Analyses of Socio-economic Status and Livelihood Patterns of Coastal Communities Dependent on Mangrove Forest Resources in Guinea

ギニアにおけるマングローブ林資源に依存した海岸コミュニティの社会経済的地位や生活パターンの分析

A Dissertation

By

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Dedication

This thesis is dedicated to my wife and daughter for their endless encouragement, support, and love.

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CHAPTER I

INTRODUCTION

1.1. Background of the study

In Guinea, ecosystem degradation results primarily from economic activities including agriculture and logging for firewood and construction. Coastal communities bordering mangroves derive significant revenue from mangrove wood logging, fishing, mangrove rice cultivation, salt extraction and other activities. All these activities result in the clearing of mangrove forest for agriculture, supply of firewood and construction, and can have a negative impact on the fragile balance of the ecosystem correlatively to population growth along the coast. The climatic variations have also an impact which translates among other things in rainfall deficit and a reduction in the length of the rainy season that aggravates the degradation of all ecosystems.

Mangroves cover approximately 260,000 hectares in Guinea, chiefly around the estuaries of the main rivers. There are extensive untouched areas in places, but elsewhere the mangroves have been widely exploited and cleared, as they play an important role in socio-economic activities in Lower (Maritime) Guinea. They form a much coveted and so far only locally degraded habitat, on which population increase and its resulting food and energy requirements are bound to bring pressure.

Coastal people worldwide face a constant dilemma between economic development and pressures towards resource conservation. While the increasing process of resource depletion leads to conservation-oriented policies, the demand for regional development fosters the development of infrastructure, and increases the pressure over the ecosystems (Hanazaki et al., 2007). According to FAO (1998), the potential for economic opportunities in coastal cities is a strong attractive force, fuelling immigration, often from economically depressed rural areas. The coastal areas are extremely important for the social and economic welfare of current and future generations, as coastal resources support key economic and subsistence activities. The economies of most developing countries are currently very dependent on natural resources, for agriculture, fisheries and forestry subsectors, mining, oil and gas extraction, marine tourism and ocean transport. Many of the world's most productive agricultural areas are located in river deltas and coastal plains. Coastal areas are also important ecologically, as they provide a number of environmental goods and services. Favorable biophysical and climatic conditions, together with the ease of communication and navigation frequently offered by coastal sites (by sea or up river valleys), have encouraged human settlement in coastal zones since prehistoric times.

The Atlantic corridor has some of the highest centers of population density in Africa due to high intrinsic rate of growth (NOAA/NOS, 2002). This rapid development is placing growing pressure on coastal natural resources, often regarded as open-access resources. Immigration and deepening poverty in rural communities have led to the exploitation of these resources for subsistence, and by industries (e.g. forestry and fisheries sectors), which have taken advantage of poor management and legislation (World Bank, 1994). As the coastal populations in Africa continue to grow, and pressures on the environment from land-based and marine human activities increase, coastal and marine living resources and their habitats are being lost or damaged in ways that are diminishing biodiversity and thus decreasing livelihood opportunities and aggravating poverty. Degradation has become increasingly acute within the last 50 years (Crossland et al., 2005).

The Guinean coast, 300 kilometers long, is composed of a network of estuaries, populated by mangroves. Mangrove forests are fragile areas coveted by over two million Guineans. Fishermen, farmers and foresters all live off of the mangroves. Five years ago, the coast was completely covered by mangroves, with the exception of Cap

Verga and the areas surrounding Conakry. Agricultural clearing and the commercial logging has contributed to the destruction of a major part of the forest cover. In 1956 the mangrove covered 350,000 hectares, of which there is only 250,000 hectares left today. The annual loss has been 4.2% of the surface area. In Guinea, deforestation remains a constant issue (Yansané A. 1998).

In Guinea, coastal lands play a key role in national food security in terms of agricultural production focused on mangrove rice cultivation, salt production, mangrove wood exploitation, fish smoking, etc., and over one-third of the country's population who live in coastal lands. The mangrove of West Africa comprises an important vegetation type and natural resource that increasingly is coming under threat from human activities. There is now a considerable body of descriptive information concerning mangroves in the region but data on the dynamics of this complex and diverse system are lacking.

The coastal area of Guinea due to its multiple resource endowments is undergoing demographic transition and rapid urbanization. This coastal ecology is coming under tremendous pressure from increased demand for land for food production, transhumance, fuel wood, etc. These pressures have been exacerbated by the persistence of poverty and lack of alternative sources of income or access to appropriate technologies.

Hence, owing to the significant value of the interrelationship between livelihoods of coastal communities and environment, appropriate management of livelihood activities (mangrove rice farming, salt production techniques, wood extraction etc.) is required in order to bring the improvement of the socio-economic status of peasants involved in these activities. It is pertinent to examine the most suitable practice and environment sustainable activities which can contribute to the livelihood improvement and conservation of mangrove forest. Under these circumstances it is vital to analyze the socio-economic status and livelihood patterns of coastal communities dependent on mangrove forest resources in Guinea. The strength of the sustainable livelihoods concept lies in its local focus on communities and actors, and in its ability to unite all three dimensions of sustainable development: economic, social and environmental. The mangrove rice cultivation, salt production, mangrove wood extraction, fish smoking, etc. constitute the main livelihood activities of the community in the Guinean coastal zone. Hence, investigating dynamics of natural resources such as land, mangrove forest etc. will contribute to improve the livelihoods in a sustainable manner. In developing countries like Guinea, the population relies on the natural resources for their livelihood. The present study mainly focused on the livelihood activities (e.g. salt production, mangrove rice production and mangrove wood logging) of coastal communities in the littoral Guinea.

1.2. Objectives of the Study

The main objective of the study was to conduct an analysis of socio-economic status and livelihood patterns of coastal communities dependent on mangrove forest resources in Guinea. This allows examining the development pathways towards the improvement of peasants' livelihood activities and mangrove forest management in the coastal area of Guinea. In order to achieve the main goal, the study focused on the following specific objectives:

1) To analyze the role of land use change and their determinants in livelihood improvement in the coastal area of Guinea.
2) To analyze the present status and determinants of mangrove rice production based on the improvement of the socio-economic status of farmers.
3) To conduct the socio-economic analysis of small-scale salt production techniques for the improvement of livelihood status and sustainable mangrove forest management.
4) To measure the technical efficiency of major livelihood activities (salt production and mangrove rice production) in the coastal area of Guinea.

5) To investigate the effects of rural livelihood activities on income inequality and poverty reduction in the coastal area of Guinea.
6) To assess the impacts of household energy consumption and livelihood activities on the coastal forests of Guinea.
7) To provide policy prescriptions for improving the livelihood coastal communities and to recommend the most suitable and environmentally sustainable practices contributing to livelihood improvement and conservation of mangrove forest.

1.3. Scope of the Thesis

The current thesis is organized into ten chapters (Figure 1.1). The first chapter presents the background of the study, defines the general and specific objectives of the current research study and its scope. The second chapter reviews the literature of livelihood activities in the Guinean coastal area dependent on the mangrove forest resources. It outlines the coastal area of Guinea, presents coastal forests mainly comprising the mangrove and upland forests. Based on previous studies, it also reviews the household livelihood strategies and some major livelihood activities practiced in the coastal area of Guinea.

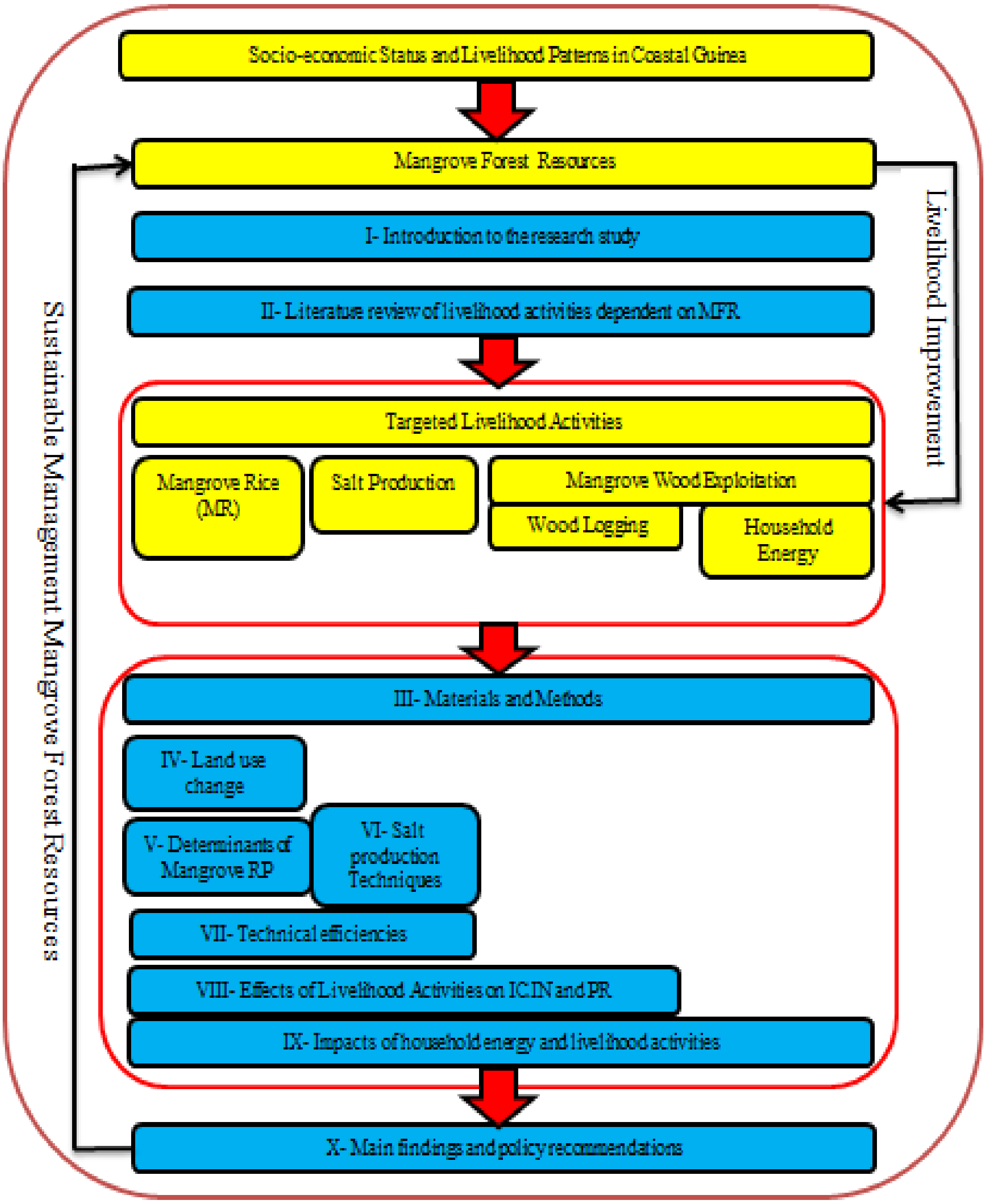

Figure 1.1: Scope of the study

The third chapter presents the methodology adopted for conducting the thesis. It describes the study areas, sampling procedures, data collection and analytical tools (for further details refer to Chapter III). The fourth chapter determines the role of land use change analysis and their determinants in livelihood improvement in the coastal area of Guinea based on the spatial analysis and field survey. The present status and determinants of the mangrove rice production, the analysis of socio-economic status of small-scale salt production techniques for improving livelihood status and sustainable mangrove forest management are discussed in chapters five and six, respectively. The performance in terms of technical efficiency of small-scale improved salt producers and mangrove rice farmers is measured in chapter seven. The investigation on the effects of rural livelihood activities on income inequality and poverty reduction in the Guinean coastal area is presented in chapter eight. The impacts of household energy consumption and livelihood activities on coastal forests in Guinea are shown in chapter nine. Finally, the conclusion, policy recommendations and future research directions cover chapter ten.

CHAPTER II

LITERATURE REVIEW ON LIVELIHOOD ACTIVITIES IN THE GUINEAN COASTAL AREA DEPENDENT ON MANGROVE FOREST RESOURCES

2.1. Introduction

This chapter reviews the literature related to the livelihood activities dependent on mangrove forest resources in the coastal area Guinea. The present chapter gives an outline of the coastal area of Guinea, presents the coastal forests mainly composed by mangrove and upland forests. As the mangrove forest constitutes one of the focus points among others in this thesis, thus the mangrove status in the coastal zone of Guinea is highlighted based on some previous studies. Furthermore, the chapter also highlighted the household livelihood strategies and major livelihood activities practiced by peasants in the coastal area of Guinea. These major livelihood activities reviewed here are the following: the mangrove rice production, salt production, mangrove wood exploitation (firewood and logging) and fishing.

2.2. Outline of the Coastal area of Guinea

According to Rue and Fontana (1995), the coastal zone of Guinea represents a geographical area of approximately one million ha which stretches 300 km between Guinea-Bissau and Sierra Leone. This coastal area, crossed by numerous rivers that originate from the Fouta Djallon, covers an estuary side clogged up by a mangrove swamp forest and it is formed from east to west by:

(1) A coastal plateau (Table 1-1) of about twenty kilometers wide, leant to the east by the foothills of the Fouta Djallon and constitutes the frame of the road and urban area or plateau covered with sandy soil lateritic highly degraded and infertile where slash-burning agriculture (upland rice, peanuts, fonio, palm oil trees, etc.) is practiced.

(2) A broad tidal marsh (Table 1-1) that extends over 400,000 ha and composed of an alluvial substrate estuary where various species of mangrove trees are formed. These tree formations occupy a total area estimated at 270,000 ha. It is on these fertile soils, after clearing, that the coastal mangrove rice fields (almost 80,000 ha) are established.

Table 1-1: Summary of the Guinean coastal zone

Facial (features)	Characteristics	Corresponding coastal forests
1.Coastal plateau	➢ 20 km (wide); ➢ Limited to East by the foothills of Fouta Djallon; ➢ Constitutes the frame of the roads and urban area; ➢ Recovered by a very degraded lateritic soils and low fertility; ➢ Slash and burn done (rain-fed rice, peanut, fonio, etc.) and undemanding palm trees	Upland forest (UF)
2.Maritime (mangrove) swamp	➢ Mangrove forests (270,000 ha) ➢ Coastal rice cultivation (80,000ha) ➢ Decomposed into three sets of landscapes: Mangrove of Upper estuaries, Mangrove of Middle estuaries and Mangrove in Front of Sea. ➢ Area of intensive of wood extraction, mangrove rice cultivation, salt production, fish smoking, shrimp farming, etc.	Mangrove forest (MF)
3.Coastal marine (near shoreline)	➢ Marine extension of the estuaries constituted by the front of the mangrove; ➢ Characterized by the seaward extension of the coastal mudflats; ➢ Average wide 20 km , and its limit roughly with a depth 15-20 m ; ➢ Seat of intense fishing activities;	Mangrove forest (MF)

The mangrove swamps can be subdivided into three sets of landscapes:

(a) Mangrove upper estuaries elongated along the axes of the rivers and opportunities embedded in the lowland coastal plateau and they extend over 120,000 ha.

(b) Mangroves waterfront, stretched parallel to the shore, crossed by barrier beaches fringed by fossils and littoral current forming plains waterfront or Chenier's plains they extend over 38,000 ha.

(c) Mangrove middle estuary located in the central space between the two other types, characterized by a great development of channels and a complex hydrological circulation pattern and is the forest area itself, which covers 180,000 ha. This tidal marsh is the site of intense exploitation of timber, mangrove rice cultivation, salt production, livestock farming, gathering oysters, fishing and fish smoking.

(3) A coastal marine area (Table 1-1), which is an extension of this large marine estuary formed by the head of mangrove and is characterized by the seaward extension of coastal mudflats. This coastal mudflat has an average width of 20 km and its limit corresponds roughly with a depth of 15-20 meters. It is the seat of intense fishing activities, both by the artisanal sector, which operates from a hundred docks and the industrial sector.

2.3. Coastal forests

According to FAO (1998), coastal forests in developing countries are mainly mangroves, which cover an estimated 15.5 million hectares worldwide. Other coastal forested ecosystems include savannah woodlands, dry forests and rain forests.

Commercial production from mangroves is comprised of building materials, such as poles and timber, and numerous non-forest products. Savannah woodlands and dry forests are used primarily for grazing, while rain forests are used for their commercial timber.

Guinea has an extensive network of terrestrial and aquatic environments, including vast estuaries, a large archipelago rising from a continental shelf, and seasonally flooded coastal plains. Its coastal ecosystem includes 305 km^2 of intertidal flats, 2,230 km^2 of mangroves, 755 km^2 of fresh- or brackish-water coastal marshes, and 605 km^2 of inundated rice fields. USAID (2007) indicated that about 28 % of Guinea's total land area is made up of tropical forests. It houses a quarter of West Africa's total mangrove wetlands. Guinea's protected areas include 156 classified forests, two national parks, and four biosphere reserves. Its classified forests cover 11,866 km^2, while its two national parks (the Parc du Haut Niger and the Parc du Niokolo-Badiar) together cover 922 km^2. Guinea's four biosphere reserves (Mount Nimba, Siama, Badiar, and Haut Niger) cover 11,000 km^2. In total, Guinea's protected area system covers about 10 percent of its total land area (FAO 2004).

2.3.1. Mangrove forest in Guinea

Mangroves along tropical and sub-tropical coastlines have well-established ecological and economic potential. Their vulnerability with respect to natural and anthropogenic impacts is frequently emphasized (Duke et al. 2007; Alongi 2008; Bosire et al. 2008). The Guinean coast, 300 kilometers long, is composed of a network of estuaries, populated by mangroves. There are freshwater marshland forests which stand behind this wall of mangroves. Floodable valleys fed by heavy seasonal rains stretch from the running waters. Mangroves, amphibious forests which link the sea to land are typical of the Lower Guinean landscape. Periodically flooded by the tides, the mangroves extend a few hundred kilometers in the rivers, where the influence of the sea can still be felt. Here there is mainly *Rhizophora mangl*e, and *Avicennia nitida.* Mangrove forests are fragile areas coveted by over two million Guineans. Fishermen, farmers and foresters all live off of the mangroves.

Five years ago, the coast was completely covered by mangroves, with the exception of Cap Verga and the areas surrounding Conakry. Agricultural clearing and the commercial logging has contributed to the destruction of a major part of the forest cover. In 1956 the mangrove covered 350,000 hectares, of which there is only 250,000 hectares left today. The annual loss has been 4.2% of the surface area. In Guinea, deforestation remains a constant issue (Yansané A. 1998).

The mangrove is vital habitat for many species of flora and fauna. The natural fertility and productivity in these zones is quite high. The coastal communities in this area are composed primarily of Baga, Soussou and Landouma ethnic group, as well as Peul and Malinke immigrants. This fragile zone supports several economic activities such as fishing, agriculture, salt production, timber exploitation, maritime transportation, and commerce.

In addition to the human pressure, climate change is an increasingly important factor in mangrove degradation. Rainfall has been declining since the 1980s along with the generally observed decline across West Africa. This has had a strong impact in the north of the Guinean coast due to the North-South rainfall gradient (Bazzo et al. 1988). This translates into irregular tides along the coast due to changes in freshwater flows and increasing risk of saline intrusion. This declining climatic situation has also contributed to less unreliable rice cultivation which in turn has forced the rural population to substitute their incomes with increase exploitation of other resources.

(1) Mangrove Status in Guinea

Mangroves are found along the length of the Guinean coast except for Cape Verga and Kaloum Island. The coastal topography facilitates the deposition of sediment and submersion of the mouths of the rivers. There is a long tidal reach up the estuaries, which causes flooding of the rivers, leaving raised bars. It is here that the mangroves can develop, within the bay of the estuary. Mangroves extend more than 10 km inland and, for the widest rivers, even up to 40 km inland (UNEP 2007).

Iles Tristao (Ramsar Site) is an estuarine complex of extensive mangrove forests and sandy intertidal zones. The site contains several villages where activities include traditional fishing, rice cultivation, and small-scale horticulture. The area supports nesting and wintering birds and hippopotamuses (“Annotated Ramsar List” 2013).

Konkouré (Ramsar Site) is an estuarine complex, forming part of the Konkouré River Delta, with extensive intertidal mud/sand flats, mangrove forests and adjoining marsh. Primary human activities include subsistence fishing and rice cultivation. Mangroves provide nesting sites for several rare bird species. Mudflats support large numbers of wintering Palearctic shorebirds (“Annotated Ramsar List” 2013).

Rio Kapatchez (Ramsar Site) is a complex of mangrove forests, intertidal mud/sand flats, and freshwater marshes supporting various nesting waterbirds (two rare species), flamingos, and wintering shorebirds. The site includes marshy coastal plains bordered by a stabilized dune cordon. A small island is important as a high tide roost for shorebirds. Human activities include traditional fishing and subsistence rice cultivation. Intensive rice cultivation occurs in surrounding areas ("Annotated Ramsar List" 2013).

Rio Pongo (Ramsar Site) is an extensive estuarine complex dominated by mangroves. Several small villages found on stabilized dune ridges within the site depend on traditional fishing and subsistence rice growing. Other human activities include woodcutting by outsiders, poaching, and disturbance of nesting birds ("Annotated Ramsar List" 2013).

2.3.2. Upland forest

Upland areas are cultivated for several years and then left to fallow. There is no information about the length of fallow periods and whether they are decreasing. Diallo (1974) reported that the Baga farmers cultivated alternate sections of their lowland mangrove fields from year to year. Common goods such as water and forest resources that provide food, fuel wood, and construction materials appear to be available to the use of whoever collects them. There is some control exerted over when certain items may be collected. For example, oil palms that were not planted are not considered individual property. In a given area, the fruits mature about the same time although people wait for the word from village elders before they begin to harvest fruits. The fruit belongs to whoever collects it once the season has been recognized.

2.4. Household Livelihood Strategies

Livelihoods in tropical coastal communities often rely on a range of occupational sectors, such as agriculture, fisheries, and informal economic activities (i.e. small shops, transportation, etc.) (Barret et al, 2001). In rural Africa, large household size is an indication of wealth, as well as a means for obtaining wealth through labor and, to some degree, "pooling" incomes to meeting needs. The following are sketches of household production strategies:

Fishing/Rice Cultivation: large family for large labor force, improve fishing productivity and access to markets, wives extract salt.

Tropical Fruit Cultivation: pineapples, kola nuts, mangoes, oil palm, as primary sources of income. Smaller family size, secondary activity would be some subsistence cultivation to reduce food costs, use money from fruits to begin local commerce.

Variant: Wage earner/contract farmer on industrial operation in the south, single man or just married, looking to earn money but not stay in this position.

Livestock/Mixed Upland Crop Farmer: looking at livestock products as source of income and investment, livestock integrated into agricultural production, subsistence grain production with peanuts as a cash crop, some fruit production. Livestock is important because of inaccessibility due to poor roads (livestock to markets) demand for meat and milk products high. The principal social groups in the Coastal Zone, as defined by their occupations, are village farmers and fisherman, town merchants and transport workers, government civil servants, patriate and companies' workers (e.g. CBG staff), immigrant wage laborers, contract farmers, and artisans.

2.5. Livelihood activities in the coastal area of Guinea

Based on literature reviews, this sub-section presents some majors livelihood activities practiced by coastal communities in the littoral of Guinea. The following livelihood activities (mangrove rice production, salt production, mangrove wood exploitation (firewood and logging) and fishing are presented below. Furthermore, Chapter III (sub-section 3.4.1) presents also some livelihood activities practiced by surveyed peasants.

2.5.1. Mangrove rice production

Rice growing is, together with fishing, the main economic activity in Lower

Guinea. It takes place in the coastal region, either on flooded plains or in areas where the mangroves have been cleared. Out of 390,000 hectares of brackish water marshes which could support mangroves, 78,000 hectares have been more or less converted to paddy fields, of which only 40 per cent are really productive. The most important rice growing areas are from north to south along the Rio Kapatchez and In the Monchon plain (Tougniflli), Taboria, Coyah, the islands of Kaback and Kakossa. Cultivation exists on a small scale everywhere in the mangroves, along all the rivers and creeks and near Conakry. It takes place on strips of cleared mangrove of varying widths, but often of up to several hundred metres, which are flooded more or less daily by the tide. During the rainy season the tide pushes the fresh water back upstream, which then floods into the cleared areas. Salinity there fluctuates between 1.8% and 2.5% (Sako, pers. comm.).

A distinction can be drawn between two different types of paddy field: those with dykes which are regularly flooded on the lower stretches of the rivers, and those without dykes where there is less salt water (Wassou and Forécariah). The former either border the creeks directly or are separated from them by a mangrove strip of varying width (Wassou). In the case of the latter, the mangroves have been cleared except for a few trees remaining singly or in clumps, mostly dead or unhealthy, along the channels. Dead trunks are sometimes left standing in the middle of the paddy fields. The conversion to paddy fields along the channels is accomplished by the following operations: (1) Clear cutting the mangrove forest; (2) Extracting the best wood for sale or for domestic use; (3) Waiting period of 1 to 2 years, to allow for decay of the roots and the remnants. (4) Cleaning up and ploughing the plot at low tide at the end of the dry season; (5) Planting the rice (late long grain salt resistant varieties) at the onset of the rainy season. (6) Harvesting in March-April of following year, i.e. after 8 to 9 months.

