectively

4.9 Relation between Education and Access to Mobile phone, Radio, TV and Telecenter as source of land use information

There was significant positive correlation between education and access to mobile phone, TV, telecenter and radio as source of land use information (Table 8).

Table 8. Relation between education and access to mobile phone, radio, TV and telecenter as source of land use information

Sources	Value	Standard Error (a)	Approx. Sig(b)
Radio	0.286	0.073	0.000
TV	0.149	0.052	0.036
Mobil phone	0.190	0.078	0.007
Telecenter	0.282	0.053	0.000

n= 200, (a) Not assuming the null hypothesis. (b) Based on normal approximation.

Spearman correlation.

CHAPTER FIVE
DISCUSSION

5.1 Household Characteristics and Institutional Information at the Study Sites

Household characteristics indicated that 60% of household were female. Most of respondents were agriculturalist (58 %) and 48 % were engaged in forestry (Figure 4). Studies have shown that women and men perform different tasks and activities, and hence have different preferences, knowledge and skills (UNDP/FAO, 2001). Knowledge retained by men and women on biodiversity differs and varies according to their age, ethnicity and geographical location (UNDP/FAO, 2001; Ghimire *et al.*, 2004; Yaofeng *et al.*, 2009).

The mean age of households' heads was 45 years (Table 4). This can improve rural livelihood because in all study sites mangroves provide sources of food and medicine, charcoal, firewood, timber for building, and fodder. On the other hand, this can have a negative impact on mangroves forest conservation in light of the results.

The overage year of education for the household heads were 5 years (Table 4). Education level can influences communication and information flow because it can be associated with ability to synthesize more information and adopt technologies on land use information. This was proved in this study because the relationship between education and use of radio, mobile phone telecenter and TV as sources of land use information was significant (Table 8). This indicates, there is significant influence of farmer's education on land use information and mangrove conservation.

The study found out that the mean income was $779 per year (Table 4). This means that household heads that have a large family size need more resources. These households are left with inadequate excess cash to buy inputs, to buy the few vital consumer goods they cannot produce themselves, and, when necessary, to pay taxes. Under such conditions, respondent indicated they used mangrove for charcoal, timber and wood and they practiced forestry as a second livelihood choice (Figure 9).

The results show also that, farmers interviewed are satisfied with the content and the impact of information delivered by local NGOs and the mass media. However, they were dissatisfied with the frequency of delivery. It is also important to note that the respondents were dissatisfied with government institutions in terms of content of information, frequency of delivery and impact of information (Figure 5).

5.2 Temporal Mangroves and Rural Farming Land Cover Variability

Remote Sensing and Geographic Information System served as valuable aids in providing fast, efficient and accurate information to detect the changes in mangroves forest area. The temporal variability of mangrove and rural farming land cover variability has been assessed by visual interpretation. Given the complexity of mangroves forest and rural farming cover, remote sensing and GIS were the only reasonable ways to perform the landscape analysis. Therefore, maps produced in this study were efficient graphical instruments for communicating information, land planning and decision making. Studies have shown that Land use and land cover maps are regarded to be fundamental for the purpose of coastal management planning (Cicin-Sain and Knecht 1998; Mumby *et al.* 1999; Stevens and Connolly 2004).

Comparison of the data between the three time periods show that (1) There has not been a dramatic change in mangrove cover the last 22 years; although this does not necessarily mean that the mangrove ecosystem is in a good condition because about 31 % of the respondent interviewed indicate mangroves have greatest value as site that provides charcoal, timber and wood. This requires a system of landscape level planning which respects both the ecological limitations to human use and the established cultural uses of forests. (2) From 3 986.74 in 1988, farming area increased to 7 998.68 and 8 452.91 in 2002 and 2010 time periods respectively (Table 6). (3) Forest cover declined by 113 160 ha to 93 690.22 ha in 2002, however from 2002 to 2010, the forest loss amounted to 93 690.22 and 93 580.82 ha respectively. (4) The greatest threat to the largest forest stands was housing, farming and industry expansion in the Moanda territory. It can be hypothesize that the progress realized from 2002 is the result of the global policy reform undertaken by the COMIFAC for the Congo basin forest preservation over the last 10 years. (5) Open grassland declined from 33 405.42 in 1988 to 14 179.78 ha in 2010 (Table 6).