Acidification seems to occur less frequently than in Senegal or Gambia, presumably due to a higher rainfall. Much encroachment of grass, however, takes place in areas where the salinity is lowest, especially on the islands of Kaback and Kakossa and on the flats in the inland mangroves. This kind of rice cultivation presents serious difficulties and uncertainties, such as the exhausting work of clearance, the need for manual ploughing, the problem of drainage at times of harvest, and the possible toxicity of the soil. Nevertheless such land is much sought after for growing paddy in view of its advantages: high fertility during a short period, favorable soil structure and moisture content, and near-absence of aggressive weeds in the more salty areas.

The twice-daily flooding and the work Involved hi preparing the paddy fields for cultivation have required the development of a sophisticated co-operative system. Each co-operative unit contains 30 to 40 farmers, who do the ploughing, planting and harvesting collectively. The system has made ft possible to carry out work over large areas within the short periods of low tide. Nurseries are established on the dry land nearby.

One of the crucial problems in Lower Guinea is the comparatively high density of population and the shortage of arable land for rice growing. At the present time it seems that all the potentially usable mangrove sites have been converted to paddy fields. By contrast, in the inland mangroves and adjacent areas suitable for rain-fed paddy, there is a shortage of labor and the productivity is low because the fields are poorly maintained.

Guinea currently Imports about 150,000 tons of paddy (80,000 tons for Conakry alone) which is equivalent to about 90,000 tons of rice. The production of the coastal area is nearly 40,000 tons, or 60% of total domestic production, of which 50% comes from the mangrove area alone and 10% from the fresh water flats In the Inland mangroves. It is estimated that the rice requirements for Conakry and Lower Guinea will increase by 50,000 tons and 15,000 tons respectively by 1995. The area of land required to meet such an increase is substantial (at yields of around 1.5 tons per hectare), the more so since there are very large areas (some 50,000 ha, and Increasing) of paddy land which are in poor condition (dykes, drainage, weeds, etc.) and in need of rehabilitation. At present there do not seem to be any suitable techniques available to cope with the scale of the problem. (P. Navas-sartian -SCET AGRI -Pers.comm.)

2.5.2. Salt production

This is a seasonal activity which is carried out in abandoned paddy fields, sometimes with a rotation of plots. The salty soil, after removal of its vegetation, is put into raised baskets and leached. This leaching is continued as long as the soil in the baskets is salty. The water collected is then poured into large rectangular steel tanks put on clay stoves, and heated until evaporation is complete. This occurs quite rapidly because of the wide area of contact between the tank and the flames, and the small depth of water in the tank. Incompletely burnt wood is recovered as charcoal. The salt is packed in large bags to be sold in Conakry. Other smaller scale techniques are also used. This activity, although practiced all along the coast, is not of great economic importance.

2.5.3. Mangrove wood exploitation

1) Firewood

The Guinean mangroves are intensively exploited for firewood, but the quantities available are so large that the resource does not seem to have been overexploited up to now, except perhaps around Conakry and on the Tristao islands towards the Guinea-Bissau border. Extraction of domestic firewood take place all along the coast near the villages, the areas exploited depending on their accessibility. North of Conakry and up to the Tristao islands, more wood is extracted because the numerous fishing communities use wood for smoking fish. This stretch of coastal Guinea supplies almost all the fish consumed in the country.

In areas of rice cultivation wood is also cut around the rice fields during the dry season for the production of salt. Considerable quantities are extracted in this way, but the techniques used generally allow the forest to recover. Small scale logging to meet family requirements is confined to small isolated plots. Production of seeds and seedlings in the untouched stands seems sufficient to ensure regeneration of the logged areas.

The decline of the mangroves is however more serious in fishing areas. Smoking techniques are inefficient (smoking in the open air with considerable loss of heat and smoke), and consume large amounts of wood. The fishermen also tend to be very poor managers of the forested areas. Whereas in most of the coastal region wood is mainly cut for local use, the exploitation and sale of wood for energy and general purpose timber has become very important around Conakry. The business is carried on in at least two harbors and markets: Dixin Port in Conakry and Dubréka 45 km from the capital.

2) Logging

The methods used for the extraction of mangrove timber supplied to Conakry were studied in Sangaréya Bay. The logging takes place as far as the Konkouré, more than 50 km to the north of the capital, and the Kiéma to the south. In the northern area, wood is transported by canoes to Dubréka, or by dhows to Diksin Port. The wood (mainly Rhizophora) is cut either in plots or as single trees. Only the main stem, often of the best trees, is taken. Cutting is done at low tide, and the wood is sometimes piled on the stilt roots for a few hours before being transferred to the boats. Trees more than 7 cm in diameter are cut into billets 1.4 meters long. Trees more than 15 cm in diameter are rarely taken, because to carry them away is so difficult, and sectioning takes more time. Wood from 5 to 7 cm in diameter is cut into poles between 3.6 and 4.0 meters long.

The trunks are cut into billets 0.7 meters long, and sold as such or split in two or four according to diameter, if there is a strong demand for split wood. Loggers recognize two different "qualities" of Rhizophora:

(1) "Male" Rhizophora, called "Kinsi Rame" in the Soussou dialect. This wood is difficult to split, and has a brown colour. It is mostly *R. racemosa.*

(2) "Female" Rhizophora, called "Kinsi Guiné". It is readily split, and has a lighter colour after splitting, turning darker in the sunlight. It is mostly *R. harrisonii.*

These names apply to tall, healthy stands. Unhealthy, stunted *R. harrisonii* is called "Segueri Kinsi" (Segueri is the Soussou name for the monitor lizard). Loggers say that such stands always remain small-sized, even though they too are exploited in case of shortage. The trunks are not debarked. The bark peels off partially when the wood is dry. It is only stored for short periods before being sold: 14 days to one month in the dry season, and up to 2 months in the rainy season. The wood is sold in small piles of 3 to 5 pieces. Avicennia is rarely exploited, as its wood has an inferior calorific value to that of Rhizophora. There is little charcoal production because loggers, dealers and consumers do not consider that mangrove charcoal is of good quality. Neither is cooking habits adapted to this fuel.

2.5.4. Fishing

Small-scale fishing takes place widely in coastal Guinea, particularly north of Conakry. There are many fishing villages, and some of them are of regional or even national importance (Kamsar, Taboria). Smoked fish is marketed throughout the country. The fishing is done either in the mangrove creeks by local fishermen using lines or nets, or at sea. In the latter case the fishermen are often foreign.

2.6. Summary

In order to understand the situation of livelihood activities dependent on the mangrove forest resources in Guinea, this chapter reviewed the literature on some major livelihood activities (e.g. mangrove rice production, salt production, mangrove wood exploitation, etc.) practiced in the coastal area of Guinea. These livelihood activities depend on the mangrove forest resources because they are conducted by slashing or logging this coastal forest. Firstly, the chapter made an outline of the coastal area of Guinea; described the coastal forests and the mangrove status. Finally, it also reviewed some strategies of household livelihood and major livelihood activities in the coastal area of Guinea.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

Chapter III presents the methodology adopted to conduct this research study. Mainly, the methodology consists of two parts: the materials and methods. The materials consider the study areas and 260 surveyed peasants. The methods represent the analytical methods (tools) applied for performing analyses regarding to the targeted objectives. In addition, the methodology requires an important part representing the sampling procedure and data collection. This current study applied both multi-stage sampling and random sampling procedures for the purpose of primary data collection using structured questionnaire through two field surveys conducted from March to April 2011 and 2013. The secondary data collection refers to the remote sensing of Landsat imagery data, administration offices data and desk work of available literatures (published and unpublished) for the study areas and related topics to our current study.

3.2. The Study areas

3.2.1. Dubreka prefecture

The Dubreka prefecture (Figure 3.1) is located in the North-East of Guinea, 50 km from the capital city of Conakry but under the influence of its suburban fringe. It is a coastal area and covers a total area of 3,973 km^2. Dubreka is limited to the West by the Atlantic Ocean; to the East by the prefectures of Coyah, Kindia, and Telimele; to the North by the prefectures of Fria and Boffa and to the South by the town of Conakry.

According to the 1996 general census, the population of this prefecture is 131,750 comprising 16,564 households. 70% of its population lives in rural areas. The study site is located in the urban commune of Dubreka, with a population of 23,072 inhabitants in 1996 [Note 3.1] and was estimated to be 172,593 by 2008 [Note 3.2]. This area presents a wet subtropical climate with abundant of seasonal rainfall. Its soils are suitable for cereal cultivation. The area is exposed to the sea through a 50 km stretch of land containing a hydrographic network that favors the practice of maritime fishing. The land serves multiple purposes, but the main agricultural activity in the area is the cultivation of mangrove rice. Both traditional and improved mangrove rice farming require a complex management to utilize both sea and fresh waters.

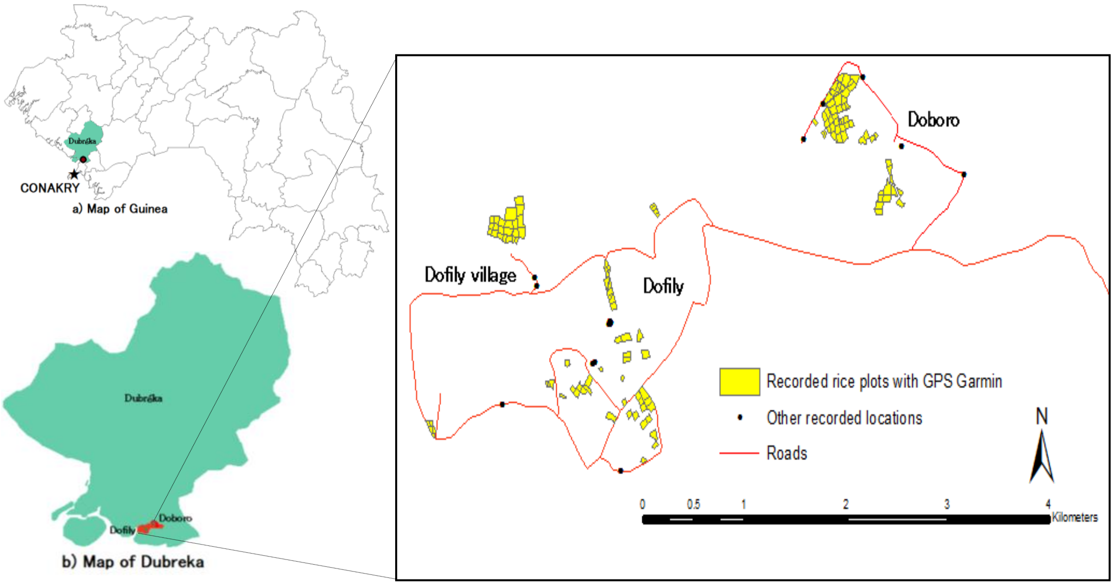

Figure 3.1: Location of Dubreka

The traditional mangrove rice farms (TMRF) are enclosed by small embankments constructed by the farmers. They make ridges in the plots where rice is planted, to control the inflow of sea water and protect the rice field from crabs. Often palm tree trunks, and occasionally pipes, are used for the drainage systems. In contrast, the irrigated perimeter developed by the government for the improved mangrove rice farming (IMRF), is surrounded by a large embankment preventing the intrusion of sea water into the rice fields. These fields are separated by dikes and flood gates. Thus, during the dry season, the sea water intrusion is allowed for weed control and to prevent soil acidification, and during the cropping season, the gates remain closed to prevent sea water intrusion. However, farmers from the IMRF have reported that high tides during

July and August lead to the intrusion of sea water, inflicting damage to the embankment, the dikes and to the rice production. Figure 3.1 shows the location of each recorded IMRF (Doboro and Dofily) and TMRF rice field (Dofily village).

3.2.2. Boffa prefecture

Koba sub-prefecture (Figure 3.2b) is one of the eight sub-prefectures (Tamita, Lisso, CU Boffa [urban commune of Boffa], Douprou, Kolia, Tougnifili and Mankountan) of Boffa prefecture (Figure 3.2a). It is located hundred kilometers away from the Boffa prefecture, covering an area of 1,026 km^2 with a total population of 52,720 inhabitants of which 27,304 are females. Koba is bordered to the North by Tanene sub-prefecture of Dubreka prefecture, to the West by Mara Island in the urban commune of Boffa and to the South-East by the Atlantic Ocean. Koba is the main area in Guinea in terms of mangrove rice and salt production. The study area is home for the agronomic research center of Koba (CRAK) which specializes in the experimentation of mangrove and freshwater rice varieties. This area has many facilities and infrastructures compared to all other sub-prefectures throughout Guinea.

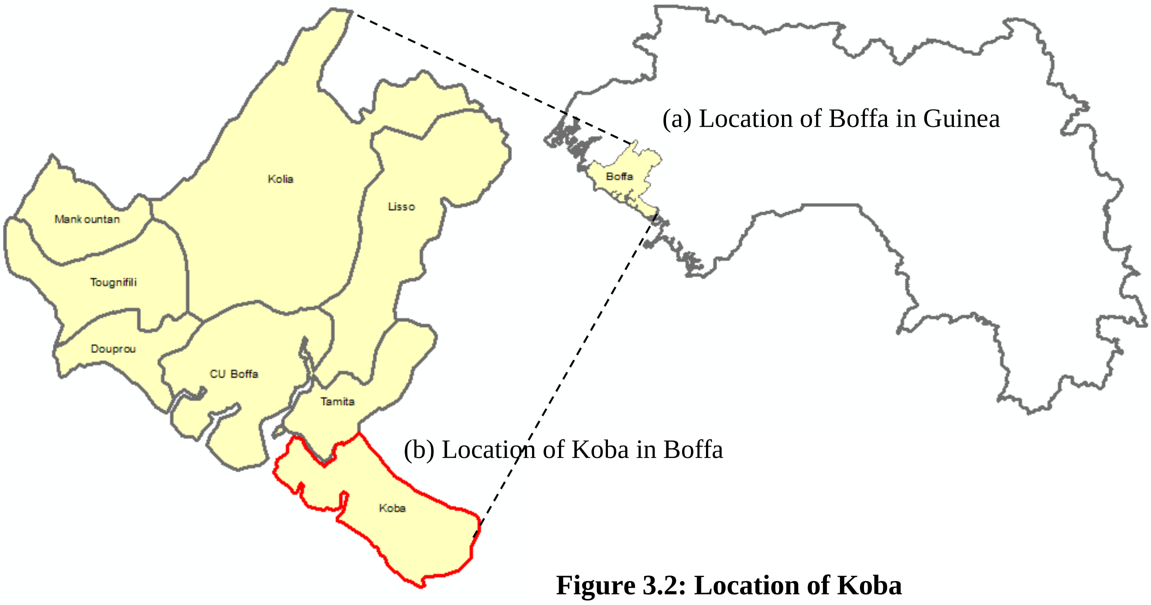

Figure 3.2: Location of Koba

3.3. Sampling procedure and Data collection

As outlined in Table 3.1, the research used two types of data: (1) primary data and (2) secondary data. The primary data were collected through two survey questionnaires (see Appendix I and II) within two periods. The first survey was conducted from March to April 2011 (Appendix I) in Dofily and Hamdallaye (Dofily) districts both located in the urban commune of Dubreka precfecture. The second field survey selected four districts (Makinsi, Balessourou, Bentya and Taboria) located in Boffa prefecture, particularly in Koba sub-prefecture from March to April 2013 (Appendix II). The data collected consists of socio-economic status, demographic, livelihood patterns of coastal communities' dependent on mangrove forest resources, their perception on the effects of major livelihood activities (salt production, mangrove rice and mangrove wood exploitation) on the coastal forest such as mangrove and upland forests. The secondary data were collected through Landsat satellite images data, ground truth control points using handheld GPS Garmin, field observation, group discussions with peasants and stakeholders, etc. The forthcoming sections explore further the sampling procedures and data collection.

(1) Sampling procedure and Data collection in Koba sub-prefecture

The study is based on primary cross sectional data collected from four districts (Balessourou, Taboria, Makinsi and Bentya) located in Koba sub-prefecture in the Boffa prefecture. These are the major districts in which economic activities such as salt production, wood extraction; traditional and improved mangrove rice production are undertaken. Districts were selected based on information obtained from key informants. These districts were purposively selected in order to cover the main livelihood activities (previously mentioned above) in the study site. This purposive sampling was based on advice from experts combined with researchers' judgment and rapid exploratory studies in the study area. A Field survey was conducted from March to April 2013 (Appendix II).

Table 3.1: Outline of sampling procedures and data collection

Study areas		Sample	Main livelihood activity	Data collection	
				Primary data	Secondary data
Dubreka prefecture (Urban commune)	Hamdallaye (Doboro) Dofily	15 25	✓ Mangrove rice	✓ General household information ✓ Land use and farm management ✓ Economic aspects ✓ Social aspects and farmers' perceptions about government policies on land use	✓ Satellite images data ✓ Field observation ✓ Ground truth control using GPS ✓ Data from various institutions ✓ Group discussions
Boffa prefecture (Koba sub-pref.)	Makinsi	50	✓ Mangrove rice	Refer to Appendix II	✓ Field observation ✓ Data from various institutions ✓ Group discussions
	Balessourou	60	✓ Salt production ✓ Mangrove rice	✓ Characteristics of salt producers ✓ Factors affecting salt production and/or mangrove rice production ✓ Economic of salt production and/or mangrove rice production ✓ Household resources endowments	
	Bentya	50	✓ Mangrove rice	Refer to Appendix II	
	Taboria	20	✓ Mangrove wood extraction	Refer to Appendix II	

A structured questionnaire was used to collect data on:

(a) Characteristics of peasants and their income sources from different economic activities in which they are involved. The questionnaire was administered to 220 respondents mainly belonging to five different groups: 60 traditional salt producers, including mixed salt (Guinean saline) producers; 40 salt marsh producers; 20 wood loggers; 50 traditional mangrove rice producers and 50 improved mangrove rice producers. It is important to indicate that respondents in each group were randomly selected. Personal interviews and field observations were undertaken to compliment and triangulate the answers provided by the respondents to the questionnaire.

(b) Characteristics of salt producers and factors affecting their revenue from salt production. The questionnaire was administered to 100 respondents belonging to three different groups: 35 traditional salt producers, 25 mixed salt (Guinean saline) producers and 40 salt marsh producers. These producers were purposively selected in order to analyze the types of salt production in the study area. This purposive sampling was based on advice from experts combined with researchers' judgment and possibly checked through rapid exploratory studies. Personal interviews and fields observations were made to compliment and triangulate the answers provided by the respondents to the questionnaire.

(c) Structured questionnaire designed to capture information related to the characteristics of salt producers, their inputs allocated to the salt industry and its output. This questionnaire was administered to 100 respondents belonging to three different groups: 35 traditional salt producers, 25 mixed salt (Guinean saline) producers and 40 salt marsh producers. However, this research focused only on improved salt producers (the last two groups).

(d) A Field survey was conducted from March to April 2013. Structured questionnaire designed to capture information related to the characteristics of mangrove rice farmers, their inputs allocated to the rice cultivation and its output. This questionnaire was administered to 140 respondents belonging to three different groups: 50 traditional mangrove rice (TMR) [Note 3.3] farmers, 50 improved mangrove rice (IMR) [Note 3.4] farmers and 40 salt marsh (SM) [Note 3.5] producers. These 40 salt producers were included because they were also cultivating the mangrove rice. It is important to highlight that respondents in each group were randomly selected. Personal interviews and field observations were undertaken to compliment and triangulate the answers provided by the respondents to the questionnaire. Among these 140 farmers listed above, the current study selected only 69 farmers (20 from the TMR; 9 from IMR and 40 from SM) considering the fact they hired labor forces and applied agricultural inputs such as fertilizer and pesticide.

(e) From March to April of 2013, I conducted structured interviews with 220 peasants in four districts (Balessourou, Taboria, Makinsi and Bentya) regarding their sources of household energy consumption, monthly expenditures on energy consumption, on food and social factors and types of cooking devices used. Furthermore, major livelihood activities (salt production, mangrove rice production and wood extraction) practiced by these 220 peasants and their household energy consumption pattern in each district were investigated in order to develop the scenarios that negatively impact the mangrove and upland forests. The structured questionnaire administered to 220 respondents mainly belonging to five different groups: 60 traditional salt producers, including mixed salt (Guinean saline) producers (TSP/GS) (Chapter VI, Chapter VIII), 40 salt marsh producers (SM) (Chapter VII, part A); 20 wood loggers (WE); 50 traditional mangrove rice (TMR) producers and 50 improved mangrove rice (IMR) producers (Chapter VIII, Chapter VII, part B). It is important to indicate that respondents in each group were randomly selected. Personal interviews and field observations were undertaken to compliment and triangulate the answers provided by the respondents to the questionnaire. Interviews were conducted in local languages, first translated into French, and subsequently transcribed into English. The English transcripts were coded for key sections and sub-sections related to household energy consumption and issues contributing to the degradation of the coastal forests in the study area.

(2) Sampling procedure and Data collection in the urban commune of Dubreka

Satellite image data from Landsat Thematic Mapper obtained between December 24, 1990, and December 22, 2010, and corresponding to path 202 and row 53 (Table 3.2) were used to detect land use change in the area. In addition, data were also collected from March to April 2011 using a field survey questionnaire (Appendix I) covering 40 farmers, 15 from the Doboro district and 25 from Dofily. The interview schedule covered four main sections. The first section inquired about general household information. The second section covered information regarding land use and farm management. The third section covered information on economic aspects, and the final section inquired about social aspects and the farmers' perception about government policies on land use. In addition to this field observation 348 data points were recorded through a GPS Garmin as ground truth control, to better understand the land cover of the area and to produce an accurate land use classification for the two selected years.

Table 3.2: Landsat Satellite images Data acquisition

Image	Sensor	Date	Path/Row	Lat. /Long.	Cloud Cover (cc)
Landsat TM	Thematic Mapper	1990/12/24	202/53	10.1/-13.0	0%
Landsat TM	Thematic Mapper	2010/12/22	202/53	10.1/-13.0	4%

Source: USGS (United States of Geographical Survey)

3.4. Analytical tools

This section presents the analytical methods applied in this present research. These analytical tools are shown in Table 3.3 and classified into three groups: descriptive statistics, empirical analyses and spatial analysis. The descriptive statistics refer to the mean, percentage, ANOVA, cross tabulations and some basic econometrics analyses. These methods were applied for describing the characteristics of surveyed peasants in one hand and in the other hand the different livelihood patterns.

The analytical techniques used are the crosstabs' statistics and one-way ANOVA. The Crosstabs procedure forms two-way and multiway tables and provides a variety of tests and measures of association for two-way tables. The structure of the table and whether categories are ordered determine what test or measure to use. Crosstabs' statistics and measures of association are computed for two-way tables only. The One-Way ANOVA procedure produces a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. Analysis of variance is used to test the hypothesis that several means are equal. This technique is an extension of the two-sample *t*-test. Furthermore, the analysis used a flowchart in order to describe the scenarios (Figure 9-1) related to the impacts of both household energy consumption and livelihood activities on coastal forests. These scenarios were classified into three phases.

Table 3.3: Outline of Analytical Methods applied in this research

	Analytical tools	Purpose
(1) Descriptive statistics	✓ Mean ✓ Percentage ✓ ANOVA ✓ Cross tabulation	✓ Describing the characteristics of peasants
	✓ Net profit, ✓ Rate of income, ✓ Benefit cost ratio	✓ Profitability estimation of mangrove rice farming based on the selection or combination of rice varieties by different farmers
	✓ Net income, ✓ Income ratio	✓ Profitability measurement of three salt production techniques
(2) Empirical analyses	✓ Gini decomposition analysis	✓ Income inequality measurement
	✓ FGT index	✓ Poverty reduction measurement
	✓ Multiple linear regression	✓ Factors affecting mangrove rive production
	✓ Quantile regression	✓ Factors affecting salt production
	✓ Stochastic frontier production	✓ Technical efficiencies measurement of salt production and mangrove rice production
	✓ Loss due to inefficiency (output forgone)	✓ Measuring the loss of output and call for better utilization of resources.
	✓ Binary logistic regression	✓ Farmers' contribution to land use transitions
(3) Spatial analysis	✓ Post-classification comparison	✓ Producing matrix of change directions.
	✓ Supervised classification	✓ Discrimination of land use patterns
	✓ Reconnaissance Survey data	✓ Accuracy assessment of land use classes.
	✓ Error (confusion) matrix	✓ Accuracy assessment of land use classes.
	✓ Kappa coefficient	✓ Accuracy assessment of land use classes.