That is the result of the conversion of large areas of open grassland to residential and agricultural use.

5.3 Socio-Economic Values of Mangrove Forests in Moanda Territory

Food and herbal were the main current annual economic benefits accruing from mangroves forest as have been indicated by 70 % of respondents (Figure 9). The result also shows also that, 30 % of the respondent interviewed designate that mangroves have greatest value as site that provides charcoal, and timber. The fact is that the mangrove forest is being destroyed for income and profits it yields. Many organizations have demonstrated that if forest products are harvested sustainably, it will have much more economic value than if just timber is harvested or burned down for cattle or farming operations (Miko *et al*, 2009).

The study shows also that 25 % of respondent indicated mangroves as greatest settlement value (Figure 9). This reinforce that the problem and the solution of the destruction of the mangrove forest are both economic. Local authorities need money to service their amount overdue, residents and settlers need money to feed their families, and oil companies need to make profits. A few (15 %) of respondents indicated mangrove site has a highest touristic values. However, there is potential for considerably increasing nearly all the different existing economic benefits in a sustainable way. In particular, there is scope for significantly increasing the economic benefits relating to tourism. Most importantly, the only way of obtaining maximum economic benefits, is to ensure that resources are effectively managed so that the attributes that give the area its value are retained. This calls for a way to reconcile the contrasting goals of conservation that entails "protectionism (that seeks to exclude human consumptive uses other than tourists advocated mainly in national parks) and utilization (premised in community conservation initiatives including private reserves)"(IAASTD, 2009).

5.4 Ecologic Values of Mangrove Forests in Moanda Territory

The predominant ecological value indicated by respondents was conservation area. It is also important to note that, 90 % of the respondents rated mangroves has low water value for farming and 54% of the respondents interviewed rated mangroves has low value of feed for domestic animals (Figure 10). Moreover, the list does not include the more strictly ecological functions of coastal plants, such as shade, protection from wind, sand and salt spray, erosion and flood control, coastal reclamation, animal and plant habitats, and soil improvement, all of importance to Moanda area.

In terms of specific uses, the most widely reported uses are for medicine, general construction, and fuelwood. Forests, both primary and secondary, continue to be transformed into degraded, savannas and cultivated land. Mangroves and lagoons are also being transformed into housing and industrial estates. The temporal Moanda territory variability cover shows that urban-industrial development has led to degradation and extinction of the mangrove biodiversity endemic to the area. Overall guidance for the conservation and sustainable use of mangrove resources, and mechanisms to ensure protection for mangrove associated biodiversity can only be assured with the provision of new local, national and international legal frameworks. Unfortunately, most agencies, except for some NGOs, have focused their efforts on expensive conservation area (CA) projects instead of on the systematic nationwide promotion of biodiversity conservation at the community level. However, a positive sign and recognition of the need for biodiversity conservation in Moanda area, is the recent approval Conservation Programs by the National Assembly of the Democratic Republic of Congo.

5.5 Sources of Information Used by Farmer in Conservation and Management of Mangrove Forests

In this study sources of information were grouped as conventional and emerging. Concerning emerging sources of information, besides accessing land use information through radio, no other emerging sources (television, radio call, telecentre, and mobile phone) reached respondents (Figure 12). Farmers indeed need support from institutions that have the expertise. Therefore, creating awareness through provision of information product and services to the rural people should become an essential component of development. This information does not need to come from high-cost sources knowing that the overall mean of household income was $100 per year (Table 4). Farmer's cooperatives which are well informed are able to respond appropriately to changes in the market resulting in increase in incomes (Nyongesa, 2008).

The survey shows that in the all study site respondent have access to radio and 65% of indicated having access to a mobile phone (Figure 13). However, respondents were dissatisfied with government institutions in terms of content of information, frequency of delivery and impact of land use information (Figure 5) while the mean of number of extension services visitors was 1 per year. This implies that availability of new technology in the study area is not by the extension services. This contrast could be attributed to the slowness on the part of government to initiate programs that would use emerging communication technologies to promptly cater for their land use information needs. Information infrastructure is an essential requirement to be satisfied when implementing information dissemination projects (Ombati *et al*, 2001). Capitalization of information technologies at farmer level can make them to compete with commercial farmers.