The empirical analyses applied in this research refer to the Gini decomposition analysis for measuring the income disparities regarding the portfolio of livelihood patterns practiced surveyed peasants. The FGT index assesses the degree of poverty. The multiple linear regression, quantile regression and binary logistic regression determine factors influencing the mangrove rice production, salt production and farmers' contribution to the land use transitions, respectively.

The stochastic frontier production function measured the technical efficiencies of both salt production and mangrove rice farming. The spatial analysis is based on the application of the post-classification comparison for producing a complete matrix of land use change directions. The land use classes were discriminated using the supervised classification method. The validation of their classification is based on the reconnaissance survey data, confusion matrix (overall accuracy, user accuracy and producer accuracy) and kappa coefficient. The forthcoming sections present further information on each analytical method.

3.4.1. Income sources from a portfolio of livelihood activities in the Guinean coastal zone

The livelihood portfolio is bundle of activities households engage in to generate livelihood and achieve a certain level of livelihood security (Rudie, 1995), while diversification of income sources has been put forward as one of the strategies households employ to minimize household income variability and ensure a minimum level of income (Alderman & Paxson, 1992). In this paper, the total income of interviewed peasants is mainly divided into the following categories: 1) Agricultural income is sub-divided into mangrove rice farming, lowland rice production, vegetable production, seasonal and perennial crop production. 2) Salt production, 3) Wood extraction, 4) Livestock, 5) Non-farm income and 6) Remittance. Following Azam & Shariff (2011), each component of household income listed here is normalized by household size to get per capita, and analysis is performed on the per capita of income from different categories of income sources. Referring to Reardon & Taylor (1996), disposable income sources are in net terms.

1) Agricultural income:

(a). Mangrove rice production income: imputed value of the total production of mangrove rice varieties (local and improved) including household consumption, quantity reserved for future seed, gift, etc., plus gross sales less input costs. Except the mangrove rice production in Balessourou (Sub-section 2 below related to salt production income), it was also cultivated in Bentya and Makinsi districts. The traditional mangrove rice cultivation was practiced in Makinsi and the only improved area was the large abandoned basins of shrimp farming. The improved mangrove rice farming was practiced in Bentya except the one mentioned in Balessourou. The mangrove rice farming involves the use of cleared mangrove forest land for rice production (Chapter V). It represents rice cultivation in the plains of the mangrove forests. This farming system, practiced in coastal areas where the population is relatively dense, is one of the oldest forms of rice culture in West Africa.

(b). Lowland rice production: the income from lowland rice production constitutes also the imputed total production value of lowland rice produced by farmers plus gross sales less input costs. In the whole Guinea, the lowland rice accounts for 10% of land under rice. Forest Guinea region accounts for the largest stretch of lowland compared to the country's other natural regions (Maritime/Lower Guinea, Middle Guinea and Upper Guinea).

(c). Vegetable production income: here the total income constitutes the imputed value of total production of the following crops: pepper, eggplant, okra and tomato plus gross sales minus input costs.

(d). Annual or seasonal crop production income: value of seasonal crop production for sale, own consumption and other uses. The seasonal crops refer to the cassava, peanut, sweet potato and fonio [Note 3.3] (local cereal, it is also cultivated in other West African countries like Senegal).

(e). Perennial crop production income: value of production for sale, consumption and other orientation of uses. Perennial crops include banana, kola and palm trees belonging to the household.

2) Salt production income: imputed value of salt production for sale and own consumption from the traditional and improved techniques of salt minus input costs. For further details about these techniques of salt production in the Guinean coastal area refer to (Chapter VI, Section 6.2). Salt production was practiced along the coastline of Balessourou including Pompage sector in Koba. This area was separated from the improved area of mangrove rice farming by a large embankment which also serves as a route connecting Balessourou to Kindiady, another fishing port and mangrove wood market. This proximity of salt production area and improved zone of mangrove rice farming could explain the involvement of Salt Marsh (SM) producers in both activities. In addition, saving time due to the adoption of improved salt production is another reason. It was reported Chapter VI that the saving time due to improved salt production enable SM producers to earn a profit from the mangrove rice production.

3) Wood extraction: value of the pole (laths) and chopped-off wood for sale. The length of poles varies between 6 to 7 m; while the chopped-off wood between 1.10 to 1.20 m. Surveyed wood loggers operate at two sites, Keregnon and Kito (Main Island) accessible only by canoes from Koba, the main inland. These wood loggers live in Kito, but mangrove woods are marketed in Taboria, principal port in Koba. Their permanent contact, proximity to the mangrove forest and isolation from cultivated mangrove areas indicated the reason that wood extraction remains as their main income source as indicated in Table 3. Wood loggers were found practicing livestock, non-farm activities and receiving remittance.

4) Livestock: it represents the net sales plus the imputed value of home consumption. This livestock ranges from poultry (domesticated birds such as chickens, turkeys and ducks), cattle, sheep and goat.

5) Non-farm income: this indicates the income from regular and casual employment of the household members. In the other words, this is the local income from sources other than cropping, livestock husbandry, etc., including commerce, local wage employment, services and so on.

6) Remittance: this represents remittances from absent family members and from relatives living in other cities in Guinea or abroad.

3.4.2. Empirical analyses

1) Income Inequality and Poverty Reduction

Data were analyzed by selecting the common methods for the determination of inequality and poverty indices. The Gini decomposition analysis is considered to be the best measure of inequality and is widely used in economic research (Shorrocks, 1982). The ability to decompose measures of inequality from contributing sources is a desirable property for studies of economic inequality (Okamoto, 2009). Given its advantages and usefulness, the Gini decomposition analysis is employed to determine the income inequalities of livelihood activities. To estimate the effects of livelihood activities on poverty reduction, the well-known poverty measure, the Foster-Greer-Thorbecke class (including the headcount ratio and the poverty gap ratio) was computed. The poverty measurement can also be computed by using the following methods: the income gap ratio and the aggregate poverty gap, the Sen, Takayama, Thon and Watts indices, and measures from the Clark-Hemming-Ulph class (Stata Technical Bulletin, 1999 (STB-48)).

(a) Gini Decomposition Analysis

The measures of income inequality can be divided into positive and normative measures. The positive measures are derived from statistical concepts and make no explicit use of any concept of social welfare. These include the Gini coefficient, Lorenz curve, Theil measure, relative mean deviation and the coefficient of variation. In contrast, the normative measures, the Dalton measure and Atkinson index, links and integrates the measure of inequality with social welfare and rely on value judgments and a properly defined function. According to Shorrocks (1982), the Gini coefficient is considered to be the best measure of inequality and is widely used in economic research.

The Gini coefficient or index (Gini, 1912; Alina, 2008) is perhaps one of the most used indicators of social and economic condition. This measure is understood by many economists and has been applied in numerous numerical studies and policy research. The Gini index can be used to measure the dispersion of a distribution of income, or consumption, or wealth or any kind of distribution. In this study, the Gini coefficient was used to measure the degree of inequality of income generated by farmers involved in various activities in the coastal area of Guinea. The Gini coefficient is a number or index varying between zero and one; zero signifies perfect equality, and one perfect inequality. The United Nations Development Programme (1992) indicated that Gini coefficients for countries with high inequality typically lie between 0.5 and 0.7. Following Shorrocks (1982), Lerman & Yitzhaki (1985), the Gini coefficient for total income inequality, G, can be represented as:

$$\mathrm{G} = \sum_{k=1}^{K} R_k G_k S_k \qquad (1)$$

Where S_k represents the share of component k in total income, G_k is the source Gini corresponding to the distribution of income from source k, and R_k is the Gini correlation of income from source k with the distribution of total income. According to Stark, Taylor and Yitzharki (1986), the relation among these three terms has a clear and intuitive interpretation; the influence of any income component upon total income inequality depends on: (a) how important the income source is with respect to total income (S_k); (b) how equally or unequally distributed the income source is (G_k); (c) how the income source and the distribution of total income are correlated (R_k). If an income source represents a large share of total income, it may potentially have a large impact on inequality. However, if income is equally distributed ($G_k = 0$), it cannot influence inequality, even if its magnitude is large. On the other hand, if this income source is large and unequally distributed (S_k and G_k are large), it may either increase or decrease inequality, depending on which households, at which points in the income distribution, earn it. If the income source is unequally distributed and flows disproportionately toward those at the top of the income distribution (R_k is positive and large), its contribution to inequality will be positive. However, if it is unequally distributed, but targets poor households, the income source may have an equalizing effect on the income distribution.

(b) FGT (Foster-Greer-Thorbecke) index

In order to investigate the effect of livelihood activities on poverty reduction in the coastal area, this study used the Foster-Greere-Thorbecke (FGT) poverty index (1984). The FGT poverty measure is defined as:

$$P_{\alpha} = \frac{1}{n}\sum_{i=1}^{m}(\frac{z-y_i}{z})^{\alpha} \qquad (2)$$

Where n is the sample size, i subscripts the household or individual, m is the total number of households living under the poverty line, y_i is the relevant measure of welfare or the income of poor household from i to m which arrange in ascending order, z is the poverty line income and α is a poverty aversion parameter. When $\alpha = 0$, the resulting measure is the headcount index which provides an estimate of the proportion of households living in poverty. When $\alpha = 1$, the FGT index results in the poverty gap index which provides a measure of the depth of poverty, that is the amount by which an average poor family is below the poverty line. The squared poverty gap index, which is sensitive to the extent of inequality among the poor, results when $\alpha = 2$. In addition to these three measures, which are provided by default, the user may specify any non-negative value of alpha.

2) Multiple Linear Regression Model

Conventional farm management analysis and profitability measures were carried out to examine the resource productivity in rice farming. Factors determining the mangrove rice production were studied using a multiple linear regression model, represented by this equation:

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots b_8X_8. \quad (3)$$

Where, Y refers to the dependent variable. Then, b_0 is the constant in the model. X_1 to X_8 represent independent variables and b_1 to b_8 their coefficients showing the marginal effect. The off-farm income per family members(X_1) represents the non-farm income perceived by the household which was divided by the family size. Fertilizers (X_2) and agrochemicals (X_3) are two inputs expressed in monetary value, the Guinean Franc (GNF) per unit (ha). The application of these inputs by farmers remains low 10.0% and 15.0% respectively. However, the improved seed varieties usage (X_5) was considered as dummy (1=Yes and 0= No). 85% of farmers did not use the improved seed. X_7 and X_6 represent the selection of only local rice varieties and the combination of both local and improved seed of rice grown in the mangrove area respectively. The opinions on the type of irrigation systems(X_4) considered as dummy (1=R; 2=HR). Receptive (R) means that farmers are welcoming assistance for improving the traditional rice farming. Highly

Receptive (HR) refers to farmers' good feeling related to the improved irrigation despite some issues.

3) Quantile Regression Model

The analytical techniques used include descriptive statistics such as mean, standard error, and percentages to describe the socio-economic characteristics and resources endowment of salt producers in respect to the salt production techniques. Gross marginal analysis was employed to estimate the profitability of salt production. Quantile regression model was used to determine the factors affecting the revenue of salt production in the study area. Both descriptive and regression analysis were performed by using Stata 12.

(1) Rationale for using quantile regression

Standard linear regression techniques summarize the average relationship between a set of regressors and the outcome variable based on the conditional mean function $E(y/x)$. This provide only a partial view of the relationship, as we might be interested in describing the relationship at different tails (low and high tails of salt production) in the conditional distribution of y. Quantile regression provides that capability. Quantile regression is an econometric tool in which a specified quantile (or percentile) of the conditional distribution of the response variable is regressed on subject characteristics (Buchinsky, 1998; Koenker and Bassett, 1978). Quantile regression is applied when an estimate of the various quantiles in a population is desired. First proposed by Koenker and Bassett (1978), quantile regression enables the estimation of conditional quantile functions, where each function characterizes the behavior of a specific point in the conditional distribution, and thus it fully represents the conditional distribution. Besides characterizing the full description of the conditional distribution, the quantile regression has several other useful features. First, the quantile regression model employs a linear programming representation which simplifies examination. Second, the quantile regression objective function is a weighted sum of absolute deviations, and thus the estimated coefficient vector is not sensitive to outliers. As discussed in Koenker and Hallock (2001), an attractive property of the quantile regression estimator is its robustness to the presence of outlying observations on the dependent variable. While the ordinary least square (OLS) estimator magnifies the effect of outliers, the quantile regression estimator penalizes tail observations. Third, quantile regression estimators may be more efficient than OLS estimators when the error term is non-normal (Buchinsky, 1998). Thus, the quantile regression approach can obtain a more detailed picture of the relationship between selected variables and salt production. The quantile regression model, introduced in Koenker and Bassett's (1978), can be written as:

$$y_i = x_i'\beta_q + u_{qi} \qquad \text{with } \text{Quant}_q(y_i/x_i) = x_i'\,\beta_q \qquad (4)$$

Where, y_i is the dependent variable (log total revenue of salt production), x_i' denotes a vector of regressors (age, household head origin, family size, total variable cost of salt production, land rent cost, dairy working time, unit price per salt bag and profit from mangrove rice cultivation), β_q represents the vector of parameters to be estimated, and u_{qi} is a vector of residuals. $\text{Quant}_q(y_i/x_i)$ represents the q^{th} conditional quantile of y_i given x_i'. The q^{th} regression quantile $0 < q < 1$ solves the following minimization problem:

$$\min_{\beta} = \{\textstyle\sum_i q|y_i - x_i\beta| + \sum_i (1-q)|y_i - x_i\beta|\} = \min_{\beta} \sum_i \rho_q u_{qit}\,,\ q \in (0,1) \qquad (5)$$

Where, ρ_q is known as the 'check function', is defined as

$$\rho_q(u_{qit}) = \begin{Bmatrix} qu_{qit} & \text{if } u_{qit} \geq 0 \\ (q-1)u_{\theta it} & \text{if } u_{qit} < 0 \end{Bmatrix} \qquad (6)$$

Equation 5 is then solved by linear programming methods. As one increases q continuously from 0 to 1, one traces the entire conditional distribution of y_i, conditional on x_i (Buchinsky, 1998). The median regression, which is a special case of the quantile regression, is obtained by setting q = 0.50. Other quantile of the conditional distribution can be obtained via variation of q. To convey a sense for the relationship of selected explanatory variables across the entire conditional of the revenue of salt production distribution, the results for the 25^{th}, 50^{th}, 75^{th} and 95^{th} quantiles are reported. Additionally, this paper also illustrates and compares the quantile regression estimates that differ from the OLS estimates. For more discussion on the model specification of quantile regression, refer to Koenker (2005).

4) Stochastic Frontier Production (SFP) and Efficiency Measurement of Small-scale Improved Salt Production

Coelli (1996) had developed the software FRONTIER 4.1, which can be used to generate both the stochastic production frontier and the inefficiency model simultaneously. The FRONTIER 4.1 was widely applied in different fields of research in the past 15 years, especially in agricultural studies (Binuomote et al., 2008; Bakhsh et al., 2006; Bamiro et al., 2006; Battese and Coelli, 1995). This study applied FRONTIER 4.1 with the trans-log production function for the analysis of technical efficiency. The Stochastic Frontier Approach (Coelli et al., 1998) was used for measurement of technical efficiency. Inefficiency was defined as the distance between a producer's actual salt production value and the estimated frontier salt production value that corresponds to the state of its production technology. Output value, the revenue from salt production, in Guinean Franc (GNF) was used as the dependent variable since some previous empirical studies have used the monetary value as the dependent variable (Coelli and Battese, 1996; Aigner et al., 1977). The explanatory variables used to explain efficiency were included in the model when estimating the measures of technical efficiency. The results of the likelihood ratio-type test, used to test Cobb-Douglas against the translog, showed that Cobb-Douglas was an appropriate model for the present data. Based on Battese and Coelli (1995) and Coelli et al. (1998), the following model was used:

$$lnY_i = \beta_0 + \sum_{i=1}^{x} \beta_j lnX_{ij} + v_i - u_i \quad (7)$$

Where, Y_i is the dependent variable in the production function representing the revenue from salt production value expressed in GNF of i^{th} salt producers, X_{ij} is the j^{th} input (j=1-4) used by i^{th} farmer. β_0 is intercept (constant) and β_j are response parameters to be estimated or elasticity corresponding to each input (j=1-4), including labor cost, equipment cost, dimension of basins and tarpaulin cost. v_i and u_i are components forming an error term (ε_i). v_i is random variable error associated with random factors such as measurement errors and other statistical noise and exogenous factors beyond the producers' control such as natural disasters. v_i is assumed to be independently and identically distributed, and independent of u_i. While u_i is non-negative random variable associated with farm's specific factors which would affect technical efficiency of salt producers. u_i is assumed to be independently truncated-normal distribution with mean μ and variance δ^2. Although u_i can also have other distributions, FRONTIER 4.1 computer program used in the study can only harmonize with above assumption. The term μ_i is defined as follows:

$$\mu_i = \delta_0 + \delta_1 Z_{1j} + \delta_2 Z_{2j} + \delta_3 Z_{3j} + \delta_4 Z_{4j} + \delta_5 Z_{5j} + \delta_6 Z_{6j} + \delta_7 Z_{7j} + \delta_8 Z_{8j} + \delta_9 Z_{9j} + \delta_{10} Z_{10j} + \omega_i \quad (8)$$

Where, μ_i is inefficiency effects that could be estimated by 2 stage estimation technique in FRONTIER 4.1 spontaneously. δ_0 is the intercept term, δ_j is the parameter for jth independent variables. Z_{1j} is distance to the campsite (km); Z_{2j} is land rent considered as dummy variable (0=free;1=rental); Z_{3j} represents age of salt producers (years). Z_{4j} is gender participation in salt production (1=male;0=female); Z_{5j} is educational level (schooling years); Z_{6j} is family size (persons); Z_{7j} is participation in activities conducted by local or international NGOs in the study area. Z_{8j} represents membership in salt production (1= membership and 0 = otherwise); Z_{9j} is unit price per salt bag in Guinean franc (GNF). Z_{10j} is the off-farm income & remittance per family size. ω_i is an error term (unobservable random variable). Maximum likelihood estimates (MLEs) for all parameters of the stochastic frontier production (Equation 7) and inefficiency model (Equation 8) were simultaneously estimated by using the FRONTIER 4.1 computer program (Coelli, 1996). This program also presented the coefficients of variance parameters.

$$\sigma^2 = \sigma^2{}_v + \sigma^2{}_u \qquad (9)$$

$$\gamma = \sigma^2{}_u / \sigma^2{}_v \qquad (10)$$

$$0 \leq \gamma \leq 1 \qquad (11)$$

Where γ parameter gamma shows the share of inefficiency in the overall residual variance and lies between zero and one. If gamma is equal to zero, then it means that all variations of salt production revenue are due to noise. And if it is equal to one, then it means that all variations are due to technical inefficiency (Coelli and Battese, 1996). It is worth mentioning here that the above models for the inefficiency effects are stochastic and have a particular distributional specification. Here, it is interesting to test the following hypotheses:

(1) H_0: $\gamma = \delta_0 = \cdots = \delta_{10} = 0$, i.e., inefficiency is absent.

(2) H_0: $\gamma = 0$, i.e., inefficiency effects are not stochastic.

(3) H_0: $\delta_0 = \cdots = \delta_{10} = 0$, i.e., the coefficients of explanatory variables in the models are simultaneously zero.

(4) H_0: $\delta_1 = \cdots = \delta_{10} = 0$, i.e., the coefficients of the variables in the model for inefficiency effects are zero.

The tests of these hypotheses for the parameters of the frontier are conducted using the generalized likelihood ratio statistics, λ defined as;

$$\lambda = -2[LR_R - LR_U] \quad (12)$$

Where LR_R is the value of the likelihood function for the frontier model in which parameter restrictions are specified by the null hypothesis and LR_U is the value of the likelihood function for the general linear frontier model. If the null hypothesis is true, then λ has approximately a chi-square (or mixed square) distribution with the degrees of freedom equal to the difference between the parameter estimated under LR_R and LR_U, respectively. The technical efficiency of the salt producer, given the specification of the model, is defined by $TE_i = E(-U_i)$. Thus, the technical efficiency of the salt producer lies between zero to one and it is inversely related to the inefficiency model. The parameters of the stochastic frontier production function model are estimated by the method of the maximum likelihood using the Econometric Computer Program Frontier Version 4.1 (Coelli and Battese 1996).

5) Stochastic Frontier Production (SFP) and Efficiency Measurement of Mangrove Production

This section applied FRONTIER 4.1 with the trans-log production function for the analysis of technical efficiency. Coelli (1996) had developed the software FRONTIER 4.1, which can be used to generate both the stochastic production frontier and the inefficiency model simultaneously. The FRONTIER 4.1 was widely applied in different fields of research in the past 15 years, especially in agricultural studies (Binuomote *et al*., 2008; Bakhsh *et al*., 2006; Bamiro *et al*., 2006; Battese & Coelli, 1995). The Stochastic Frontier Approach (Coelli *et al*., 1998) was used for measurement of technical efficiency. Inefficiency was defined as the distance between a farmer's actual mangrove rice production value and the estimated frontier mangrove rice production value that corresponds to the state of its production technology. Output value, the revenue from mangrove rice production, in Guinean Franc (GNF) was used as the dependent variable since some previous empirical studies have used the monetary value as the dependent variable (Coelli & Battese, 1996; Aigner *et al*., 1977). The explanatory variables, used to explain efficiency such as: fertilizer & pesticide cost (GNF/acre), hired labor cost (GNF/acre), depreciation cost of farm tools (GNF/acre), seed quantity (kg/acre), active family labors per family size (%) and farm area under mangrove rice cultivation (acre), were included in the model measures of technical efficiency. Based on Battese & Coelli (1995) and Coelli *et al*. (1998), the following model was used:

$$lnY_i = \beta_0 + \sum_{i=1}^{x} \beta_j lnX_{ij} + v_i - u_i \qquad (13)$$

where, Y_i is the dependent variable in the production function representing the total production value expressed in GNF of i^{th} mangrove rice farmers, X_{ij} is the j^{th} input (j = 1- 6) used by i^{th} farmer. β_0 is intercept (constant) and β_j are response parameters to be estimated or elasticity corresponding to each input (j = 1- 6), including fertilizer and/or pesticide cost (GNF/acre), hired labor cost (GNF/acre), depreciation cost on farm tools (GNF/acre), seed quantity (kg/acre), active farmily labors per family size (%) and farm area under mangrove rice cultivation (acre). The estimation of stochastic production frontier functions assumes that the underlying production technology is the same for all firms or common to all productive units (Orea, L., & Kumbhakar, S. C. 2004; Danquah et al. 2013). In line with this assumption, as some farmers applied either only fertilizer or pesticide and others both of these inputs, we combined these two inputs into one variable (fertilizer and/or pesticide). v_i and u_i are components forming an error term (ε_i).

v_i is random variable error associated with random factors such as measurement errors and other statistical noise and exogenous factors beyond the producers' control such as natural disasters. v_i is assumed to be independently and identically distributed and independent of u_i. While u_i is non-negative random variable associated with farm's specific factors which would affect technical efficiency of salt producers. u_i is assumed to be independently truncated-normal distribution with mean μ and variance δ^2. Although u_i can also have other distributions, FRONTIER 4.1 computer program used in the study can only harmonize with above assumption. The term μ_i is defined as follows:

$$\mu_i = \delta_0 + \delta_1 Z_{1j} + \delta_2 Z_{2j} + \delta_3 Z_{3j} + \delta_4 Z_{4j} + \delta_5 Z_{5j} + \delta_6 Z_{6j} + \delta_7 Z_{7j} + \delta_8 Z_{8j} + \delta_9 Z_{9j} + \delta_{10} Z_{10j} + \delta_{11} Z_{11j} + \delta_{12} Z_{12j} + \omega_i \quad (14)$$

Where, μ_1 is the inefficiency effects that could be estimated by 2 stage estimation technique in FRONTIER 4.1 spontaneously. δ_0 represents the intercept term, δ_j is the parameter for j^{th} independent variables. Z_{1j} is the age of the head of household (years). The variable age may indicate the likelihood of a given mangrove rice farmer (younger or older) to adopt innovations (new ideas and techniques in farming). This variable is also a proxy for experience which represents human capital revealing that farmers with more years of experience in farming will have more technical skills in management and thus higher efficiency than younger farmers. Z_{2j} is the education level (number of schooling years). Education and age (proxy for experience) are important variables that help to improve the managerial ability of the farmer and both are expected to contribute positively for improvement of technical efficiency (Abedullah et al. 2007). It supports the hypothesis that education and experience are important for dealing with rapid change in farming systems. Therefore, both have been included in technical inefficiency effect model (Equation 14). Z_{3j} is the origin of the farmers which is considered as a dummy variable (1 = native and 0 = migrated). Z_{4j} represents household size (persons). Z_{5j} is the distance from the homestead to rice field (km). Distance from homestead to mangrove rice field captures the frequency of a given farmer's visit to the field. It is reasonable to assume that when this distance is less, more the farmer visits his farm and consequently the farm receives more attention in terms of its management. Therefore, farms located closer to the homestead will be more technically efficient than the once located further away from the homestead. Z_{6j} represents farming experience of the head of household in mangrove rice production (years). This variable is important for the identification of factors determining the technical efficiency because better experience in mangrove rice cultivation may also enhance critical evaluation of the relevance of better production decisions, including efficient utilization of productive resources. Z_{7j}

corresponds to usage of improved seeds measured as a dummy variable (1 = yes and 0 = otherwise). Z_{8j} is off-farm income and remittance considered as the monetary value of the Guinean franc (GNF). Z_{9j} is extension provided by the government of Guinea (GOG) considered as dummy variable (1 = yes and 0 = otherwise). Z_{10j} is extension received from NGOs (1 = yes and 0 = otherwise). These variables (Z_{9j} and Z_{10j}) refer to technical assistance from extension personnel provided by local government and NGOs, respectively. The access of mangrove rice farmers to technical assistance may enhance their access to information and use of improved farming techniques. Z_{11j} represents networking with neighbors for farming advice (1 = yes and 0 = otherwise). This variable is included to capture the influence of social capital that arises from networking with neighbours. Z_{12j} is access to credit (1 = yes and 0 = otherwise). A study by Etim & Okon, (2013) revealed that the accessibility and availability of credit relax the production constraints and hence makes it easier for timely purchase of resources, thereby increasing productivity through efficiency. ω_i is an error term (unobservable random variable).