Figure 11 shows that among the five conventional sources of land use information indicated, only two (Face to face and baraza) were mostly used by respondents. The result confirms that informal social networks such as relatives, friends and groups are important avenues for spreading technologies. Farmers who hold leadership and those who belong to many groups were more likely to give out land use information. These people can therefore be targeted to spread information and technologies in their communities. These approaches promote farmers in the communities and focus on enhancing their learning processes (Kiptot *et al*, 2007). Conventional sources of land use information were highly applied in this region because of its particular cultural contexts. As reported by many studies (M'fu, 1995; Vunda, A., 2000 and Lukamba, 2008), Moanda area is characterized by poor information; lack of financial resources; the absence of or inadequate selection control, and reproduction.

As discussed above, conventional sources of information remain important in the study area. Institutions involved in disseminating land use information can also take advantage of the several farmer groups to disseminate information. What is needed are simple techniques and decision support tools such maps, developed jointly between farmers and researchers to help support information flow and understanding of more complex principles of mangrove forest conservation. It will then be easier for farmers to readily share land use information and experience of mangrove conservation with other farmers.

Summarizing, initiatives for rural community development must then emphasize on the importance of information in addressing the needs of rural communities. There is a need for refocusing on the role of information in rural communities' development and ICT as a tool for achieving this development does not necessarily have to come from high-cost sources. What are needed are simple techniques and decision support tools, such as maps, developed jointly between farmers and researchers to help support information flow and understanding of more complex principles of mangrove forest conservation.

5.6 Factors Influencing the Choice of Information Sources for Conservation and Management of Mangrove Forests

Several socio-economic factors were found to influence farmers' decision to use emerging sources of information (Table 7). According to the result of the Logit model, the estimated coefficient of age of the farmer was negative (-0.147) and statistically significant, indicating that respondent with highest age category are less likely to use emerging source of information only. The coefficient of Farmers' years of schooling (0.441) was positive and statistically significant. Consequently, indicates that having a college education has a positive influence on use of emerging sources of information. However, past studies examining the effect of education on adoption of agricultural technologies have been mixed. Whereas some have found education to influence adoption positively (Erwin and Erwin, 1982; Sureshwaran et al., 1996), others have found education to influence adoption negatively (Lapar and Pandey, 1999; Bett, 2004). Higher education influences adoption decisions because it is associated with ability to synthesize more information and technologies on offer and improvement on land use information and management.

The coefficient for number of time per month farmers received land use information through radio and Leaflets/literature were both positive and significant. According to Garforth and Lawrence (1997), mass media can be a cost effective way of reaching a large population. Nevertheless the result from the survey reveals that, majority of the respondent (more than 86%) were not aware of any government plans to deliver land use information through mass media (Figure 5). The significant association between farmers received land use information through radio and the level of education (Table 8) could suggest need for appropriate format of land use information.

The other variables that had been hypothesized to influence use of emerging sources of information, such as, credit access, number of time per month farmers received land use information through TV and radio call did not show a significant association with the adoption decision of the surveyed households. Similarly the results also showed that, fewer farmers had access to the credit and credit plays an important role in improving decision on the use of sources of information. Consequently, farmers with lower incomes were less likely to use emerging sources of information. Still, the credit allows borrowers to pay for information communication tools, such as, TV, radio, mobile phone, and for social emergencies in addition to production expenditures on inputs.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study integrated spatial analytical methods and social-ecologic data to improve land use information and decision making for mangroves forest and rural farming. In view of the results the following conclusion cans be ended:

1. Comparison of the data among the three time periods shows us that there have not been remarkable changes in mangrove forest cover for the last 22 years. Decrease in vegetation has taken place as a result of anthropogenic activities in the study area. Farming area increased by double from 1988 to 2010.
2. In all study sites, mangroves were indicated as sources of food and medicine, charcoal, firewood, and timber. The predominant ecological value for mangrove forest was indicated as conservation area.
3. Except accessing land use information through radio, no other emerging sources (television, radio call, telecenter, mobile phone) significantly reached farmers. Barazas and face-to-face communication remain the most important conventional sources of information in the study area.
4. The adoption of emerging sources of information was found to be positively influenced by farmers' years of schooling, the number of times per month farmers received land use information through radio and leaflets/literature. Age of respondent was also an important influence, but its influence was negative.

6.2 Recommendations

With the baseline information that was developed, the regular monitoring and proper management decisions should be pursued for the sustainability of the mangrove resources and rural farming in Democratic Republic of Congo. Therefore,

1. Sustained enforcement of regulations, frequent monitoring, and clear demarcation of forest boundary and discontinuation of the non-resident cultivation were recommended as the necessary steps to check deterioration in the forest reserve.
2. Where possible, the conservation or enhancement of useful plants, animals and components of terrestrial and marine mangroves ecosystems be required or encouraged in all agricultural, forestry, fisheries, livestock, tourism, and urban-industrial development projects.
3. There is need to increase investment in agricultural information and knowledge systems, which will include development of rural infrastructure, capacity building in ICT and establishing information points at appropriate locations where farmers can easily access them.
4. That multimedia programs be developed, in the vernacular, to stress the nature and long term economic, social and ecological importance of existing biodiversity and the problems associated with the loss of biodiversity.
5. Policy makers and non-governmental organizations (NGOs) should design strategies targeting specific groups since farmers in each group are affected with diverse socio-economic and geographic factors. This can be achieved by considering training skills at farmer and extension levels and provision of micro-credit and marketing opportunities to smallholder farmers.

6.3 Suggestions for Further Research

The study focused on farming improvement and mangrove forest conservation through information flow. Therefore,

- It would be useful to conduct studies about mangrove ecosystem functions and density of the mangrove trees to answer ecological questions on sustainable development.
- Similarly, it is important to contract socio-economic estimate study, will include the economic value of the mangroves forest (use and non-use value).
- In addition, the study of information transfers while allocation of financial resources through supply driven approach to disseminate land use information to farmers is needed.
- Also, a study on integrating Indigenous Knowledge into GIS to produce Community-based maps for collaborative Natural Resources Management.

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APPENDICES

APPENDIX 1: Household Questionnaire

"Improvement of land use information flow for mangroves forest conservation and rural farming in democratic republic of Congo"

You have been selected among other residents to assist in providing information on the mangrove forest in Moanda Territory. Any information provided will be treated with confidentiality.

Date of interview: _______ name of interviewee: _______ name of site: _______

Section A: (Household social data) and institutional information

i. General Information

1. Gender of respondent □ male □ female
2. Age (year)
3. Average years of completed schooling
4. Occupation □ Farmer □ business □ employed □other (specify) _____
5. Size of land owned (ha)
6. Farming System used □ Agriculture □ livestock □ fishing □ wood cutting □ forestry
7. Income from farming activities (per year)
8. Number of extension visit (per year)
9. Distance to the forest (Meters)
10. Access to the credit (1= yes, 0= otherwise)
11. Group Membership (1= yes, 0= otherwise)

ii. Institutional information

In term of preference, how would you rank the following sources of information on land use practices? (*Fill in your choice*)

1 = Very satisfied; 2 = Satisfied, 3 = Not satisfied

C	Source of Information	Content	Frequency	Impact
1	Government			
2	Mass Media			
3	NGOs			

Section B: Socio-economic and ecological values (*ranking is based on the listed values*)

2.1.SOCIO-ECONOMIC VALUES	IMPORTANCE (*)	RANK (#)
i) Settlement of people		
ii) Food and herbal		
iii) Heritage		
iv) Charcoal, Timber and wood		
v) Research activities		
vi) Tourism		
2.2.ECOLOGICAL VALUES	**IMPORTANCE(*)**	**RANK(#)**
i) Conserve Forest and animals		
ii) Food for domestic animals		
iii) Water for farming		

*Importance: 5-very important 4-important 3-less important 2-not important 1-neutral#

Rank value: 5-greatest 4-greater 3-great 2-average 1-little values.