Maximum Likelihood Estimates (MLEs) for all parameters of the stochastic frontier production (Equation 13) and inefficiency model (Equation 14) were simultaneously estimated by using the FRONTIER 4.1 computer program (Coelli, 1996). This program also presented the coefficients of variance parameters:

$$\sigma^2 = \sigma^2{}_v + \sigma^2{}_u \quad (15)$$

$$\gamma = \sigma^2{}_u / \sigma^2{}_v \quad (16)$$

$$0 \le \gamma \le 1 \quad (17)$$

where, γ parameter gamma shows the share of inefficiency in the overall residual variance and lies between zero and one. If gamma is equal to zero, then it means that all variations of mangrove rice production revenue are due to noise. And if it is equal to one, then it means that all variations are due to technical inefficiency (Coelli & Battese, 1996). It is worth mentioning here that the above models for the inefficiency effects are stochastic and have a particular distributional specification. Here, it is important to test the following hypotheses:

(a) H_0: $\gamma = \delta_0 = ... = \delta_{10} = 0$, i.e., inefficiency is absent.

(b) $H_{0:}$ $\gamma = 0$, i.e., inefficiency effects are not stochastic.

(c) $H_{0:}$ $\delta_0 = ... \delta_{10} = 0$, i.e., the coefficients of explanatory variables in the models are simultaneously zero.

(d) H_0: $\delta_1 = ... = \delta_{10} = 0$, i.e., the coefficients of the variables in the model for inefficiency effects are zero. The tests of these hypotheses for the parameters of the frontier are conducted using the generalized likelihood ratio statistics, λ defined as;

$$\lambda = -2[LR_R - LR_U] \quad (18)$$

where, LR_R is the value of the likelihood function for the frontier model in which parameter restrictions are specified by the null hypothesis and LR_U is the value of the likelihood function for the general linear frontier model. If the null hypothesis is true, then λ has approximately a chi-square (or mixed square) distribution with the degrees of freedom equal to the difference between the parameter estimated under LR_R and LR_U, respectively. The technical efficiency of the mangrove rice farmer, given the specification of the model, is defined by $TE_i = E(-U_i)$. Thus, the technical efficiency of the mangrove rice farmer lies between zero to one and it is inversely related to the inefficiency model. The parameters of the stochastic frontier production function model are estimated by the method of the maximum likelihood using the Econometric Computer Program, Frontier Version 4.1 (Coelli & Battese, 1996).

6) Binary logistic regression model

Logistic regression was used to examine determinants of land use change. For this purpose, socio economic variables were grouped into three levels (farm, household and community) and used in the following equation:

$$\ln [p/(1 - p)] = a + B_nX_n + e. \quad (19)$$

Where, X_n represents the independent variables (farm size, family size; education level, membership in farmers' organization, migration, and yield) in the regression model and B_n their coefficients showing the marginal effect. $Y_{i\ (1/0)} = \ln[p/(1 - p)]$ refers to the dependent variable with a value of one indicating that the farmers contributed to the land use transition and a value of zero indicating otherwise.

Table 3.4: Farmers' contribution to land use change transition (LUCT)

Transition	M→P	M→S	S→P	No transition
	Binary logistic regression (1; 0)			
	1= contribution to LUCT			0= otherwise
Plot number	8 (3)[a]	5 (1)	22 (2)	3 (1)
	6 (1)	4 (4)	8 (1)	2 (4)
	4 (1)	3 (4)	6 (1)	1 (3)
	3 (1)	2 (6)	4 (1)	
	2 (1)	1 (10)	1 (6)	

[a] Value in parenthesis indicates number of farmers

The farmers' contribution to the land use transitions (Table 3.4) is based on two premises: (1) Contribution to the land use change transition (LUCT), which was attributed a value of one as mentioned above, and was categorized into three land transition groups. The mangrove forest to paddy fields (M→P) transition designates migrant or native farmers cultivating plots allocated by the management committee. The mangrove forest to slashed area (M→S) transition considers members in farmers' organization that has obtained permission [Note 3.4] to slash a very limited stand of mangrove forest for rice cultivation. The slashed area to paddy fields (S→P) transition includes land owner farmers who practiced the traditional mangrove rice farming. (2) No contribution to land use change transitions implying no transition (Table 3.4) and is attributed the value zero. They included non-members in farmers' organization and non-land owners, irrespective of whether they are native or migrant farmers.

3.4.3. Spatial analysis

1) Analytical Framework for integrating remote sensing and socio-economic data

Figure 3.3 describes the analytical framework adopted to integrate of the remote sensing and socio economic data to identify patterns of land use change. First, we obtained remote sensing data, based on satellites images of 1990 and 2010, obtained through Thematic Mapper ™ sensors and defined by the orientation numbers of path and row as mentioned in section 3.3, sub-section (2) or Table 3.2. These raw data were corrected for internal and external distortions. The geometric correction, or rectification, was performed by using Ground Control Points (GPCs) from the 1/50,000 topographical map (IGN France 1953). The rectified images were then projected on the plane coordinates using the common Universal Traverse Mercator (UTM) projection.

These data were resampled using the nearest neighbor algorithm, maintaining the original brightness values of each pixel (Weng 2002). Keys to a successful supervised classification are how well training samples can be obtained on site. Training samples significantly affect the accuracy of the final output, namely, the land cover maps. A supervised signature extraction using the maximum likelihood algorithm was employed to classify the Landsat images. Subsequently, eight classes of land use patterns were generated for comparison: (1) Build up area, (2) Mangrove forest, (3) Paddy fields, (4) Palm trees, (5) Savannah forest, (6) Slashed area (cleared mangrove forest for rice farming), (7) Upland area and (8) Water bodies. Land use maps were overlaid and compared using ERDAS IMAGINE 9.2. Some of the training data were collected by on-screen selection of polygonal training data (Weng 2002). A total of 100 training sites were chosen for each image, to ensure that all spectral classes constituting each land use and land cover category were adequately represented in the training statistics. The accuracy of the two classified maps was checked with a stratified random sampling method. Through this method, sample points were trained for each land use and land cover category. The reference data was collected from a field survey and from existing land use and cover maps and field-checked (IUCN 2010, Weng 2002). Large scale aerial photos (IGN France 1953, JICA 1982) were also used as reference data to assess the accuracy when necessary. A cross-tabulation detection method was used to detect land use and cover change (Juan et al. 2005), through which a land use change matrix was produced. The change matrix enables to understand the main types of changes (directions) in the study area. Quantitative areal data, of the overall land use and land cover changes, as well as gains and losses (Braimoh et al. 2004, Weng 2002) for each category between 1990 and 2010 was compiled. Finally, the accuracy of the land use change maps was validated using an error matrix and kappa coefficient.

The Kappa coefficient is a discrete multivariate technique used in accuracy assessment. This coefficient typically ranges between 0 and 1, where the latter indicates a perfect match. It is often multiplied by 100 to give a percentage measure of the classification accuracy. Kappa values are also characterized into 3 groups: (1) a value greater than 0.80 (80.0%) represents a strong agreement, (2) a value between 0.40 and 0.80 (40.0 to 80.0%) represents moderate agreement, and (3) a value below 0.40 (40.0%) represents poor agreement (Congalton 1996). There are many techniques available to detect land use change, such as image differencing, post-classification comparison, etc.; however, post-classification comparison can provide a complete matrix of change directions. These change directions represent gains (increases) and losses (decreases) for each land use class. In addition, a logistic regression was used to examine determinants of land use change. For this purpose, socio economic variables were grouped into three levels (farm, household and community) and used in Equation 19.

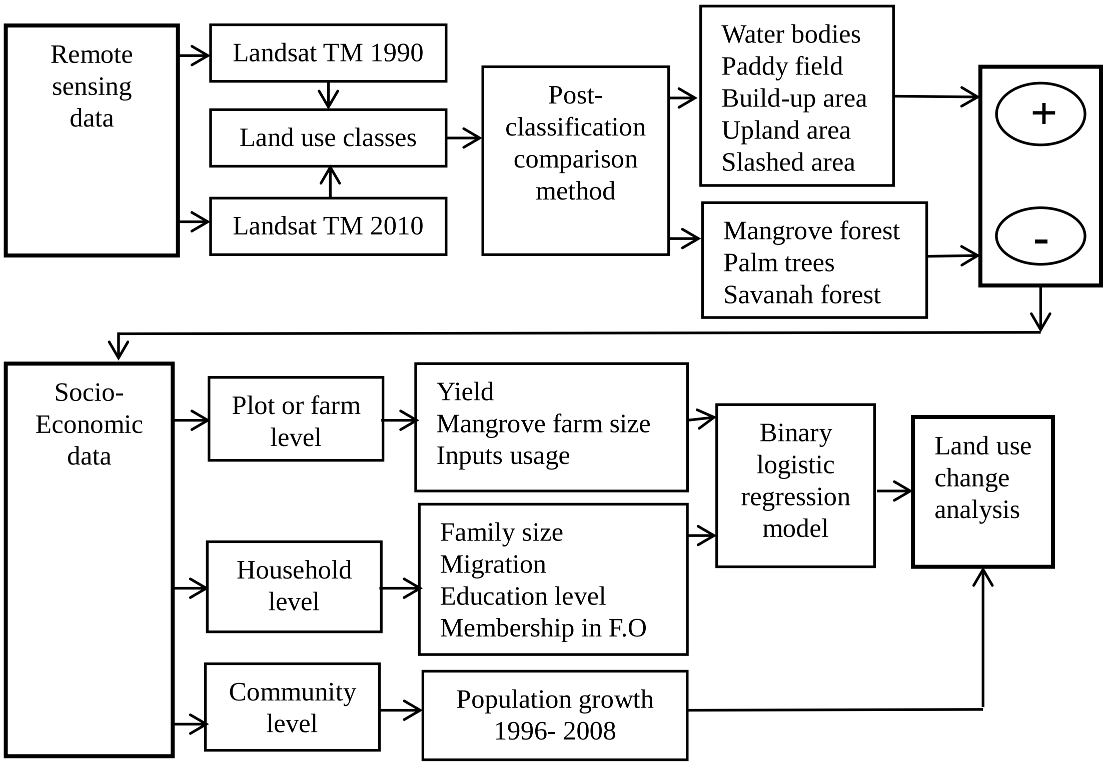

Figure 3.3: Analytical framework

2) Accuracy Assessment of Land Use Change using Error Matrix and Kappa Coefficient.

Points used in accuracy assessment were based on the GPS points acquired during the field work and 1956 topographic map. The accuracy assessment points were independent from those used in land use classes labeling. A confusion matrix was generated for both 1990 and 2010 land use maps with both producers and users accuracies. Kappa statistics were also calculated for the two land use maps. The accuracy assessment has been done throughout Arc Map 9.3.1 where random points were created. A total of hundred (100) random points generated for each land use maps (1990 and 2010) by checking the corresponding class for each point. It is important to mention here that during the field control ground truth, 348 others points have been recorded by using GPS Garmin. Then after generating random points, we convert raster field to polygon data by using the supervised data obtained from ERDAS Imagine 9.2.

In many instances the stratified random sampling strategy is the most useful tool to use. In this case the map area is stratified based on either a systematic breakdown followed by a random sample design in each of the systematic subareas, or alternatively through the application of a random sample within each of the map classes. The use of this approach will ensure that one has an adequate cover for the entire map as well as generating a sufficient number of samples for each of the classes on the map. Once a classification has been sampled a contingency table (also referred to as an error matrix or confusion matrix) is developed. This table is used to properly analyze the validity of each class as well as the classification as a whole. In this way we can evaluate in more detail the efficacy of the classification.

One way to assess accuracy was our reconnaissance survey data as references for image interpretation by observing the actual land classes of locations (Doboro and Dofily), and compare to the land classification, it was assigned on the thematic map. There are a number of ways to quantitatively express the amount of agreement between the *ground truth* classes and the remote sensing classes.

(a) Error matrix (confusion matrix):

One way is to create a confusion matrix, alternatively called an *error matrix*. Each row of tables is reserved for one of the information, or remote sensing classes used by the classification algorithm. Each column displays the corresponding ground truth classes in an identical order. However, there is no standard agreement on this orientation; sometimes the information recorded in the rows and columns of the error matrix is inverted. So from this assessment we have three measures of accuracy which address subtly different issues:

(1). Overall accuracy: The overall accuracy takes no account of source of error (errors of omission or commission). It is the total classification accuracy.

(2). User accuracy: The user accuracy is a measure indicating the probability that a pixel is Class “A” given that the classifier has labeled the pixel into Class “A”. It is the probability that a pixel classified on the map actually represents that category on the ground.

(3). Producer (analyst) accuracy: The producer accuracy is a measure indicating the probability that the classifier has labeled an image pixel into class “A” given that the ground truth is Class “A”. It is the probability of a reference pixel being correctly classified. In other terms it’s measures the proportion of the land base which is correctly classified.

(b) Kappa coefficient: Another measure of the land use maps (1990 and 2010) accuracies is the kappa coefficient, which is a measure of the proportional (or percentage) improvement by the classifier over a purely random assignment to the eight (8) classes as indicated in Chapter IV (Table 4.3 and Table 4.4). For an error matrix with “r” rows, and hence the same number of columns, let A = the sum of “r” diagonal elements, which is the numerator in the computation of overall accuracy, let B = sum of the r products (row total x column total). $\boldsymbol{K} = \frac{\mathbf{NA - B}}{\mathbf{N^2 - B}}$. (20)

In this formula, N is the number of pixels in the error matrix (the sum of all r individual cell values). The Kappa coefficient is a discrete multivariate technique of use in accuracy assessment. It lies typically on a scale between 0 and 1, where the latter indicates complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy. Kappa values are also characterized into 3 groupings:

(1) Value greater than 0.80 (80%) represents strong agreement,

(2) Value between 0.40 and 0.80 (40 to 80%) represents moderate agreement, and

(3) Value below 0.40 (40%) represents poor agreement (Congalton, 1996).

3.5. Summary

In order to achieve the objectives previously enumerated (in Chapter I), a methodology is adopted to fulfil this purpose. After the collection of data based on primary (field surveys, group discussions, GPS, etc.) and secondary (census, reports, literatures of published and unpublished studies based on desktop researches, Landsat satellites imageries, topographic maps, etc.) sources, I adopted analytical methods to analyze the socio-economic status and livelihood patterns of coastal communities dependent on the mangrove forest resources in Guinea. Such analytical methods were categorized into three parts. The first group is based on descriptive analyses in order to elucidate the difference between the peasants involved in the livelihood activities and describe the peasants' characteristics. The second group consists of advanced empirical analyses for examining the determinants of livelihood activities on the mangrove forest resources. The last group represents spatial analysis for the detection of land use transitions and their determinants for the purpose of the livelihood improvement of coastal communities.

Notes

[Note 3.1] Data from the General Census of Population and Habitat of the urban commune of the Dubreka prefecture in 1996 collected as secondary data.

[Note 3.2] Census of Population of the urban commune of the Dubreka prefecture in 2008, this census was carried out on the occasion of the Guinean presidential election in 2010. It was used as secondary data.

[Note 3.3] TMR farmers practiced the traditional mangrove rice cultivation in *Makinsi* district and the only improved area was the large abandoned basins of shrimp farming. The traditional mangrove rice farms (TMRF) (Chapter IV) are enclosed by small embankments constructed by the farmers. They make ridges in the plots where rice is planted, to control the inflow of sea water and protect the rice field from crabs. Often palm tree trunks, and occasionally pipes, are used for the drainage systems.

[Note 3.4] IMR farmers practiced the improved mangrove rice farming (IMRF) in the district of *Bentya*. These irrigated perimeters developed by the government are surrounded by a large embankment preventing the intrusion of sea water into the rice fields. These fields are separated by dikes and flood gates. Thus, during the dry season, the sea water intrusion allows for weed control and to prevent soil acidification, and during the cropping season, the gates remain closed to prevent sea water intrusion into the rice fields.

[Note 3.5] SM producers are both improved salt producers and improved mangrove rice farmers. In this study, we included them by considering only the aspect of the mangrove rice production. Salt marsh (SM) production was practiced along the coastline of *Balessourou* including *Pompage sector* in Koba. This area was separated from the improved area of mangrove rice farming by a large embankment, which also serves as a route connecting Balessourou to Kindiady, another fishing port and mangrove wood market. This proximity of the salt production area and improved zone of mangrove rice farming could explain the involvement of Salt Marsh (SM) producers in both activities. In addition, saving of time due to the adoption of improved salt production is another reason. It is reported in Chapter VI that the saving time due to improved salt production enable SM producers to earn a profit from the mangrove rice production. For further details about these techniques of salt production in the Guinean coastal area refer to Chapter VI.

[Note 3.6] Fonio (*Digitaria exilis and Digitaria iburua*) is probably the oldest African cereal. For thousands of years West Africans have cultivated it across the dry savannas. Indeed, it was once their major food. Even though few other people have ever heard of it, this crop still remains important in areas scattered from Cape Verde to Lake Chad. In certain regions of Mali, Burkina Faso, Guinea, and Nigeria, for instance, it is either the staple or a major part of the diet. Each year West African farmers devoted about 300,000 hectares for cultivating fonio, and the crop supplies food to 3-4 million people (NAP, 1996). Fonio (*Digitaria exilis*) has been grown in West Africa for centuries. For a long time, it was of marginal importance as a cereal due to its small seeds, but is now the object of renewed interest as consumers begin to recognize its flavour and nutritional qualities. Research is under way with a view to mechanizing several processing stages, so as to increase fonio sales in the urban areas, where it is particularly popular.

[Note 3.7] This permission requires some prerequisites which include: being a member of the farmers' group, to contact subsequently the prefectural authorities and also the Water and Forest Service for instructions on delimitation and finally the prefectural service of agriculture for development of the given area. This delimitation requires keeping a distance of over 100 meters between plots and the rivers in the middle estuaries, and just 100 meters in the case of upper estuaries according to the information provided by the surveyed farmers.

CHAPTER IV

ROLE OF LAND USE CHANGE ANALYSIS AND THEIR DETERMINANTS IN LIVELIHOOD IMPROVEMENT IN THE COASTAL AREA OF GUINEA: A STUDY BASED ON SPATIAL ANALYSIS AND FIELD SURVEY

4.1. Introduction

In Guinea, 85% of the 10 million inhabitants work in the agricultural sector, mainly dedicated to produce rice, the country's staple food. Rice provides 35% of the population's daily calorie intake; however, national consumption (800,000 t) exceeds rice production (650,000 t in 2001) (MAL 2009), leading to concerns about food security. Thus, recent governmental measures have been directed towards promoting rice production, particularly through the use of irrigation, to ensure higher productivity and stable production discouraging the current volatile and low productive rain-fed agriculture. In Guinea, rice cultivation is practiced under four majors cropping systems: (1) The traditional rain-fed rice farming, known as dry rice farming, is by far the most widespread system (65% of the cultivated area). It is mostly carried out on mountain hillsides, and forested areas after slash and burning. Cultivation is done manually and no fertilizer is used. Yields may vary from 500 to 900 kg/ha depending on natural soil fertility and rainfall. (2) The lowland rice system accounts for 10% of rice crop land.

Yields usually range between 1.5 and 2.5 t/ha. The Guinean forest accounts for the largest stretch of lowland compared to other natural regions in the country. **(**3) The "upland" rice system (the term "upland" is used to represent Upper Guinea region) is grown on river valleys and differs from dry rice farming. This system is the most dominant system in Upper Guinea and in the Gaoual/Koundara areas. It accounts for 9% of the total rice cultivated area and its yields vary between 500 kg/ha and 2 t/ha depending on the water levels of the Niger and its tributaries. It is highly sensitive to changes in climatic conditions and flood levels. (4) The mangrove rice farming makes use of cleared mangrove forest land. It includes plains spread into the mangrove forests where rice can be cultivated. Mangrove rice farming represents 16% of the total rice crop area in Guinea (MAL 2009) and 18% of the total rice production in the country. It is considered the most important rice crop system due to the wide variability in yield (1.5-3.5 t/ha). This system is limited to the coastal area of Guinea. Mangrove swamp rice production is found in flood plains inundated at high tide and drained at low tide. Most mangrove swamps experience a salt-free growing period during the rainy season when freshwater floods displace tidal flows. These soils are generally more fertile than those of other cropping systems, since they benefit from regular deposits of silt during annual flooding; however, they are also characterized by the presence of high salinity and sulfate acidity. Soil fertility in these soils could be maintained if sea water rich in sediments is allowed to flood the land also during the dry season.

The multiple natural resources (firewood, rice, salt, fish, etc.) of Guinean coastal area are under pressure due to rapid demography transition and urbanization. The capital city, Conakry urban expansion is taking over nearby Dubreka (our study site) and Coyah prefectures, highlighting the pressing need for studying the causes and consequences of land use change in Dubreka. This chapter focused particularly on land use change related to mangrove rice cultivation, as it constitutes the main livelihood of these coastal communities. The growth of mangrove rice farming coupled with urban migration has already transformed the entire upland area. Hence, investigating the spatial dynamics associated with the provision of natural resources such as arable land, mangrove forest etc. will contribute to improve these populations' livelihood in a sustainable manner.

The advances in remote sensing and global positioning systems (GPS) have given rise to the advent of more precise and geographically referenced data on land cover and use, which in turn have created many opportunities for improved assessments and analysis. With the aid of these new tools, researchers have now started to unravel the processes that drive the cycle of land use change and resource degradation. Airborne and satellite remote sensing data have been proven to be a valuable technique for monitoring forest clearing, shifts in cultivation, and land use conversion patterns; therefore, it has been gradually integrated with socio-economic surveys, census data and other biophysical information, to bring about a better understanding of land use/cover dynamics and the factors that drive them (Samuel 2007).

Studies detecting land changes based on remote sensing and GIS have predominantly focused on examining how much, where, what type of land use and land cover change has occurred. However, only a few models have been developed to examine how and why the changes have occurred. The models dealing with land use and land cover change fall mainly into two groups: regression-based and spatial transition-based models (Baker 1989, Lambin 1997, Theobald and Hobbs 1998). Most land use models, which relates the geographical locations of land use and land cover change detected to a set of spatially explicit variables (Landis 1994). Therefore, due to the lack of available land use change monitoring data from the study area integrated both spatial transition and regression-based models.

This chapter aims to analyze the contribution of land use change to livelihood improvements in the Guinean coastal area in Dubreka prefecture. It has the following specific objectives: (1) to determine land use change using satellite data and (2) identify which factors influence land use change using field survey. Ultimately, this study aims to provide a set of guidelines for policy-makers to take a balance development approach in view of the policy thrust, and to improve rice production in the rural area of Guinea.

4.2. Socio-economic background

Table 4.1: Socio-economic backgrounds of surveyed mangrove rice farmers

Attributes	Min	Max	Mean	Attributes	Farmers[a] (%)
1- Head of household age	35	82	58.45	7- Farmer organization: Member	23 (57.5)
2- Family size	5	27	13.75	Non-member	17 (42.5)
Attributes	Farmers (%)			8- Access to credit: No	32 (80)
3- Farm size : < 1 ha	21 (52.5)			Yes	8 (20)
1 - 2 ha	17 (42.5)			9- Access to extension service: No	16 (40)
6 ha	1 (2.5)			Yes	24 (60)
8 ha	1 (2.5)			10- Use of improved seed varieties: No	34 (85)
4- Land tenure system: State	33 (82.5)			Yes	6 (15)
Rental	4 (10)			11- Fertilizer usage: No	36 (90)
Owner	3 (7.5)			Yes	4 (10)
6- Migration: Native farmers	18 (45)			12- Agrochemical usage: No	34 (85)
Migrated farmers	22 (55)			Yes	6 (15)

[a] Farm households = 40. Source: Author's survey (2011)

The average family size is 13.8 members and 55.0% of surveyed peasants were migrants (Table 4.1). These variables seem to affect the farm size in the mangrove rice farming, as 52.5% of farmers are cultivating less than 1 ha and 42.5% between 1to 2 ha. The only farmer recorded to own 6 ha of land previously owned 12 ha. He handed over half of his farm to the government in exchange for developing irrigation in its perimeter. The handed over plots were subsequently distributed to landless farmers. This is why 82.5 % (Table 4.1) of the surveyed farmers received plots from the state endorsed by the management committee. Around the irrigated perimeters in the IMRF, peasants are not allowed to slash the mangrove forest without permission, limiting their access to the mangrove forest. However, the 8 ha under the TMRF were reported as the biggest farm size. Around this TMRF, farmers slashed over larger extents because the mangrove forests are controlled by the farmers themselves.

The application of improved seeds, fertilizer and agrochemicals by farmers represents only 15.0%, 10.0% and 15.0% respectively, indicating that the usage of modern farming technologies remains low in the study area (Table 4.1). Due to the reduced use of modern farming technologies (Table 4.1), their contributions to crop yield were not examined.

4.3. Determination of land use change based on satellite data

The land use maps obtained through the supervised classification displaying the different classes found in the study area are shown in Figure 4.1. The recorded data of the rice fields shown in Figure 3.1 (chapter III) are also displayed in these land use maps (Figure 4.1). The total area display in the each figure is 5,099 ha. This chapter mainly investigated the mangrove rice farming indicated in yellow (Figure 4.1). The slashed area also constitutes an extension of the mangrove rice farming areas. This slashed area was the result of the actions by both TMRF farmers and peasants belonging to farmer's organizations under the IMRF, who obtained permission to slash a new area by adhering to the conditions described in section 3.4.3, sub-section 1 (chapter III). During our field visit, we observed that the TMRF farmers have access to larger farms (e.g., 8 ha, Table 4.1); however, they still slashed new stand of mangrove forest to extend their farm size.

Table 4.2 shows the land use change matrix of 1990 and 2010, indicating a considerable change (42% of the total area) during the 20-year period. Mangrove forest, savannah forest and palm trees have decreased in the area by 19.8%, 41.1% and 63.9%, respectively. In contrast, other land uses such as paddy fields, build up area, slashed area targeted for rice farming, upland area and water bodies have increased by 77.1%, 87.7%, 99.8%, 448.2% and 11.5%, respectively. The significant increase of upland area (448.2%), build up area (87.7%) and slashed area (99.8%) can be attributed to factors such as local population growth, whose annual growth rate is estimated to be 54% [Note 4.1], and immigration of farmers' (55.0% in Table 4.1).

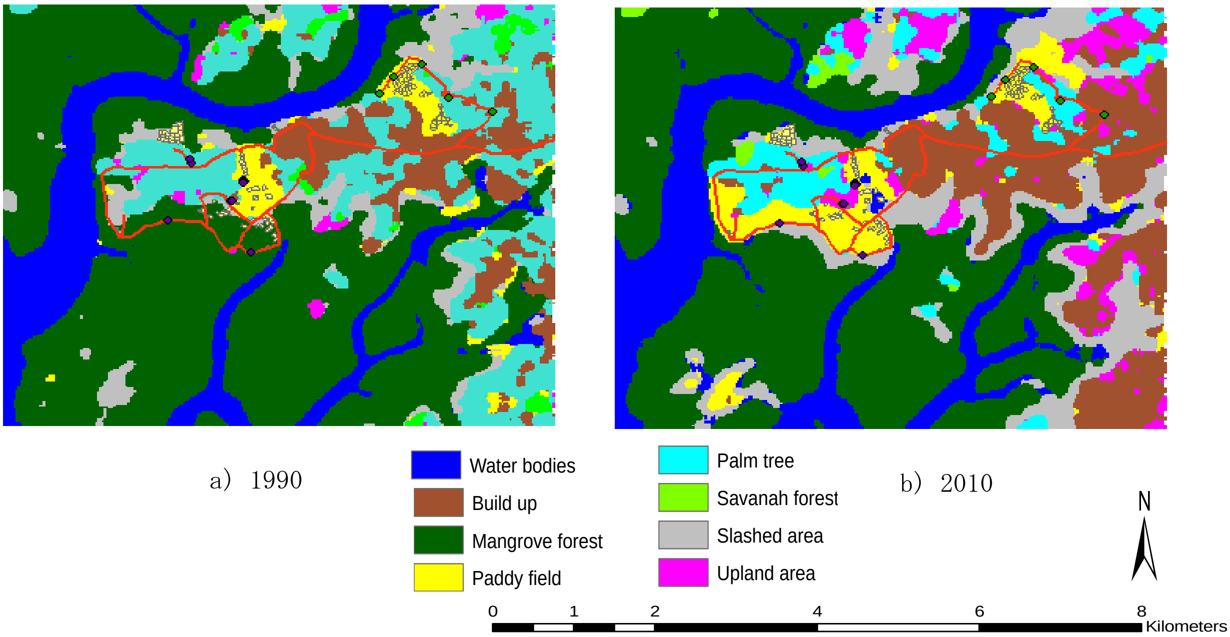

Figure 4.1: Land use maps

Table 4.2: Land use change matrix, 1990 – 2010 (ha)

1990	1990[a]	2010							
	Total	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Water bodies (1)	727	678.87	25.29	0.36	0.09	0	0	0	22.29
Mangrove forest (2)	2558	115.65	2004.03	108.99	8.01	1.35	2.61	5.04	311.94
Paddy field (3)	165	9.9	2.16	85.14	14.76	6.57	0	9	37.17
Build up (4)	407	0	0	9.54	344.52	24.12	0.72	15.21	12.69
Upland area (5)	42	1.17	1.08	0.45	0.09	8.64	1.71	26.1	2.61
Savanah forest (6)	64	0	0	0.09	23.94	33.12	0	5.13	1.17
Palm tree (7)	829	0	1.8	10.44	368.1	150.84	31.23	230.67	35.64
Slashed area (8)	309	4.77	15.75	76.59	4.23	4.77	1.08	8.01	193.59
2010[b] Total	5099	810	2050	292	764	229	37	299	617
Change	2126.34	83.46	-507.51	126.90	356.94	187.56	-26.1	-529.56	308.31
Change (%)	41.70	11.48	-19.84	77.05	87.74	448.17	-41.13	-63.9	99.84

[a]: Overall accuracies = 72.0%. Kappa coefficient = 0.62. [b]: Overall accuracies = 87.0%. Kappa coefficient = 0.83.

The increase in paddy fields (77.1%), along with slashed area targeted for mangrove rice cultivation, could also be attributed to these factors. The main land use types that have been transformed into paddy fields include mangrove forest (37.0% of paddy field) and slashed area (26.0% of paddy field). Accuracy assessment is a very important tool to understand these results and use them for decision-making. The validation of the land use/ land cover maps for 1990 and 2010 was carried out using our reconnaissance survey data as reference for the image interpretation, by observing the actual land classes of the study site and comparing them with the land classification, as assigned in the thematic map.

There are a number of ways to quantitatively express the level of agreement between the ground truth classes and the remote sensing classes. The most common accuracy assessment elements include overall accuracy and Kappa coefficient. The overall accuracies of the analysis in this paper are 72.0% and 87.0% (see Table 4.2; Table 4.3 and Table 4.4) for the land use maps of 1990 and 2010, respectively. The high accuracy for the 2010 land use can be attributed to the availability of field data. Based on Congalton (1996) and in terms of kappa coefficient, we can conclude that the accuracy assessment of land use map 2010 shows a strong level of agreement (83.0%).

In the case of the 1990 map, its accuracy shows a moderate agreement (62.0%).

4.4. Accuracy Assessment of Land Use Change

Accuracy assessment is very important for understanding the developed results and employing these results for decision-making. The most common accuracy assessment elements include overall accuracy, producer's accuracy, user's accuracy and Kappa coefficient. The accuracy assessment for change detection is particularly difficult due to problems in collecting reliable temporal field-based datasets. Therefore, much previous research on change detection cannot provide quantitative analysis of the research results.

The resulting overall accuracies in this present study represent 72% and 87% respectively for the land use maps of 1990 and 2010. The high accuracy of 2010 land use map is due to our ground control field during the survey where many locations were visited by observing a various land cover categories in the study area. Regarding to land use map of 1990, the user accuracy (Table 4.3) of the water class represents 92%, paddy field 80% and mangrove forest 76%. It means that 92% of pixels classified on the map as water class actually represent that category on the ground. 80% of pixels classified on the map (as paddy field) represent that category on the ground. Thus, remaining classes indicate the same meaning.

Table 4.3: 1990 land use change accuracy assessment and error matrix

	Reference Data								Row	User	Commission
	1	2	3	4	5	6	7	8	Total	accuracy	errors
1-Build up	8		1				1		10	80%	20%
2-Water bodies		11				1			12	92%	8%
3-Paddy field			4				1		5	80%	20%
4-Mangrove forest		5	2	41		6			54	76%	24%
5-Palm tree	6				4				10	40%	60%
6-Slashed area			1	2		4	1		8	50%	50%
7-Upland area							0		0	0%	0%
8-Savanah forest	0	0	0	0	0	0	1		1	0%	1%
Column Total	14	16	8	43	4	11	4	0	100		
Producer accuracy	57%	69%	50%	95%	100%	36%	0%	0%			
Omission errors	43%	31%	50%	5%	0%	64%	100%	0%			
Overall accuracy = 72%. Kappa coefficient (K) = 0.61 (61%)											

Table 4.4: 2010 land use change accuracy assessment and error matrix

	Reference Data							Row total	User	Commission
	1	2	3	4	5	6	7		accuracy	errors
1-Build up	13		1		1			15	87%	13%
2-Water bodies		13		1				14	93%	7%
3-Paddy field			7				1	8	88%	12%
4-Mangrove forest		1		40		2		43	93%	7%
5-Palm tree					3			3	100%	0%
6-Slashed area		2		2		9	1	14	64%	36%
7-Upland area	1						2	3	67%	33%
Column total	14	16	8	43	4	11	4	100		
Producer accuracy	93%	81%	88%	93%	75%	82%	50%			
Omission errors	7%	19%	12%	7%	25%	18%	50%			
Overall accuracy = 87%. Kappa coefficient (K) = 0.83 (83%)										

In 2010 land use map, it was found that the user accuracies (Table 4.4) are the following: 100% for palm tree class, water and mangrove forest classes 93%, paddy field 88% and so on. Referring to Table 4.3, the 1990 land use map indicated the following producer accuracies: 100% for palm tree, 93% for mangrove forest, water bodies 69%, etc. In Table 4.4, the producer accuracy of mangrove forest represents 93% among the 43 pixels labeled by the classifier and 7% represent the omission error. Thus 40 pixels (93%) measure the proportion of mangrove forest class which is correctly classified. Other classes show the same explanations.

In view point of kappa coefficient; we can conclude that the accuracy assessment of 2010 land use map represents a strong agreement (Congalton, 1996) giving a value greater than 80% in one hand. In the other one, regarding to the 1990 one, the accuracy assessment represents a moderate agreement (Congalton, 1996) because comprising between 40% and 80%.

Since the main purpose of this present chapter aims to analyze the land use change in the coastal area of the urban commune Dubreka prefecture by integrating the remote sensing, GIS tools and socio-economic data for the period of twenty years from 1990 to 2010. In the next section, the land use change from the view point of socio-economic analysis is discussed through the application of the binary logistic regression modeling.

4.5. Factors influencing land use change based on the field survey

Table 4.5 shows a positive regression coefficient between farm size and land use transition (although not significant), meaning that an increase in farm size will increase the likelihood of land use transition from mangrove forest to paddy fields. Membership in farmer's organization shows a significant negative regression coefficient implying that being a member of a farmers' organization could significantly contribute to a decrease in land use transition. However, farmers under the TMRF system manage more plots than those under IMRF. These farmers were slashing more area, as they inherited the land, while they are not members of a farmers' organization. In addition, the traditional irrigation system was more prone to damage during high tide, leading to an extremely low production. In some instances, they could not get any harvest during particular seasons due to strong high tides (in 2009 and 2010, tides had a negative impact on the production).

The peasants involved in the traditional irrigation system are illiterate farmers and are not members of any farmers' organization. Therefore, assistance and supervision by farmers' organizations could limit the extent of the land use change. Yield showed a significant negative regression coefficient with land use change, implying that the increase in crop yield decreases the probability of land use transition and therefore, a decrease in the crop yield leads to land use transition. When yield decreases, farmers need more land to meet to their food needs. The yield is mainly affected by sea water intrusion into the rice plots during the cultivation season, mainly due to the destruction of the dike constructed to prevent sea water intrusion into the rice plots.

Table 4.5: Farmers[a]' contribution to land use change in the mangrove rice farming

Variables	Coefficient	Std. error	p-value
Farm size (ha)	1.747	1.152	0.129
Family size (number of people in the household)	0.184	0.158	0.242
Education level of household (years of schooling)	-0.083	0.8	0.298
Membership in farmers' organization (0 = no; 1= yes)	-7.331	3.377	0.030**[b]
Migration (0 = native; 1= migrant farmer)	-2.114	1.566	0.177
Yield (t/ha)	-3.513	1.943	0.071*[c]

[a] Farm households = 40. Model Chi-square= 19.745; significance at 1%. [b], [c] significance levels at 5% and 10% respectively. Source: Author's survey (2011).

4.6. Summary

Lack of statistical data constitutes the main constraint to assess the effects of land use change in developing countries like Guinea. Here we examine the role of land use change in improving the livelihood of local mangrove rice farmers in the Guinean coastal zone based on both satellite and field survey data. We investigated land use change dynamics using spatial analysis and field survey data for the Dubreka prefecture, Guinea, where statistics and maps are not sufficiently available. For this research, Landsat Thematic Mapper (TM) remote sensing data were used to perform the imagery analysis on land use change. In addition, a field survey was conducted to collect socioeconomic data on households and farm management. Our results showed a substantial recent land use change with 41.7% of the total area (5,099 ha) undergoing transition. The logistic regression analysis revealed that membership in the farmers' organizations and crop yields are the two main factors determining land use transition from mangrove forest to paddy land.

This chapter presents several guidelines or policy directions for improvement of farmer's livelihood and mitigation of rapid land use change in the Guinean coastal belt. These include; improvement of mangrove rice productivity by incorporating modern farming technologies, strengthening and maintaining strong embankments to prevent sea water intrusion into the rice fields, and strengthening farmers' organizations to enhance farmer participation.

Notes

[Note 4.1] The population growth rate (PR) was computed based on the following formula: PR = [((V_{2008} - V_{1996})/ V_{1996})*100]/N. Thus, PR becomes

PR = [((172,593 - 23,072)/ 23,072)*100]/12 = 54.0%.

CHAPTER V

PRESENT STATUS AND DETERMINANTS OF MANGROVE RICE PRODUCTION IN DUBREKA PREFECTURE

5.1. Introduction

In Guinea, according to the Ministry of Agriculture and Livestock, (2009), the rice cultivation is practiced under the following farming systems: dry rice farming or rain-fed rice (65% of the total cultivated rice area), upland rice (9%), lowland rice (10%) and mangrove rice farming (16%). Based on the identification and ranking specific environmental challenges and related opportunities by order of priority fixed by the Guinean Government, this chapter focuses on the mangrove area specially located into the Maritime Guinea Region where the mangrove rice farming represents 51% of cultivated area (Diawara et al., 2011).

The mangrove rice farming constitutes the use of cleared mangrove forest land for rice production. It represents also plains located into the mangrove forests where rice is practiced. This farming system, located in coastal areas where the population is relatively dense, is one of the oldest forms of rice culture in West Africa. As the mangrove area remains the most fragile ecosystem, it requires more particular attention in order to maintain the balance between livelihoods and this environment.

The selection of the mangrove rice production for this chapter is based on the improvement of the socio-economic status of farmers involved in this farming. So by improving mangrove rice productivity, the socio-economic status of farmers can be uplifted. It is said that one of the possible ways of increasing productivity is the greater use of material inputs coupled with new varieties of rice and an adequate irrigation (Fujimoto, A., 1976). In view of above considerations, this chapter has been formulated to analyze the present status and determinants of rice-growing in the mangrove area of Dubreka prefecture in Guinea. Hence, the following points were considered:

(1) To describe the characteristics of mangrove rice farmers,

(2) To estimate their profitability in respect to the selection types of rice varieties and

(3) To perform factors determining the mangrove rice productivity.

5.2. Characteristics of mangrove rice farming

The mangrove rice ecologies, located on tidal estuaries that are near the ocean, are important rice growing environments. Mangrove swamps are characterized by high levels of salinity as a result of seawater intrusion brought by the ocean tides. About 84%

of the potential area is uncultivated; development is expected to be very slow for the following reasons: high cost of development, inadequate tools for development, long distance of swamps from villages making access difficult, shortage of labor, high cost of labor, etc.

Table 5.1 presents characteristics and information of rice varieties cultivated in the study area. Table 5.2 discusses about hired labor's activities. All these activities except weeding and ridges making, were also done by family labors. Others activities done by family labors include nursery, pulling up the nursery and threshing. Overall, these activities were performed manually due to the lack of animal power and mechanization.

Table 5.1: Information related to the type of rice varieties

Varieties	Varieties names	Characteristics	Duration (months)	Treated plots	Users (%)
Local	Balanta	*Resist to the salinity.	6	28.5	11 (27.5)
	Elhadjikhadheba	*Less inputs usually with organic	5	4	3 (7.5)
	Kaolaka	matter brought by ocean tides.	5	33	25 (62.5)
	Dissi	*Rotting after 24 hours unless	5	14	2 (5)
	Kalaya	improved varieties	6	3	2 (5)
	Samou	* Easy threshing	4	7	2 (5)
	M'bami		5	1	1 (2.5)
	Karea		5	24.5	13 (32.5)
	Makeni		5	3	3 (7.5)
Improved	Nankin 8	*Can't resist to the salinity.	3	3	1 (2.5)
	WAR 70	*Require more inputs usage	3	1	1 (2.5)
	ROK 5	(fertilizer and agrochemical).	4	3	2 (5)
	Caroline	*Weak adoption (more capital and	-	1	1 (2.5)
	CK 291	farmers are poors).	-	1	1 (2.5)

Source: Author's survey 2011

Table 5.2: Activities and farm labors forces

Activities	Hired labor (man)	Employment (days)	Man-days	Farmers
Plots preparation	60	97	5820	20
Ploughing	46	85	3910	17
Transplanting	15	11	165	5
Weeding	3	4	12	2
Ridges	4	3	12	1
Cleaning canal	2	28	56	2

Source: Author's survey 2011

5.3. Characteristics of mangrove rice farmers in the urban commune of Dubreka

The adoption of the rice varieties (local and improved) is materialized mainly into two groups. The first group represents 85% of farmers who cultivated only the local rice varieties and it is subdivided into 3 sub-groups (1L, 2L and 3L) according to the number of local varieties managed by farmers. The second group representing 15% of farmers who combine both local and improved varieties and it is sub-divided into two sub-groups (2L+1HY and 3L+1HY). The farmers' profile from the study area is presented in Table 5.3 based on the number of selected seed varieties. In terms of family labor forces, its average increases following the increase level of selected rice varieties. This factor seems to play an important decision for respondents to the adoption level of rice varieties. In relation to the average farming experience into the mangrove rice production, this factor also increases following the increase level of adopting seed varieties. Interestingly, the access to extension service indicated that more farmers are receiving the extension (Table 5.3); more they performed the highest average yield.

Table 5.3: Characteristics of mangrove rice farmers in the urban commune of Dubreka

Particulars	Selection level of local rice varieties			Local and improved rice varieties	
	1L	2L	3L	2L+1HY	3L+1HY
Number of farmers	20 (50%)	12 (30%)	2 (5%)	4 (10%)	2 (5%)
Head household's age (years)	56.90	59.67	58.00	58.50	67.00
Family size (household members)	11.90	13.00	20.00	20.50	17.00
Family labor (family workers)	5.25	6.00	11.00	9.00	12.00
Education level (schooling years)	3.70	5.75	9.00	10.75	7.50
Farming experience (years)	13.15	16.67	33.50	12.00	29.50
Access to credit (%)	15	25	50	0.00	50
Number of plots	1.85	4.17	3.50	5.00	13.00
Farm size (ha)	0.40	1.20	0.98	1.07	3.36
Average yield (t/ha)	1.39	1.74	1.67	1.69	2.20
Access to extension service (%)	40	83	50	75	100
Non-farm income (GNF)	4,725,000	9,416,667	5,580,000	6,000,000	4,100,000

Notes: 1L= one local variety, 2L= 2 local varieties, 3L= 3 local varieties, 2L+1HY= 2locals +1improved variety and 3L+1HY= 3locals +1 improved variety. Source: Author's survey 2011

5.4. Profitability estimation of the mangrove rice farming in respect to the selection of rice varieties

Based on this selection or combination of rice varieties by different farmers, an economic analysis has been performed in order to estimate the profitability of mangrove rice farming in the study area. The gross income [Note 5.1] (total production value) was seen as the function of the total production and prevailing markets price. The Variable Cost (VC) includes the cost of the following items: seed (improved and local), fertilizer [Note 5.2], agrochemical (pesticide and herbicide) and the hired labor. Among all inputs included under the average variable costs, the hired labor per hectare represents the highest variable input in terms of cost (77-97% of variable cost). In relation to the Gross Margin (GM) also called income above variable costs, it was higher to users of 2L, because their variable costs remain the lowest one among others; but have presented the highest net return per ha. The fixed cost was calculated based on the depreciation of farm equipment and tools owned by farmers. During the survey, each farmer has been asked about the purchased year of items he has declared.

Table 5.4: Profitability estimation per hectare of the mangrove rice selected varieties

Attributes	Selection level local rice varieties			Local and improved rice varieties	
	1L	2L	3L	2L+1HY	3L+1HY
1- Gross Income (A)=GI	2,089.3 (100)	2,613.5 (100)	2,510.1 (100)	2,527.6 (100)	3,303.1 (100)
Self-consumption (GNF)	1,563.5 (75)	2,013.2 (77)	1,720.0 (69)	1,945.4 (77)	2,158.0 (65)
Sold (GNF)/ha	179.2 (9)	241.1 (9)	462.1 (18)	215.9 (9)	630.3 (19)
Future seed (GNF)	137.6 (7)	112.7 (4)	77.0 (3)	113.5 (5)	184.5 (6)
Other share (GNF)	208.9 (10)	246.5 (9)	251.0 (10)	252.8 (10)	330.3 (10)
2- Variable Cost (B)=VC	769.3 (100)	277.0 (100)	563.6 (100)	1,214.8 (100)	1,256.3 (100)
Local varieties cost	18.8 (2)	5,6 (2)	0.0	48.4 (4)	77.9 (6)
Improved varieties cost	0.0	0.0	0.0	50.57 (4)	5.0 (0.4)
Fertilizer cost	1.7 (0.2)	1.5 (0.6)	13.3 (2)	0.0	20.6 (2)
Pesticide cost	3.5 (0.5)	2.8 (1)	69.1 (12)	50.2 (4)	5.9 (0.5)
Herbicide cost	0.0	0.0	0.0	35.9 (3)	176.5 (14)
Hired labor cost	745.2 (97)	267.0 (96)	481.1 (85)	1,029.8 (85)	970.4 (77)
3- Gross Margin (GM)=A-B	1,320.0	2,336.5	1,946.5	1,312.8	2,046.8
4- Fixed cost (FC)	398.3	194.0	124.3	197.4	295.0
5- Net Profit (NR)=GM-FC=A-TC	921.7	2,142.5	1,822.3	1,115.4	1,751.9
6- Total Cost (TC= B+FC)	1,167.6	470.9	687.9	1,412.2	1,551.2
7- Rate of income= (NR/A)*100	44.1	82.0	72.6	44.1	53.0
8- Benefit Cost Ratio (BCR=A/TC)	1.8	5.6	3.7	1.8	2.1

Note: Values in parentheses are percentage. Source: Author's field survey (March-April 2011)

The net return [Note 5.3] indicated that farmers involved in the mangrove rice farming were able to make positive returns to variable costs, showing that all types of selection of rice varieties are profitable as returns to variable costs were positive. In respect to the concept of Benefit Cost Ratio (BCR), this also referred to as profitability index and is defined as gross revenue divided by total costs of mangrove rice production. The higher the BCR is, the better the investment. Hence, the decision of combination of mangrove rice varieties by farmers revealed a greater benefit to users of local rice varieties. This can be achieved through reduction in cost of production as demonstrated by farmers combining local varieties (the 2L and 3L) and/or improvement in crop yield referred to farmers who selected 1 improved and 3 local varieties (3L+1HY).