Section C: (sources of information on land use practices)

In term of preference, how would you rank the following sources of information on land use practices? (*Fill in your choice*)

1 = highest competence; 2 = high, 3 = average; 4 = low; 5 = lowest competence

C	Source of Information	Rank	Number of Time received Information (Per month)
1	Farm visits by extension personnel		
2	Farmer research groups (FRG)		
3	Barazas		
4	Leaflets/literature		
5	Drama		
6	Agricultural shows/Field days		
7	Radio		
8	Mobile phone		
9	Telecenter		
10	Radio call		
11	Television broadcast		

APPENDIX 2: Key Informants

(NGOs Staff, Opinion leader, Extension)

"Improvement of land use information flow for mangroves forest conservation and rural farming in democratic republic of Congo"

A. Date of interview: _______duration: _______ (min) respondent: ______________

Name of interviewee: ____________________

1. What are the uses of Congo's mangrove forest?

i)__________ ii)____________ iii)__________ iv)___________

2. What products do the communities get from Congo's mangrove forest?

i)__________ ii)____________ iii)__________ iv)___________

3. List activities that can help wise information management for Congo's mangrove forest conservation?

i)__________ ii)____________ iii)__________ iv)___________

4. Which of the language(s) do you use when talking to the farmers

i)__________ ii)____________ iii)__________ iv)___________

5. Listed some of the methods used to desseminate land use information to rural farmer.

i)_______________ ii)____________ iii)_________________

6. Which kind of information does your service delivers to rural farmer for land use practices.

i)_________________ ii)____________ iii)______________

7. what are the size occupy by farming activities arond mangrove forest compared to the rest of rural farming land cover.

i) 5- 20 %   ii) 21- 40 %   iii) 41- 60%   iv) 61- 80%   v)81- 100%

B. (The extent of use of ICT in management and conservation of mangroves forest)

(Extension Staff only)

Date of interview: _______duration: _______ (min) respondent:_____________

Name of interviewee: ____________________Grade:_________________________

I wish to know your opinion about the following issues on extent of use of ICT in your organisation (Place a tick in the cell representing your choice). SA= strongly agree, A=agree, NS=not agree, D= disagree, SD=strongly disagree

C	The use of ICT in management and conservation of mangroves forest	Rank
1	Internet	
2	Microcomputers	
3	Broadcasting (Television, Radio)	
4	CD-Rom/Video/DVD	
5	Mobile phone	
6	Desktop publishing	
7	Telephone(call-in)	
8	Dial-up Radio	
9	GIS/GPS/Remote sensing	
10	Electronic communication (e-mail)	

APPENDIX 3: Farmers

(Group discussion with farmers)

C. (Ecological, socio-cultural and economic data)

Date of interview: _______ name of interviewee: _______ name of site: _______

1. Distance of household to the mangrove ______ Metres

2. Do mangroves contribute to the income sources of your household? □ yes □ no

3. Do you grow crops in the mangrove □ yes □ no

4. Which crops do you grow on the wetland

   i)__________ ii)___________ iii)_________ iv)__________ iv)_______

5. Major products obtained from the mangroves?

   □reeds □arrow roots □vegetables □fish □maize □beans □ napier grass

Any other products obtained from the mangroves?

i)__________ ii)___________ iii)_________ iv)__________ iv)_______

Plant uses

Plant name	*uses*
1.	
2.	
3.	
4.	
5	
6	

6. Name the vegetation that has been lost from the mangroves since you settled here?

i)__________ ii)__________ iii)__________ iv)__________ iv)__________

D. (Human activites and perceptions)

7. Which activities do you carry out in the mangroves?

i)__________ ii)__________ iii)__________ iv)__________ iv)__________

8. Do the activities affect the mangroves? □yes □ no

9. Do the activities affect mangroves vegetation composition? □yes □ no

10. Do the activities affect water levels? □yes □ no

11. Do the activities affect soils around the mangroves? □yes □ no

12. List the positive effect of the activities on the mangroves?

i)__________ ii)__________ iii)__________ iv)__________ iv)__________

13. List the negative effects of the activities on the mangroves?

i)__________ ii)__________ iii)__________ iv)__________ iv)__________

14. What is the extent of soil erosion around the mangroves?

□ 5-very high □ 4- high □ 3- moderate □ 2-low □ 1- none

15. What type of water do you use? □ blackish □ muddy □ clear

16. How is the water? □ flowing □ stagnant