5.5. Determinants of the mangrove rice production

In order to estimate the determinants of the mangrove rice production, a multiple linear regression model has been performed. The regression results reveal that the coefficient of multiple determinations (R^2) for the mangrove rice farming system is 0.932 indicating 93% of the total production variation which could be explained by predictors involved in the regression model. Overall, the results present a useful set of estimations for discussing the mechanism of rice productivity determination.

Table 5.5 showed that the cultivated area is a key factor in determining the mangrove rice production. This implies probably that the increase in one unit of farm size can be expected to increase the output.

Table 5.5: Determinants of mangrove rice production in the urban commune of Dubreka

Model	Regression coefficient	Std. Error	p-value
Constant	-289.168	517.426	0.580
X_1= Off-farm income per family members (GNF/number of persons)	-0.001	0.000	0.000***
X_2=Fertilizer cost per ha (GNF/ha)	0.015	0.017	0.386
X_3=Agrochemical cost per ha (GNF/ha)	0.012	0.003	0.001***
X_4=Opinions on type of irrigation systems (2=Highly receptive, 1=Receptive)	570.343	320.957	0.085*
X_5=Improved seed varieties usage (1=Yes and 0=No)	-1318.200	708.480	0.072*
X_6=Combination of seed varieties (1L, 2L, 3L, 2L+1HY and 3L+1HY)	40.312	23.294	0.093*
X_7=Selection of local varieties only (1L, 2L, 3L, 2L-1HY and 3L-1HY)	-128.569	224.847	0.572
X_8=Cultivated area (ha)	1252.532	181.112	0.000***

Notes: Dependent variable (Y) = total rice production (kg). R^2 = 0.932; Sig. =0.000; *** Significant level at 1% and * at 10%. Source: Author's field survey (March-April 2011)

The cultivated area has a direct bearing on the farmer's economic status, reflecting his capacity to buy and use required agricultural inputs and also other managerial decisions. Next, agrochemical usage (pesticide and herbicide) also has a positive relationship with the output. This implies that investing in the agrochemical may boost the production of the type of cultivated rice varieties. The reason is that the pesticide is applied against crabs which use to destroy the rice at the early stage just after the transplantation phase. Generally, farmers having plots located near inlets in the middle or upper estuaries, use the pesticide against crabs. The negative sign of the non-farm income per family size in this present study means it may be insignificant for accessing farm inputs needed or may oriented to other purpose such as the household consumption. The type of irrigation systems represents a determinant leading to a significant output. Farmers under the improved irrigation system stated that this system is highly receptive for the water control, but they noted land scarcity as limitation for the rice production. However, farmers under traditional irrigation faced many issues for managing both salty and fresh water. Hence, they are willing to get support for improving their irrigation type, as consequence, the land productivity was low, it also can be worsen during the salt water intrusion when hide tides occurred. The highest land productivity was found to farmers under the improved irrigation and adopting new technologies such as agrochemical and improved seed varieties. The negative sign of improved seed varieties can be explained through a poor inputs usage such as fertilizer application, the weakness of off-farm income per family members and probably due to the quality of these varieties or their ability to the salinity resistance. Therefore, the combination of both local and improved seed varieties was seen as significant determinant for mangrove rice productivity.

5.6. Summary

This chapter analyses the present status and determinants of mangrove rice production in Doboro and Dofily districts located the urban commune of Dubreka prefecture. In Guinea rice production is the staple food and the mangrove rice production represents the major crop production in the Maritime Guinea. The consideration of mangrove rice production in this chapter is based on the improvement of the socio-economic status of farmers involved in this farming type. Data were collected through field survey which was complemented by a field observation and group discussions. The sample size consists of 40 mangrove rice producers. The results indicated that the main purpose of this mangrove rice farming remains for self-consumption. The determinants of this farming system are the following: cultivated area, off-farm income per household members, agrochemical usage, type of irrigation systems, use of improved seed varieties and combination of local and improved rice varieties.

Notes

[Note 5.1] It was estimated by calculating and multiplying the total amount sold and those consumed and other orientations such as the future seed, gift, zakat in Muslim cases, etc., all by its market price. The average market price of different mangrove rice varieties was estimated at 1,500 Guinean Franc (GNF) per kg.

[Note 5.2] The inorganic fertilizer usage, in this mangrove rice farming system, remains very low. 92% of respondents do not apply the inorganic fertilizer. The main types of inorganic fertilizer namely urea and triple 17 were used by 8% of respondents. In general, farmers are satisfied with the organic matter, debris brought to the plots by the seawater under the influence of the tides.

[Note 5.3] The aim of any sustainable farm ventures should be to maximize its net returns in the long run and in a sustainable way. At the farm level, net income is affected by the level of production, farm price and operating costs. However, reduced production cost relative to farm productivity which gives rise to increase farm revenue are major steps to increasing net returns (Shang and Tisdell, 1997), this was demonstrated by 2L varieties adopters. Hence, the rate of farm income depends on the net return.

CHAPTER VI

SOCIO-ECONOMIC ANALYSIS OF SMALL-SCALE SALT PRODUCTION TECHNIQUES IN THE COASTAL AREA OF GUINEA: AS AN ALTERNATIVE FOR IMPROVING LIVELIHOOD STATUS AND SUSTAINABLE MANGROVE FOREST MANAGEMENT

6.1. Introduction

Salt production is a major driving force behind loss of mangrove forest in Guinea. In West Africa, salt is either produced by cooking or by sun-dried crystallization (Dacosta, R. and Sow M., 2009). The cooked salt consumes a considerable amount of wood from the mangrove while the sun-dried salt is less productive in the local communities. In Guinea, it is estimates that the production of 1 kg of salt requires 3.1 kg mangrove wood (Dacosta, R. and Sow M., 2009). Salt extraction from West African mangrove areas is widespread (Paradis, 1979; Vanden Berghen, 1984; Blasco, 1985; Bertrand, 1991).

To produce salt, the mangrove vegetation is removed in selected areas and the underlying soils are dug up to a depth of around 10 cm to facilitate evaporation. After a few days, the upper crusts are raked and scraped and, finally, collected into heaps for processing. These soils are leached several times with the same water and the saline solution is then boiled to obtain crystallized salt (Blasco, 1985). The firewood requirement is met by the neighboring mangroves. Hachimou (1993) has estimated that 1 m^3 of mangrove wood is required to produce 100 kg of salt. The environmental consequences of salt production in Benin, as in much of West Africa, include the formation of barren depressions in which the hydrological regime is modified; destruction of mangroves for firewood; compaction of the surface soil by repeated raking and trampling; and the creation of ecological conditions unsuitable for the recolonization of mangroves (Blasco 1985). Similarly, according to Paradis (1980) where there are long dry seasons, bare salty areas are formed and may further extended (e.g. in Senegal and Gambia) due to salt extraction. Even in more humid climates such as in Sierra Leone and Guinea, salt extraction has caused the formation of extensive denuded areas (Paradis, 1980; Bertrand, 1991).

The estimated demand of wood for salt production was defined based on a household survey in Conakry (Ministry of Planning and Cooperation, 1986: In Bah Maadjou, Report). The results showed that an average of 9 persons consume 61.5 kg of salt per year, or an average of 6.8 kg of salt per person per year. In rural and small town areas, the average estimated value was 5 kg per person per year. In 2008, given that 75% of the Guinean population consumes salt produced in the mangrove area, production for domestic use of the population could be estimated as 44,325 tons per year. Additionally, this production of salt for livestock and various others consumption were estimated at 30% of domestic needs (15,000 tons per year). Based on these estimates, the production of salt in Guinea was approximately 57,622.5 tons per year in 2008.

The traditional salt production is far the most widespread in the coastal area. It is by evaporation using heat generated by firewood. This traditional method is time consuming and environmentally detrimental. Due to its negative impact on the environment such as increasing deforestation and soil degradation, local organizations (*ADAM*, association for the development of agriculture in the mangrove area) and international NGOs (French non-governmental organizations *UNIVERS-SEL* and *Charente Maritime Cooperation*) introduced improved salt production techniques (Guinean saline and salt marsh). For over 15 years, *UNIVERS-SEL* operates on the coast of Guinea for the dissemination of appropriate on-farm technologies in the area on salt production (technical solar production) and traditional mangrove rice. In Coyah prefecture in 1999, *Charente Maritime* introduced an alternative sea-salt production technique using sun as the source of energy.

Hence, owing to the significant value of the interrelationship between livelihoods of coastal communities and environment, appropriate salt production techniques are required. It is pertinent to examine the most suitable and environment sustainable technique which can contribute to the livelihood improvement and conservation of mangrove forest. Under these circumstances it is vital to analyze the salt production techniques in the coastal area of Guinea. Therefore, this chapter aims:

(1) To examine the current status of salt production techniques;

(2) To examine the characteristics of small scale salt production in terms of socio-economics of producers, profitability of salt production and household resources endowments.

(3) To determine the contribution of salt production to household income

(4) To analyze the factors affecting the total revenue generated from salt production. The remainder of this chapter is organized as follows. The next section describes the status of salt production techniques followed by the empirical results and discussion. The final section presents the summary of the chapter.

6.2. Status of salt production techniques

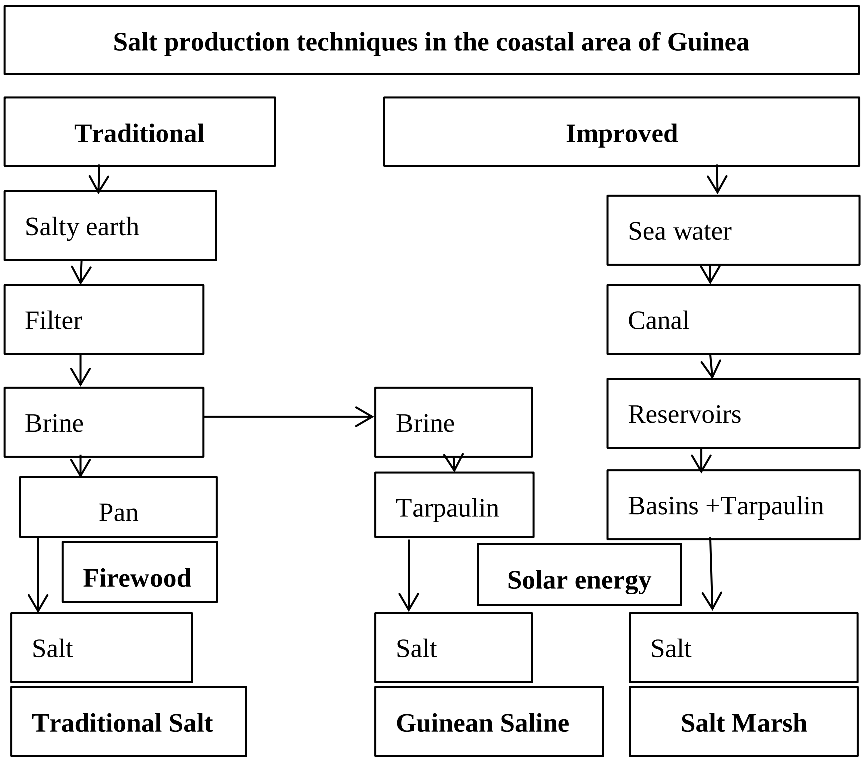

Figure 6.1: Flow-chart of salt production techniques in the coastal zone of Koba

Figure 6.1 describes three small scale salt production techniques: traditional salt production (TSP), Guinean saline (GS) and salt marsh (SM). TSP could encourage the deforestation and impact negatively on the livelihood due to the use of firewood. The GS is considered as mixed salt production because it involves half process of the TSP and other remainder process in the improved section of salt production. Both TSP and GS incorporate the use of salty soil and they could impact negatively on the environment. As the TSP causes increasing deforestation, the intensive exploitation of mangrove resources by the population has now reached a critical threshold. Therefore, extension activities of technical solar salt production on tarpaulin (canvas) have been initiated. The tarpaulin requires solar energy instead of firewood. Hence, SM and GS techniques could limit progressively the deforestation in both mangrove and upland forests, increase the total revenue from salt industry (e.g. Table 6.2) and place the SM and GS producers under better living conditions (e.g. Table 6.3).

6.2.1. Traditional salt production (TSP)

This TSP (Figure 6.1) is seasonal, practiced around four months, from February 15th to May 15th. The traditional salt production is based on evaporation under the action of heat. The salty earth is scraped and collected on the foreshore area or in a swamp drained. Collected salt crusts are gathered in the vicinity of operating sites. For the leaching stage, the collected salty earth is transferred into series of filters, which are then filled up with raw saline water. The downward seepage and infiltration of the raw saline water results in dissolution and leaching of the crystallized salts, as brine leachate, into the receiving containers (usually big plastic pot, hole, etc.) placed below the filters. The set-up can be either single or multiple filters. Periodic addition of more raw saline water maintains the continuous leaching process, until the concentration of the leachate is considered not much different from the infiltrating raw saline water. Then, the leached soil material is replaced with fresh salty earth and so the leaching process can continue again. The brine obtained by filtering the salty earth is poured into the pan. Its utilization is conditioned by the usage of wood gathered from the mangrove or upland forests.

6.2.2. Guinean saline (GS) or solar salt production on canvas or tarpaulin

As the traditional salt production causes increasing deforestation, the intensive exploitation of mangrove resources by the population has now reached a critical threshold. Therefore, extension activities of technical solar salt production on canvas (tarpaulin) have been initiated, as an alternative to the traditional salt production which consumes a lot of mangrove wood. As shown in Figure 6.1 the Guinean saline (also called mixed salt production) requires the purchase of tarpaulin (plastic sheet) which is a significantly lower investment than purchasing cooking bowls (pans). This technique requires a short support (in-situ saline school training) and making available tarpaulins to producers in the early years. The solar salt production frees producers from buying and/or collecting firewood and lightens the drudgery (by removing the cooking stage) leading to improved productivity. Once the brine is obtained by leaching the salty earth, it is poured into the tarpaulins and evaporation is carried out by the solar energy (Figure 6.1).

6.2.3. Salt marsh (SM) or sea-salt solar evaporation

For generations, sea-salt producers used mangrove wood to boil seawater for the extraction of salt. This traditional method is time consuming and environmentally detrimental. In 1999, the French non-governmental organization, Charente Maritime, introduced an alternative sea-salt production technique that uses the sun as the source of energy.

The salt marsh production is practiced for around six months from November to May. As illustrated in Figure 6.1, the sea water is collected in reservoirs and then filtered through a series of salt basins where, via evaporation and crystallization, salt crystals are deposited. These basins are always coated by tarpaulins allowing the storage of a significant volume of seawater. Producing salt from the sea, involves channeling sea water to flow into the basins and allowing the water to evaporate using wind and solar energy. The water evaporates from successive ponds until the brine is fully concentrated and salt crystallizes on the floor of the crystallizing ponds.

6.3. Characteristics of salt producers' groups

As indicated in Table 6.1, the mean and proportion of socio-economics variables were estimated in order to describe the characteristics of salt producers in the study area. The salt producers are grouped into three groups based on the salt production techniques. Table 6.1 shows that the mean of respondents' age was higher for salt marsh producers and all of them are male and 67.5% are migrants. The female participation in traditional salt production and Guinean saline was high with 88.6 % and 60.0% participation respectively.

In terms of family size, salt marsh producers have a large family with an average of 12.3 members. Despite the lower average daily working hours utilized by producers under salt marsh and Guinean saline, 7.1 and 8.8 hours per day respectively, their output (the number of harvested salt bags) was significantly higher than those using traditional salt production technique. This significant difference in output could be attributed to their access to improved materials such as the tarpaulin usage. This time saving on working hours has a significant impact on income generated from a secondary activity as it enables salt marsh producers to be involved in the mangrove rice production thereby enabling to earn an additional income as indicated in Table 6.1.

Table 6.1: Characteristics of salt producers' groups

	Variables	Traditional Salt Production (TSP)	Guinean Saline (GS)	Salt Marsh (SM)
Socio-economics	Age (years)	40.6 (2.24)	42.3 (1.10)	48.7 (1.10)
	Gender: 1= male (%)	11.4 (0.05)	40.0 (0.10)	100.0 (0.00)
	2= female (%)	88.6 (0.05)	60.0 (0.10)	0.0
	Origin: 1= native (%)	68.6 (0.08)	84.0 (0.07)	32.5 (0.08)
	2 = migration (%)	31.4 (0.08)	16.0 (0.07)	67.5 (0.08)
	Education level (years)	1.8 (0.47)	3.2 (0.73)	2.7 (0.46)
	Family size (persons)	9.9 (0.66)	9.9 (0.62)	12.3 (0.66)
	Active male children (persons)	2.0 (0.18)	2.6 (0.15)	2.2 (0.19)
	Active female children (persons)	1.3 (0.14)	1.5 (0.22)	2.1 (0.19)
	Active male adults (persons)	1.9 (0.25)	1.6 (0.10)	3.6 (0.27)
	Active female adults (persons)	2.1 (0.21)	1.6 (0.10)	1.8 (0.09)
	Salt production profit (10^3xGNF)	5,061 (746,768)	40,000 (614,589)	63,800 (4,451,140)
	Daily working time of salt (hours)	14.3 (0.10)	8.8 (0.09)	7.1 (0.17)
	Salt bags per season (number)	98.2 (5.61)	200.8 (3.10)	182.6 (12.50)
	Total salt bags sold (number)	96.2 (5.53)	198.8 (3.09)	179.2 (12.3)
	Unit price per bag (GNF)	124,714 (199.03)	200,000 (0.00)	365,000 (0.00)
	Profit from rice production (GNF)	0.0	0.0	9,007,079 (672,873.3)
	Upland firewood cost (GNF)	4,402,857	0.0	0.0
	Upland firewood transportation cost (GNF)	2,577,143	0.0	0.0
	Depreciation on pan (GNF)	29,619	0.0	0.0
	Depreciation on tarpaulin (GNF)	0.0	40,267	738,250

Note: values in parentheses are standard error. GNF= Guinean Franc

In the study area, the traditional salt production depends much more on the upland firewood where its costs are relatively significant (Table 6.1). Furthermore, traditional salt producers also invested significantly on the transportation of upland firewood. Since the ban of mangrove wood extraction in the salt production area in

2004; these producers moved to the upland forest for firewood collection. Therefore, the travelling distance from salt production campsite increased thereby increasing the firewood costs. On the other hand, producers under improved salt production techniques depend on the usage of tarpaulin instead of firewood and their salt production costs are relatively lower than traditional salt producers using pans which required the firewood.

6.4. Economic analysis of salt production

The economic analysis of salt producers was performed in order to measure their profitability based on the salt production techniques practiced in the study area. Table 6.2 indicates that the total revenue is significantly higher for salt marsh producers than the Guinean saline producers. Therefore, the total variables costs show that producers involved in the improved salt production spend less compared to traditional salt producers. The low cost can be attributed to many reasons among which none extraction of wood (e.g. Table 6.1) from upland or mangrove is significant as it leads to conservation of the mangrove and upland forests.

It is important to highlight the total variable cost which respect to each salt production technique. For the traditional salt production (TSP), its total variable costs include the labor cost of filter construction, transportation of salty soil, labor cost of firewood transportation and firewood cost. The total variable cost of the Guinean saline (GS) represents the labor cost for filter construction. Based on the salt marsh (SM), its total variable cost includes the following items: cleaning sludgy basins cost, cost of dikes loading, salt transportation cost and the labor cost of canal (5 km) digging for channeling sea water to flow into the basins. The cost of this final item is shared among 40 salt marsh producers involved in the SM technique. Additionally, as mentioned earlier, the time saving enable the salt marsh producers to earn a profit from the mangrove rice production. This profit was even greater than the salt profit realized by the traditional salt producers as shown in Table 6.2.

Table 6.2: Profitability estimation of salt production

Variables	**TSP**	**GS**	**SM**		**Overall**
	Traditional	Improved salt producers			Salt production cost per ton (GNF/T)
	Salt production			Mangrove rice production	
Average Total Revenue (A)	12,250,000	40,160,000	66,639,875	10,855,000	4,793,000
Average Total Variables costs (B)	7,070,029	19,200	1,615,883	1,684,313	642,056
Average Total Fixed costs (C)	119,371	116,093	1,259,374	163,608	78,978
Average Farm Management cost (B+C)	7,189,400	135,293	2,875,257	1,847,921	721,034
Gross Margin D=(A-B)	5,179,971	40,140,800	65,023,992	9,170,688	4,150,944
Income E=(D-C)	5,060,600	40,024,707	63,764,618	9,007,079	4,071,966
Income Ratio (E/A)*100 (%)	41.31	99.66	95.69	82.98	84.96

6.5. Household resources endowments

In order to assess whether the improved salt production techniques (GS and SM) could be considered as an alternative to the traditional salt production for improving livelihood status of small-scale salt producers and mangrove forest conservation; producers' resources endowments (condition of the house and household assets) were compared (Table 6.3). Generally, salt producers under GS and SM were far better off in terms of their housing conditions and household assets compared to those under the TSP technique. The usage of sheet metal as roof material was 44.0% and 87.5% for Guinean saline and salt marsh respectively while usage of cement as flooring was 32.0% and 92.5% respectively among the two groups.

The results also reveal that in terms of ownership of household items the improved salt producers (Guinean saline and salt marsh) are better off compared to the traditional salt producers. For example, the rate of rocket stove (representing an efficient wood cooker) utilization by salt marsh (sea-salt) producers was 75% while it was 16% and 11.4% with respect to the Guinean saline and traditional salt producers respectively. However, the rate of tripod usage, which consumes much firewood, indicated 88%, 82.9% and 27.5% respectively of traditional salt, Guinean saline and salt marsh producers.

Table 6.3: Resources endowment of salt producers

	Variables	Traditional Salt	Guinean Saline	Salt Marsh
Building materials	Roof: thatched (%)	100.0 (0.00)	100.0 (0.00)	17.5 (0.06)
	Roof: sheet metal (%)*	0.0	44.0 (0.10)	87.5 (0.05)
	Wall: thatched (%)	100.0 (0.00)	84.0 (0.07)	0.0
	Wall: wooden (%)	77.1 (0.07)	84.0 (0.07)	0.0
	Wall: mud (%)	51.4 (0.09)	16.0 (0.07)	0.0
	Wall: brick (%)*	0.0	32.0 (0.10)	100.0 (0.00)
	Floor: soil (%)	100.0 (0.00)	84.0 (0.07)	10.0 (0.05)
	Floor: cowpat (%)	5.7 (0.04)	16.0 (0.07)	0.0
	Floor: cement (%)*	0.0	32.0 (0.10)	92.5 (0.04)
Household assets	Refrigerator (%)*	0.0	0.0	0.0
	TV (%)*	6.0 (0.04)	0.0	2.0 (0.03)
	Bicycle (%)*	45.7 (0.09)	100.0 (0.00)	85.0 (0.06)
	Bike (%)*	17.1 (0.06)	40.0 (0.10)	67.5 (0.08)
	Car (%)*	0.0	16.0 (0.07)	17.5 (0.06)
	Radio (%)*	80.0 (0.07)	100.0 (0.00)	92.5 (0.04)
	Mobile phone (%)*	3.0 (0.03)	16.0 (0.07)	95.0 (0.03)
	Stove for charcoal (%)	65.7 (0.08)	40.0 (0.10)	37.5 (0.08)
	Rocket stove, efficient wood (%)*	11.4 (0.05)	16.0 (0.07)	75.0 (0.07)
	Tripod (%)	88.0 (0.07)	82.9 (0.06)	27.5 (0.07)

Note: values in parentheses are standard error.   * Convenient household resources

6.6. Contribution of salt production to household income

Table 6.4 presents how the salt production can be considered as an alternative livelihood. It presents the contribution of the different salt production techniques to the household income in the study area. The household income of salt producers derived from the following items: Net income from salt production (SP), the off-farm income, remittance provided by family members or relatives and income from mangrove rice cultivation (MRC). The net income from salt production (SP) remains the most significant component of the household income representing 68%, 98% and 86% for TSP, GS and SM respectively. The off-farm income of salt producers is not significant except producers under the TSP technique contributing 28% to the household income. This significant contribution can be attributed to fishing and other livelihood activities. With respect to mangrove rice cultivation, its contribution to the household income represents 12%. It was practiced only by salt producers under SM technique and the reason has been pointed out earlier (Section 6.3).

Overall the contribution of salt production to the total household income was 89% (Table 6.4). Followed by, the income from mangrove rice production which is 7% of household income. This is followed by the off-farm income which is 3% and finally, the remittance, from household members living outside and from relatives accounting for 1% of the household income.

Table 6.4: Contribution of salt production (SP) to the household income (GNF)

Items	TSP 35 producers	GS 25 producers	SM 40 producers	Total 100 producers
Income from SP	5,060,600 (68)	40,024,707 (98)	63,764,618 (86)	108,849,925 (89)
Off-farm income	2,117,314 (28)	391,200 (1)	612,300 (1)	3,120,814 (3)
Remittance	311,343 (4)	302,400 (1)	361,500 (0.5)	975,243 (1)
Income from MRC	0.0 (0)	0.0 (0)	9,007,079 (12)	9,007,079 (7)
Household income	7,489,257 (100)	40,718,307 (100)	73,745,497 (100)	121,953,061 (100)

Note: Values in parenthesis are percentage (%)

6.7. Factors affecting salt production in Koba using Quantile regression (QR)

Table 6.5 lists the estimated coefficients for age, origin, family size, total variable cost of salt production, land rent, daily working time in salt production, unit price per salt bag and profit from mangrove rice cultivation at the 25th, 50th, 75th and 95th quantiles. The OLS results are also listed for comparative purposes. All the OLS variables except for age, daily working time and profit from mangrove rice cultivation have a significant influence on total revenue of salt production. However, the results of different quantiles are worth special attention.

Table 6.5 shows that the effect of family size differs considerably, having a strong effect on the salt production at lower quantiles. The median and upper quantiles present similar effects on the salt production and even lower than the mean of OLS point estimate. In other words, this means that the effect of the family size decreases for the salt producers with higher revenue from salt production as also confirmed by graphs on Figure 6.2. All categories of household members (children and adults) are involved in the salt production, particularly producers under the traditional salt production composed by miscellaneous tasks such as: the salty soil collection, its transportation from the foreshore to the vicinity of operating sites, the brine preparation and its related sub-tasks, etc.

Table 6.5 indicates that the total variable cost has a positive impact on the salt production. When the quantile regression result is evaluated at the median and upper quantile (i.e. at the $q = 0.50$ and $q = 0.75$), the total variable cost appears to have significantly higher influence on the revenue of salt production but significantly lower at $q = 0.95$. The total variable costs differ according to the types of salt production techniques as shown earlier (Table 6.2). It indicated that salt producers under the improved salt production techniques (Guinean saline and salt marsh) are spending less compared to those under the traditional salt production technique. Hence, this contributes to increase the profit of salt producers using the improved techniques.

In terms of land rent, it has a negative impact on the revenue of salt production over selected quantiles as shown in Table 6.5. This negative impact on salt marsh producers is as a result of them being the only respondents paying rent for land due to salt marshes are under private ownership. Traditional and mixed salt (Guinean saline) practice salt production under area controlled by the state where land rent is not required. The profit generated from mangrove rice farming shows a positive effect at q = 0.25 and the median quantile (50th) on the revenue of salt production. This could be attributed to the use of tarpaulin, where the brine or sea water is poured, by improved salt producers. The adoption of tarpaulin shortens the daily working time and reduces the family labors determined by the family size. Salt producers practicing GS and SM used improved materials such as the tarpaulin (canvas) requiring the solar energy instead of the firewood.

Table 6.5: Quantile regression analysis of factors affecting salt production

Independent variables	OLS regression	Quantile regression			
		Q (0.25)	Q (0.50)	Q (0.75)	Q (0.95)
Age (years)	-0.0007	-0.0023	$-5.24e^{-06}$	$-1.08e^{-19}$	$-3.25e^{-18}$
Origin (1=native; 2=migration)	0.0574*	0.0230	0.0015	0.0378	0.0924***
Family size (number)	0.0226***	0.0275***	0.0133**	0.0132***	0.0133***
Total variable cost of salt (GNF)	$3.01e^{-08}$***	$1.81e^{-08}$	$3.39e^{-08}$***	$2.50e^{-08}$***	$6.01e^{-09}$*
Land rent (GNF)	$-6.35\ e^{-06}$***	$-7.13e^{-06}$***	$-6.16e^{-06}$***	$-4.55e^{-06}$***	$-2.58e^{-06}$***
Daily working time (hours)	0.0184	0.0466	0.00002	0.0096	-0.0036
Unit price per salt bag (GNF)	0.00001***	0.00001***	0.00001***	$9.50e^{-06}$***	$6.04e^{-06}$***
Profit from mangrove rice (GNF)	$8.69\ e^{-09}$	$1.88e^{-08}$*	$2.64e^{-08}$***	$2.76e^{-09}$	$-2.48e^{-09}$
Intercept	4.8768***	4.3546***	5.4376***	5.4628***	6.2613***

Note: Dependent variable = log revenue of salt production in monetary value (GNF=Guinean Franc); values in parentheses are t-statistics. *** Significance level at 1%, ** at 5% and * at 10%.

With respect to the unit price per salt bag, it indicates a positive and significant effect on the revenue of salt production over different quantiles as presented in Table 6.5. This unit price per bag depends specially on the salt production techniques and determines the quality of the salt. The salt produced by the improved techniques was of high quality due to lack of impurities. However, the salt produced by the traditional salt extraction technique had many impurities resulting from the usage of firewood collected from the upland forest. The improved salt production techniques do not require the usage of firewood. Traditional salt producers reported that the usage of mangrove wood could provide a better quality salt compared to the usage of firewood collected from the upland forest as the mangrove wood smokes less than firewood extracted from upland forest. Therefore, it is important to mention that the mangrove wood logging has been banned in the area since 2004. Additionally, Tijani and Loehnert (2004) indicated that the use of metallic boiling (pan) can cause metal pollution of salt due to the possible corrosive action of hot liquid brine.

A more comprehensive picture of the effect of the independent variables (Figure 6.2) on the response variable, log of the revenue of salt production has been performed to illustrate how the effects of independent variables vary over quantiles (percentiles) and how the magnitude of the effects at various percentiles differ considerably from the

OLS coefficient, even in terms of the confidence intervals around each coefficient. The results of graphs are shown in Figure 6.2.

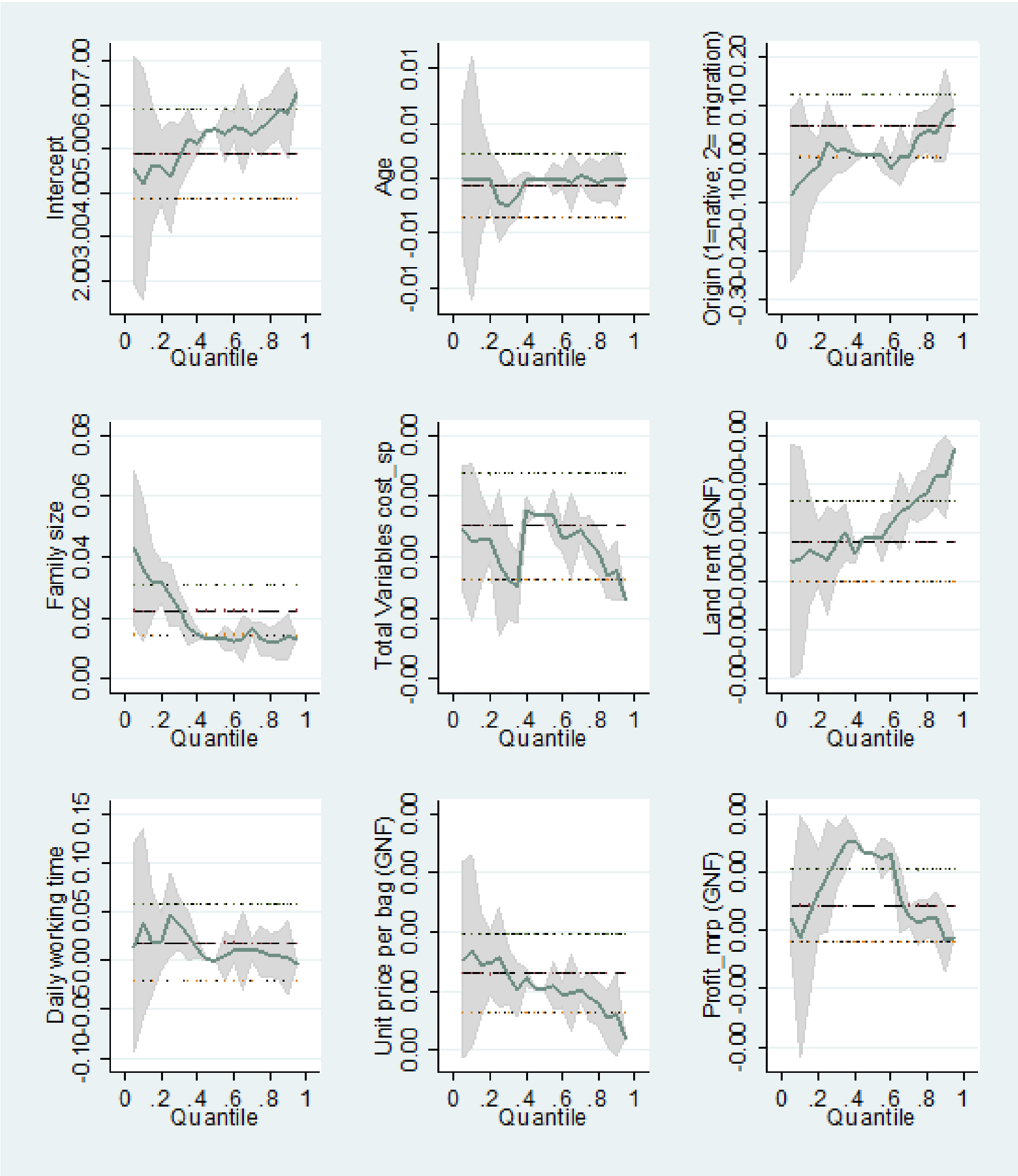

Figure 6.2: OLS and Quantile Regression Estimates for the revenue of salt production model

Figure 6.2 shows graphs where the quantiles of the dependent variable are on the horizontal axis and the coefficient magnitudes on the vertical axis. The OLS coefficient is plotted as horizontal line with the 95% confidence internals as two horizontal lines around the coefficient line. The OLS coefficient doesn't vary by quantiles. The quantile regression coefficients are plotted as lines varying across the quantiles with confidence intervals around them. If the quantile coefficient is outside the OLS confidence interval, then we have significant differences between the quantile and OLS coefficients. The quantile coefficients for the family size, origin, total variable costs, land rent, unit price per bag and profit of mangrove rice farming (independent variables) on the log of salt production (dependent variable) are significantly different from the OLS coefficients and vary over quantiles indicating the low and high tail distribution of the revenue of salt production.

Values of independent variables in Y axis (Figure 6.2) are similar to those shown in Table 6.5. The specific outcomes for using quantile regression (QR) rather than only OLS are shown in these graphs (Figure 6.2). The QR coefficient of each independent variable (except age and dairy working time) varies over different quantiles from 5% to 95% (but Table 6.5 selected just 4 percentiles) showing the distribution of the revenue from salt production. Hence, all variables exceeding the confidence interval of the OLS are significant.

6.8. Summary

The purpose of this chapter was to analyze three small-scale salt production techniques practiced in the coastal area of Guinea to examine the appropriate techniques for an alternative livelihood and sustainable mangrove forest management. Descriptive statistics, gross marginal analysis and quantile regression (QR) were used in the analysis. A sample of 100 salt producers was interviewed during March-April 2013. The results indicated that producers under improved salt production techniques (salt marsh and Guinean saline) obtained higher revenue from salt production with convenient household assets and better living conditions than traditional producers. Improved techniques required the use of tarpaulins which led to the decrease of cost of production. The traditional salt production required firewood collected from the upland and mangrove forests which resulted in deforestation of the mangrove forest.

The QR results revealed that the family size, total variable cost of salt, land rent, unit price per salt bag, origin of salt producers and profit from mangrove rice cultivation as the major factors affecting the total revenue from salt production in the study area. In order to enhance the livelihood of the coastal community and to conserve the mangrove forest this research suggests encouraging salt producers to adopt improved salt production techniques.

CHAPTER VII

PERFORMANCE OF SMALL-SCALE IMPROVED SALT PRODUCTION AND MANGROVE RICE PRODUCTION

(A) A stochastic Frontier Approach for Measuring Technical Efficiency of Small-scale Improved Salt Production in Guinea

7.1. Introduction

According to the Guinean Ministry of Planning and Cooperation, 1986, reported by Bah Maadjou, an average of 9 persons consume 61.5 kg of salt per year, or an average of 6.8 kg of salt per person per year. In rural and small town areas, the average estimated value was 5 kg per person per year. In 2008, given that 75% of the Guinean population consumes salt produced in the mangrove area, production for domestic use of the population could be estimated at 44,325 tons per year. In addition, production of salt for livestock and various others consumption were estimated at 30% of domestic needs (15,000 tons per year). Based on these estimates, in 2008, the production of salt in Guinea was approximately 57,622.5 tons. The analysis of small-scale salt production techniques (traditional salt production (TSP), Guinean saline (GS) and salt marsh (SM)) was conducted in the coastal area of Koba in Guinea.

The TSP is seasonal, practiced around four months, from February 15th to May 15th. The traditional salt production is based on evaporation under the action of heat. The salty earth is scraped and collected in the foreshore area or in a swamp drained. Collected salt crusts are gathered in the vicinity of operating sites. For the leaching stage, the collected salty earth is transferred into series of filters, which are then filled up with raw saline water. The downward seepage and infiltration of the raw saline water results in the dissolution and leaching of the crystallized salts, as brine leachate, into the receiving containers (usually a big plastic pot, hole, etc.) placed below the filters. The set-up can be either single or multiple filters. Periodic addition of more raw saline water maintains the continuous leaching process, until the concentration of the leachate is considered not much different from the infiltrating raw saline water. Then, the leached soil material is replaced with fresh salty earth and so the leaching process can continue again. The brine obtained by filtering the salty earth is poured into the pan. Its utilization is conditioned by the usage of wood gathered from the mangrove or upland forests.

The GS requires the purchase of tarpaulin (plastic sheet) which is a significantly lower investment than purchasing cooking bowls (pans). This technique requires a short support (in-situ saline school training) and making available tarpaulins to producers in the early years. The solar salt production frees producers from buying and/or collecting firewood and lightens the drudgery (by removing the cooking stage) leading to improved productivity. Once the brine is obtained by leaching the salty earth, it is poured into the tarpaulins and evaporation is carried out by the solar energy.

The SM is practiced for around six months from November to May. The sea water is collected in reservoirs and then filtered through a series of salt basins where, via evaporation and crystallization, salt crystals are deposited. These basins are always coated by tarpaulins allowing the storage of a significant volume of seawater. Producing salt from the sea, involves channeling sea water to flow into the basins and allowing the water to evaporate using wind and solar energy. The water evaporates from successive ponds until the brine is fully concentrated and salt crystallizes on the floor of the crystallizing ponds.

The improved salt production techniques (GS and SM) have revealed the importance of the adoption of tarpaulin (plastic sheet) in terms of earned profit, access to convenient household assets and better housing conditions. An improved living condition could limit the deforestation of mangrove and upland forests. The adoption of the improved salt production techniques resulted in the minimization of the total variable cost related to the salt production, which leads to high profits (Chapter VI). Thanks to the use of tarpaulin instead of firewood, improved techniques also shorten the daily working time. This time saving on working hours has a significant impact on income generated from a secondary activity as it enables salt marsh producers to be involved in the mangrove rice production, thereby earning an additional income (Chapter VI). Salt production using these improved techniques resulted in high quality salt, which was able to fetch a premium price. Therefore, in this study, only improved salt producers are considered for the efficiency analysis. Although there have been many studies on the technical efficiency of agricultural production in West Africa (Ekunwe et al., 2008, Ogundele and Okoruwa, 2004), however, there are no studies been conducted in West Africa, particularly in Guinea on the technical efficiency of salt production.

In the above context, the role of improved salt production techniques has drawn many questions and the objective of this study is to answer these questions. Whether improved salt producers in the Guinean coastal area are efficient? How significant is the loss due to the inefficiencies? In addition to investigating the level of technical efficiency, this paper also examines the factors determining the inefficiency of improved salt production industry in Guinea. A pre-requisite for enhanced efficiency is to identify the factors at the producer-level and other factors that affect the efficiency of salt production. Insights into these factors will enable the formulation of policies and strategies for enhancing salt production.

7.2. Descriptive statistics of variables

Table 7.1 provides descriptive statistics of variables used in the stochastic production frontier and the inefficiency effect model. The average value of output, revenue from salt production (Y_i), is 5.65x10^7 Guinean franc (GNF). The inputs represent labor cost, equipment cost, tarpaulin cost and dimension of basins. The first three inputs are valued per unit basis (GNF/kg) and the fourth input, the dimension of basin considered as the farm size is expressed in square meters (m^2). The dimension of basins ranges from 100 to 440 square meters (m^2) depending on the scale of referred salt production techniques.

In terms of farm specific variables, the mean distance from homestead to campsite (Z_1) of salt extraction represents 10.25 km. The land rent (Z_2) used as a dummy variable (0 equals to free and 1 equals to rental). Salt marsh (SM) producers (61.5%) rented the site of salt extraction. However, Guinean saline (GS) representing

38.5% extracted salt under area controlled by the state without charges. The age of the household head (Z_3) included as a proxy for farming experience to assess the effects of experience on technical inefficiency.

Table 7.1: Summary statistics of the study variables for salt production in Guinean coastal of Koba

Variable	Unit	Mean	Std. Dev.	Min.	Max.
Salt Production (SP) specific variables					
Revenue from SP (Y_i)	10^7xGNF	5.65	2.61	1.46	11.0
Labor cost (X_1)	GNF/kg	115.52	92.95	1.11	287.03
Equipment cost (X_2)	GNF/kg	107.10	99.05	6.60	463.83
Dimension of basins (X_3)	m^2	252.92	97.34	100	440
Tarpaulin cost (X_4)	GNF/kg	61.10	58.84	2.22	250
Farm specific variables					
Distance to campsite (Z_1)	km	10.25	8.29	0.04	25
Land rent (0=free;1=rental) (Z_2)	dummy	0.62	0.49	0	1
Age (Z_3)	years	46.2	8.71	28	60
Gender (1=male;0=female) (Z_4)	dummy	1.23	0.42	1	2
Education level (Z_5)	years	2.92	3.22	0	9
Family size (Z_6)	persons	11.48	3.96	5	18
Participation to activities (Z_7)	dummy	0.91	0.29	0	1
Membership in SP (1=yes;0=no) (Z_8)	Dummy	0.57	0.50	0	1
Unit price per salt bag (Z_9)	GNF	301,538.5	80,897.91	200,000	365,000
Off-farm income &Remittance (Z_{10})	GNF/family size	82,439.25	46,766.15	22,727.27	279,166.7

Salt operators averaged 46 years old. The gender participation in salt production (Z_4) also used as a dummy variable. The education level (Z_5) measured in terms of schooling years. It remains an indicator of a better level of education represents an advantage as it can form the basis for motivating producers to adopt the improved salt production techniques. Family size (Z_6) averaged 11.5 members ranging from 5 to 18 persons. This variable is an indicator of family labor availability. The participation of salt producers to activities organized by local and/or international NGOs (Z_7) considered also dummy variable. This reflects salt producers' access to institutions for training or sensitization such as mangrove protection. Membership in salt production (Z_8) is also considered as a dummy variable (1 = membership and 0 = otherwise). The unit price per salt bag (Z_9) depends on the salt production technique which determines the quality of the salt (Chapter VI). Based on this, its price varies from 200,000 Guinean Franc (GNF) for GS producers to 365,000 GNF for SM producers. The off-farm income and remittance (Z_{10}) is considered in monetary value per family size. According to Chapter III and Chapter VIII; off-farm income is the income earned from regular and casual employment of the household members. And remittance represents an amount transferred from absent family members and from relatives living in other cities in Guinea or abroad.

7.3. Stochastic frontier production

Table 7.2 presents the estimated coefficients for the frontier model. Both estimates parameters of ordinary least squares (OLS) and maximum likelihood estimate (MLE) methods were used. The MLE method is more representative of the data set for improved salt producers compared to the OLS method. The results of the stochastic frontier production function estimates are shown in Table 7.2. The production elasticity of improved salt production conducted by salt producers under Guinean saline (GS) and salt marsh (SM) is positive and significant as expected. The labor cost elasticity is positive and highly significant. Hence, the increasing investment by one percent on labor could raise the salt production by 26 % (Table 7.2). Investment in labor could bring a significant improvement in performance of salt production. This implies that investment in labor remains an important contributor to the improvement of technical efficiency in salt production practiced in the Guinean coastal zone. The elasticity of equipment cost presents a negative sign and it's not statistically significant. The tarpaulin cost is significant and its elasticity is negative. This could be explained by the poor quality of the canvas sheet (tarpaulin). Dimension of basins is also positive and statistically significant. This implies that the size of basin contributes to the revenue from salt production.

The overall technical inefficiency effects are evaluated in terms of the parameters associated with σ^2 and γ (Alam et al. 2012). The estimate for the variance parameters σ is significantly different from zero at one percent level (Table 7.2). This indicates statistical confirmation of our presumption that there are differences in Technical efficiency (TE) among the improved salt producers belonging to GS and SM production techniques. The gamma value (γ) of the MLEs of stochastic frontier production model is 0.995 (Table 7.2). This value is statistically significant at the 1 % level, implying that 99.5 % of variability of revenue from salt production is attributed to technical inefficiency in salt production techniques. And the rest (0.5 %) is due to random noises. This also confirms that the application of the stochastic frontier function model is appropriate for this study. Moreover, the presence of technical inefficiency was tested by the Likelihood Ratio (LR) test. The null hypothesis (H_0) implies that gamma value is equal to zero. In other words, variations of salt production revenue are due to random noises or stochastic frontier model is inadequate. Alternative hypothesis (H_1) implies that gamma value is different from zero or the application of the stochastic frontier model is adequate. LR test has a mixed chi-square (${x^2}_R$) distribution with R equal to restrictions in the model. According to statistic principles, the null hypothesis (H_0) will be rejected if LR test is greater than critical chi-square value table. Table 7.2 shows that LR value is 88.89. And the critical chi-square value (${x^2}_{(1\%,R)}$) is equal to 21.67 (obtained from Kodde & Palm, 1986). As explained above, LR test is greater than critical chi-square value. Therefore, the null hypothesis (H_0) is rejected. It means that surveyed salt producers in the study area were not fully technically efficient.

Table 7.2: Parameter estimates of the stochastic frontier analysis

Variables and Parameters		OLS estimates			ML estimates		
		Coeff.	std error	t-ratio	Coeff.	std error	t-ratio
Constant	β_0	-0.027	1.980	-0.013	1.052***	0.303	3.475
ln(Labor cost/kg)	β_1	15.673***	0.979	16.010	26.070***	0.840	31.027
ln(Equipment cost/kg)	β_2	0.011	0.042	0.259	-0.005	0.008	-0.620
ln(Dimension of basins (m^2))	β_3	0.447	1.117	0.401	0.448**	0.185	2.413
ln(Tarpaulin cost/kg)	β_4	-0.075	0.110	-0.679	-0.068***	0.021	-3.246
Variance parameters							
Sigma squared	σ^2	7.108			7.010***	1.539	4.555
Gamma	γ				0.995***	0.005	209.795
LR test					88.89		
log likelihood function		-153.370			-108.926		

Note: ***: significant at 1%, **: significant at 5%

7.4. Estimation of technical inefficiency

In addition to the analysis of technical efficiency, determinants affecting on technical inefficiency of salt production revenue were estimated. The maximum likelihood estimates (MLEs) for parameters of the technical inefficiency model are presented in Table 7.3. The estimated coefficients of the explanatory variables in the model for the technical inefficiency effects are of interest and have important implications as revealed in Table 7.3.

The impact of distance from the homestead to campsite is negative, but not significant implying that more salt producers are closed to the campsite more technically efficient they are in terms of salt production. The land rent considered as dummy variable is also negative and significant. Salt marsh (SM) producers were the only respondents paying rent for land due to salt marshes are under the private ownership. However, Guinean saline (GS) producers extract salt under area controlled by the state where land rent is not required. With respect to the age of the householder, it is considered as a proxy for farming experience to assess the effects of experience on technical inefficiency. The age coefficient indicated that the younger farmers were more efficient than the older ones (Table 7.3). This finding confirmed the results of previous studies conducted by Battese and Coelli (1995), Mathijs and Vranken (2000) and M. Bozoglu, V. Ceyhan (2007). Gender participation in salt production has a positive sign and significant effect on technical inefficiency in salt production. Also, education level presents an insignificant effect on technical inefficiency.

The variable of family size is negative and statistically significant. This implies that large family size is technically efficient than small family size. The coefficient of salt producer's participation in activities organized by local and/or international NGOs has a significant effect on technical inefficiency. This participation implies that producers are gaining knowledge and skills in sustainable use of resources for salt production. Another outcome of the inefficiency model was the negative and significant effect of membership in salt production which implied that belonging to a given group of salt production could enhance the technical efficiency of salt producers. This implies that members in salt production are technically efficient than non-members. The unit price per salt bag is negative has no significant effect on technical inefficiency (Table 7.3). The unit price per bag depends on the salt production techniques and determines the quality of the salt (Chapter VI). The salt produced by the improved techniques was of high quality as it lacked impurities. This study shows that the off-farm income & remittance (OFIR) per family member is not negative thus, not contributing to technical efficiency.

Table 7.3: Parameter estimates of the technical inefficiency model of salt production

Variables	Parameters	Coefficient	Std. error	t-ratio
Constant	(δ_0)	-12.172***	3.036	-4.008
Distance to campsite (Km)	(δ_1)	-0.133	0.147	-0.902
Land rent (0=free; 1=rental)	(δ_2)	-4.291*	2.421	-1.773
Age (years)	(δ_3)	5.459**	2.448	2.230
Gender (1=male; 0=female)	(δ_4)	0.00024***	0.00004	5.910
Education level (years)	(δ_5)	0.00002	0.00001	1.611
Family size (number of persons)	(δ_6)	-2.625**	1.308	-2.007
Participation in activities (1=Yes; 0=No)	(δ_7)	-3.658**	1.805	-2.027
Membership in salt production (1=Yes; 0=No)	(δ_8)	-29.013***	6.049	-4.796
Unit price per salt bag (GNF)	(δ_9)	-1.541	2.438	-0.632
OFIR per family member (GNF/family size)	(δ_{10})	16.381**	6.547	2.502

Note: ***: significant at 1%, **: significant at 5%, *: significant at 10 % level, OFIR = Off-farm income and remittance

7.5. Hypothesis test

Tests of null hypotheses associated with the models were carried out using the likelihood ratio (LR) statistics and the results are presented in Table 7.4. The first null hypothesis,$H_0: \gamma = \delta_0 = \cdots = \delta_{10} = 0$, i.e., that inefficiency is absent from the model, is strongly accepted. This implies that the mean response function is an adequate representation of the data for the improved salt production. The second null hypothesis, $H_0: \gamma = 0$, which specifies that the inefficiency effects are not stochastic, is rejected. So, we do not accept the null hypothesis that there was no technical inefficiency. The parameter γ is estimated to be 0.995 (Table 7.2) indicating that 99.5 % of inefficiency is due to the salt producers' own decision and the remaining 0.5 % is due to the factors outside the control of the producers. The parameter γ also reflects that the inefficiency effects are highly significant in the analysis of improved salt production.

The third null hypothesis considered in the model, $H_0: \delta_0 = \cdots = \delta_{10} = 0$, i.e., that the coefficients of the explanatory variables in the inefficiency models are simultaneously zero, is accepted. This indicates that all ten explanatory variables considered in the model did not make a significant contribution in the explanation of inefficiency effects associated with the value of output. The last null hypothesis considered, $H_0: \delta_1 = \cdots = \delta_{10} = 0$, i.e., that the coefficients of the variables in the model for inefficiency effects are zero, is also accepted. It reflects that all the coefficients of the explanatory model are not significantly influenced by the following variables: distance from the homestead to campsite, land rent, age, gender, education, family size, participation in activities organized by local and/or international NGOs, membership in salt production, the unit price per salt bag and off-farm income & remittance per family member.

Table 7.4: Generalized likelihood ratio (LR) tests

Null hypotheses	Log likelihood	LR ($\boldsymbol{\lambda}$)	Critical value	Decision
1. $\boldsymbol{H_0: \gamma = \delta_0 = \cdots = \delta_{10} = 0}$	81.15	-380.16	17.61	Accept H_0
2. $\boldsymbol{H_0: \gamma = 0}$	-225.40	232.94	28.86	Reject H_0
3. $\boldsymbol{H_0: \delta_0 = \cdots = \delta_{10} = 0}$	14.86	-247.58	9.50	Accept H_0
4. $\boldsymbol{H_0: \delta_1 = \cdots = \delta_{10} = 0}$	83.35	-384.56	17.61	Accept H_0

7.6. Technical efficiency distribution in salt production

The result derived from the ML estimates show technical efficiency (TE) indices range from 0.00 to 0.92 with a mean value of 0.27 (Table 7.5). This means that for an average efficient salt producer to achieve the technical efficiency level of its most efficient counterpart he could realize about $(0.92 - 0.27/0.92)$ savings in cost or increase in production. This gives about 70.65 % increase in production or cost saving. The least efficient salt producer can now save a cost or increase in production of 100 %.

$(0.92 - 0.00/0.92)$ to achieve the required technical efficiency of the most efficient producers in the study sample.

To provide a better indication of the distribution of TE, a frequency distribution of the predicted TE is presented in Table 7.5. Among the salt producers 61.54 % are producing at less than 30 % efficiency level while 23.08 % of salt producers have TE of above 0.69 which is an indication that both improved GS and SM salt producers still remain inefficient.

Table 7.5: Frequency distribution of technical efficiency estimates

Efficiency level (%)	Number of salt producers	Percentage (%)
≤ 30	40	61.54
30 ~ 39	2	3.08
40 ~ 49	3	4.62
50 ~ 59	4	6.15
60 ~ 69	1	1.54
70 ~ 79	8	12.31
80 ~ 89	4	6.15
90 ~ 99	3	4.62
Total	65	100
Mean efficiency	0.27	
Minimum	0.00	
Maximum	0.92	

7.7. Loss due to inefficiency and potential output

The potential output as well as loss of output is estimated by dividing the actual output by the mean technical efficiency, whereas the output forgone (loss due to inefficiency) is the difference between the potential output and the actual output (Mor and Sharma, 2012). Table 7.6 presents an account of the potential as well as the output forgone in improved salt production in the coastal area of Koba in Guinea. These improved salt producers on average loose output worth of 601,024 Guinean francs per basin (GNF/basin) seasonally solely due to the technical inefficiency. This can be regained by way of better utilization of resources which are at the disposal of the salt producers.

There are three possible ways to increase salt production in the coastal area of Guinea. Firstly, by allocating more land, secondly by developing and adopting new technologies and thirdly by utilizing the available resources more efficiently. The third option of using available resources more efficiently is the most viable approach. This implies that increased salt production hinges upon the improvement of productivity, i.e. yield per unit area. It is generally believed that resources in the agricultural sector, especially in the developing countries are being utilized inefficiently.

Table 7.6: Estimated potential output and output for improved salt production

Technical efficiency	Improved salt producers
Actual output (GNF/basin)	222,296.56
Potential output (GNF/basin)	823,320.59
Loss due to inefficiency (GNF/basin)	601,024.03

7.8. Discussion

As salt production is a major driving force behind the loss of mangrove in Guinea, an understanding of the improved techniques of salt extraction and its efficiency is vital for the mangrove conversation along the Guinean coastal area. The measurement of technical efficiency of salt producers adopting the improved salt production techniques was estimated using the stochastic frontier analysis. These improved techniques rely on the sun for energy instead of mangrove wood.

The results of the maximum-likelihood estimates show that labor cost, dimension of basins and cost of tarpaulin are significant but positive for the first two variables. This implies that hiring labors and the size of basins have a crucial role in the performance of salt production in Koba. The hired labor costs mainly include: digging the canals from which the seawater is channeled to a complex system of reservoirs; levelling the surface of basins. When the levelling is not done properly, it could produce a poor drainage of water to the series of basins. The dimension of basins represents the plot size from where salt is extracted. The negative sign of the tarpaulin or canvas (plastic sheet) reflects its poor quality. Our field investigation revealed that after the evaporation of water from the basins, salt producers collected the crystals by brushing up. This practice easily damages the plastic sheet. Most of salt producers stated that these sheets are very expensive in the open market. Presently, they use sheets provided by NGOs on credit. This credit is settled after the salt harvest in terms of the produce (salt).

As the tarpaulin, the equipment cost has also a negative sign. This demonstrates that the type of materials used with improved salt production techniques in the Guinean coastal area of Koba still remains outdated. For this reason, all stakeholders involved in the salt industry, including the Government of Guinea (GOG) are required to put more efforts in order to shift from the present so called “improved salt production techniques” to a more efficient level. This strategy will help to conserve natural resources and preserve the environment, while minimizing the environment impact of seawater use.

In addition to the maximum-likelihood estimates of the scholastic frontier, the estimated coefficients of the explanatory variables in the model for the technical inefficiency effects are also of particular interest and have important implications. Interestingly, the dependent variable of the inefficiency model, u_i from Equation 2**,** is defined in terms of technical inefficiency; a producer-specific variable associated with the negative (positive) coefficient will have a positive (negative) impact on technical efficiency. Hence, results from Table 7.3 show that land rent, family size, participation in activities and membership in salt producer organizations are significant determinants of technical efficiency (negative impact on the technical inefficiency). The distance from the homestead to the campsite and the unit price per salt bag were negative but not statistically significant. In contrast, age of the household's head, gender, off-farm income and remittance (OFIR) per family member and education have positive signs and statistically significant except the variable, education level.

The land rent has a positive and significant effect on the technical efficiency in the improved salt production technique. Salt marsh (SM) producers were the only respondents paying rent for land due to salt marshes are under the private ownership. However, Guinean saline (GS) producers extract salt from areas owned by the state where land rent is not required to be paid. Interestingly, the area where land rent is required was far from the sea and no inlets of sea were found around it. This area could be exempt to the flood limiting the processes of the salt production.

The family size has a significant influence on technical efficiency. The implication of this result is that large household size would have positive impact on the efficiency of salt production. This suggests heavy reliance on family labor since family members are expected to provide a significant contribution to the labor force. This finding is in line with Msuya et al. (2008), where it was found that family size has a negative and significant effect on technical inefficiency in maize production.

Participation in the activities initiated by both local and international NGOs has a positive effect on the technical efficiency of salt production. This reflects producers' access to institutions for training or sensitization about the mangrove conservation. The implication of this result is that participants are highly efficient than non-participants. The membership in salt producer organizations has also negative and significant effect on the technical inefficiency (positive and significant effect on the technical efficiency) of salt production. This implies that members in salt production are more efficient than non-members. Both members and non-members in salt producer organizations should be encouraged to participate in activities organized by organizations mentioned above. The focused group conducted during our field investigation found that these members were more informed in terms of the impact of salt production on the mangrove environment. This would be vital if more producer groups are formed to mobilize collective efforts of the producers. Chapter IV also highlights the importance of membership in the farmers' organization for sustainable agriculture in terms of mitigating land use transition in Dubreka prefecture in Guinea.

7.9. Summary

Salt production is a major driving force behind the loss of mangrove in Guinea. As the traditional salt production causes increasing deforestation, the intensive exploitation of mangrove resources has now reached a critical threshold. Therefore, improved techniques using sunlight as the source of energy has been introduced as an alternative to the traditional salt production techniques which consumes a significant amount of mangrove wood. Therefore, it's of interest to examine the efficiency of the new salt production technique, in this an attempt is made to determine the technical efficiency of salt producers adopting the improved techniques by using the stochastic frontier analysis method. The study used primary data collected through a survey. A sample of 100 salt producers was interviewed during March-April 2013. However, this chapter considers only 65 producers using the improved salt production techniques along the Guinean coast in Koba, particularly in Balessourou district.

The results revealed that labor cost and dimension of the basins contribute to enhance the performance of salt production in terms of revenue earned. Inefficiency model indicated that membership in salt producer organizations, producers' participation in activities organized by local and/or international institutions; family size and land rent significantly influenced technical inefficiency. Results also highlighted the fact that even the best producers were inefficient. The mean level of their technical efficiencies was estimated at 27 %, while the efficiency ranged from 0.0 % to 92 %. In addition, the estimation of the loss due to the inefficiency occurring seasonally was significant and valued at 601,024 Guinean francs per basin. In order to improve the efficiency of salt production, this study advocates some strategies such as coating basins for minimizing the loss of salt during extraction, encouraging producers' participation in activities organized by the government and its partners and strengthening producers' organizations to enhance producer participation in salt production.

(B) An analysis of technical efficiency of mangrove rice production in the Guinean coastal area

7.10. Introduction

Mangrove rice cultivation began in the middle of the eighteenth century in Sierra Leone and Guinea (CEC, 1992). Traditional cultivation practices are still the most widespread and they are followed, for example, in Senegal (the diola system), Guinea Bissau (the bolanha system), Guinea (the Bora-male) and Sierra Leone. The diola and bolanha systems consist of small basins or strips of land that are surrounded by small dikes. Within these “*polders*” the rice is cultivated on ridges. The tidal rice-cultivation system practiced in the Gambia, Guinea and Sierra Leone consists of flooded rice cultivation during the seasonal period of fresh-water flows of the major rivers. The system is tied to the length of the salt-free period. In order to reduce production risks, both the salt-free period and the rice variety should be appropriate. For over 100 years, swamp rice production in West Africa has been undertaken by farmers with limited inputs under adverse saline and acid sulphate conditions. However, some of the fertile soils have been benefited by regular deposits of silt left during annual flooding. The

Maritime Guinea or Lower Guinea extends 300 kilometers along the coast and covers an area of 47,400 km^2, making it the largest in the West Africa (GRG, 2002).

In Guinea, the coastal lands play a key role in the national food security in terms of agricultural production focused on the mangrove rice farming and over one-third of the country's population live in coastal lands. The promotion of rice growing is one of the priorities of agricultural policy in Guinea (MAL, 2009). Rice is the most important food crop and its production is the most organized crop production system in the country. In 2000, rice production covered 42 % of the total farmland (about 700,000 hectares) for a total production of 700,000 tons of paddy (Barry, 2006). In 2003, the local rice sector generated about 340 billion Guinean francs (GNF) ($67 million), which accounted for 5 % of the gross domestic product. Prior to the 1950s Guinea was the third largest rice producer in Africa, after Egypt and Madagascar (Portères, 1966).

In Guinea, rice cultivation is practiced under four majors cropping systems. These cropping systems were described earlier in Chapter IV, section 4.1. Guinea was self-sufficient in rice and exported a surplus to other countries in West Africa. In recent years, population growth (3.1 % per year) has threatened Guinea's food security. Despite a doubling in production over the past decade, to 1.47 million tons in 2009, rice is now imported to meet the rising demand. Imports were estimated at 44 % of the national rice demand in 1995, falling to 25 % in 2000 and rising again to 40 % in 2002 (MAEF, 2007a). To increase food security, the Guinean government plans to introduce rice cultivation on 25,000 more hectares in favorable areas of Lower and Upper Guinea (MAEF, 2007b). It is aimed to boost the production to 2.5 million tons by 2015. To achieve this, the government collaborates with international partners, invests in roads, bridges and dykes and supports the dissemination of new technologies, such as improved rice varieties and yield-enhancing farming practices.

In Guinea, the national rice consumption exceeds rice production, leading to concerns about food security. Thus, recent governmental measures have been directed to promoting the rice production, particularly in the coastal areas, the only zone where the mangrove rice production is practiced. The government of Guinea (GOG) is supported by many partners, e.g., AFD (French Development Agency), through financing projects that focused on capacity building and rice grower participation in this farming system. In the above context, the status of mangrove rice production has received extensive attention among policy makers and donors.

Technical efficiency in production is defined as the ability of the farmer to produce at the maximum output (frontier production), given the quantities of inputs and production technology (Aigner, *et al.* 1977). Production efficiency is concerned with the relative performance of the process used in transforming inputs into output. The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources or certain level of output at least-cost. The greater the ratio of production output to the factor input, the greater the magnitude of technical efficiency and vice versa. This definition of technical efficiency implies that differences in technical efficiency between farms exist. Variation in technical efficiency of producers might arise from managerial decisions and specific-farm characteristics that affect the ability of the producer to adequately use the existing technology.

However, there is scanty published literature available on aspects of mangrove rice production in Guinea (Adesina & Zinnah, 1993, Adesina & Baidu-Forson, 1995, Chapter IV, V and VIII), encouraging us to empirically examine important aspects of mangrove rice production. Some of the research questions addressed in this study are; how efficient are mangrove rice farmers in the Guinean coastal area? How significant is the loss due to the inefficiencies? What are the factors determining the inefficiency of the mangrove rice production in Guinea. A pre-requisite for enhanced efficiency is to identify the factors at the farmer-level and other factors that affect the efficiency of mangrove rice production. Insights into these factors will enable to come up with effective policies and strategies for enhancing sustainable mangrove rice production. The implication is that there is a scope to increase output from existing farm areas if the efficiency of mangrove rice production is improved. Since increased output and productivity are directly related to production efficiency, the study becomes imperative, as it would identify factors that influence technical efficiency in the mangrove rice production system among farmers. The identification of those factors, which influence the level of technical efficiency, is a valuable exercise because the factors are significant for policy formulation.

7.11. Descriptive statistics of variables

The average value of mangrove rice production is higher among IMR farmers, almost twofold of the average value of production by the SM and TMR farmers (Table 7.7). As expected, farmers under improved mangrove rice farming (IMR and SM) have presented a higher average of total production value than those practicing the traditional mangrove rice (TMR) cultivation. The highest production by IMR farmers can be attributed to the irrigation facility which enables them to manage appropriately the water level and start the rice planting from the beginning of the rainy season.

According to Carr (2013) [Note 7.1], among the issues concerning with the future welfare of the African continent and its people pertains to the farm size. Many argue that lands should be left in the hands of large scale commercial farmers or a multitude of smallholders. However, experiences from Japan, China, and elsewhere in Asia show us that farm size is not the key determinant of productivity. These farmers obtain levels of productivity per unit area of land which are equal or greater than those achieved by large-scale farmers anywhere in the world. The key to their success is not the size of their land holding but their access to intensive farm inputs and particularly to inorganic fertilizer. This in turn is largely dependent upon the availability of subsidies. In the case of East Asia, subsidies are of a similar level to those provided to European farmers. The comparatively low yields of staple food crops obtained from small-scale farms in Sub-Saharan Africa are not a direct result of the size of their farms, but rather that they only have access to about 5 % of the level of fertilizer per unit area of land as compared to their East Asian counterparts (Carr, 2013).

The mean value of both fertilizer and/or pesticide cost per farm area is statistically significant at the 1 % level. SM farmers have invested more on both fertilizer and pesticide. The mean and maximum of these inputs costs show higher values 2,678,254 and 1.10×10^7 GNF respectively. As these SM farmers were also practicing the improved salt production and obtaining significant income from it.

Table 7.7: Summary statistics of the study variables for mangrove rice production

Variables and units			SM	IMR	TMR	Total	p-value
Total production value	Guinean Franc (GNF)	Mean	10,855,000	19,611,111	9,896,250	11,719,202	0.000***
		Std. Error	752,772	928,999	1,663,757	752,219	
		Minimum	4.20×10^6	1.62×10^7	2.85×10^6	2.85×10^6	
		Maximum	1.88×10^7	2.30×10^7	2.78×10^7	2.78×10^7	
Fertilizer and pesticide cost per farm area	GNF/acre	Mean	2,678,254	810,241	512,998	1,806,989	0.000***
		Std. Error	332,622	215,468	288,153	244,410	
		Minimum	28,340	43,725	1,336	1,336	
		Maximum	1.10×10^7	1.84×10^6	4.22×10^6	1.10×10^7	
Hired labor cost per farm area	GNF/acre	Mean	644,980	236,167	550,808	564,360	0.053*
		Std. Error	40,280	49,355	166,261	55,483	
		Minimum	242,915	20,243	30,364	20,243	
		Maximum	1.13×10^6	384,615	3.02×10^6	3.02×10^6	
Depreciation cost on farm tools per farm area	GNF/acre	Mean	78,927	28,579	59,961	66,862	0.012**
		Std. Error	8,376	3,493	8,708	5,823	
		Minimum	8,097	19,501	12,146	8,097	
		Maximum	177,463	45,187	154,656	177,463	
Seed quantity per farm size	Kg/acre	Mean	96.24	46.30	42.67	74.20	0.000***
		Std. Error	8.06	7.59	5.75	5.92	
		Minimum	40.49	20.24	11.74	11.74	
		Maximum	202.43	75.91	121.46	202.43	
Active family labors per family size	percent	Mean	79.64	69.01	63.75	73.65	0.000***
		Std. Error	1.37	5.23	4.14	1.79	
		Minimum	61.11	45.45	33.33	33.33	
		Maximum	100.00	88.89	93.33	100.00	
Farm area under mangrove rice cultivation	acre	Mean	2.44	6.31	7.60	4.44	0.000***
		Std. Error	0.18	0.43	1.05	0.43	
		Minimum	1.24	4.94	1.24	1.24	
		Maximum	4.94	7.41	14.82	14.82	
Age of household head	years	Mean	48.65	48.00	48.10	48.41	0.959
		Std. Error	1.10	3.39	2.16	0.98	
		Minimum	36.00	32.00	29.00	29.00	
		Maximum	60.00	67.00	67.00	67.00	
Education level	years	Mean	2.73	0.89	5.95	3.42	0.001***
		Std. Error	0.46	0.56	1.14	0.48	
		Minimum	0.00	0.00	0.00	0.00	
		Maximum	9.00	5.00	18.00	18.00	
Family size		Mean	12.48	12.56	12.25	12.42	0.981
		Std. Error	0.66	1.97	1.23	0.57	
		Minimum	5.00	7.00	5.00	5.00	
		Maximum	18.00	27.00	24.00	27.00	
Distance from mangrove rice field to homestead	km	Mean	10.33	1.08	1.98	6.70	0.000***
		Std. Error	0.39	0.11	0.41	0.58	
		Minimum	4.00	0.75	0.50	0.50	
		Maximum	15.00	1.50	6.00	15.00	
Farming experience	years	Mean	17.78	31.78	28.70	22.77	0.001***
		Std. Error	1.27	4.61	3.81	1.60	

	Minimum	5.00	10.00	6.00	5.00	
	Maximum	46.00	52.00	80.00	80.00	
Off-farm income and remittance	Mean	973,800	6,194,444	7,617,100	3,580,348	0.000***
	Std. Error	66,906	1,958,323	2,094,742	745,789	
	Minimum	450,000	750,000	0.00	0.00	
	Maximum	2.55×10^6	1.63×10^7	3.40×10^7	3.40×10^7	

*** = significant at 1 %, ** = significant at 5 % and * = significant 10 %

Table 7.7: (Continued)

Variables and units		SM	IMR	TMR	Total	p-value
Origin	0 = Migrated	27 (39.1)	2 (2.9)	3 (4.3)	32 (46.4)	0.000***
	1 = Native	13 (18.8)	7 (10.1)	17 (24.6)	37 (53.6)	
Use of improved rice varieties	0 = No	32 (46.4)	0 (0.0)	12 (17.4)	44 (63.8)	0.000***
	1 = Yes	8 (11.6)	9 (13.0)	8 (11.6)	25 (36.2)	
Extension from GOG	0 = No	31 (44.9)	3 (4.3)	20 (29.0)	54 (78.3)	0.000***
	1 = Yes	9 (13.0)	6 (8.7)	0 (0.0)	15 (21.7)	
Extension from NGOs	0 = No	40 (58.0)	0 (0.0)	20 (29.0)	60 (87.0)	0.000***
	1 = Yes	0 (0.0)	9 (13.0)	0 (0.0)	9 (13.0)	
Networking with neighbors	0 = No	40 (58.0)	9 (13.0)	3 (4.3)	52 (75.4)	0.000***
	1 = Yes	0 (0.0)	0 (0.0)	17 (24.6)	17 (24.6)	
Access to credit	0 = No	40 (58.0)	0 (0.0)	20 (29.0)	60 (87.0)	0.000***
	1 = Yes	0 (0.0)	9 (13.0)	0 (0.0)	9 (13.0)	

*** = significant at 1 %, ** = significant at 5 % and * = significant 10 %

This could well explain the higher investment they are making on fertilizer and pesticide than the other group of farmers (TMR and IMR). According to the SNSA (2004a), among 2,272,638 cultivated plots corresponding to 1,370,145 hectares, only 20 % have received organic manures and /or mineral. In addition, 99 % of these cultivated plots were not applied with pesticides. The use of modern agricultural farm inputs such as fertilizer, agrochemical; improved seed, etc., is too insignificant in most of Sub-Saharan African countries. This corroborates with a census [Note 7.2] conducted in Guinea during the 2000-2001 agricultural campaign. For the entire country, the results indicated that: nitrogen fertilizer is applied to 1.5 % of the plots, phosphate fertilizer to 0.5 % of the plots, potassium fertilizer to 0.5 and 0.2 % of plots with triple fertilizer (SNSA, 2004b).

The mean of hired labor cost per farm area among SM farmers is the highest shows. This is line with the previous reasoning related to the income generated from salt production. However, it is important to highlight that the maximum value of hired labor cost per farm area was reported by the TMR farmers. This could be attributed to the presence of some civil servants among the TMR farmers. These civil servants are better off in terms of off-farm income and remittance. Their average (7,617,100 GNF) and maximum ($3.40x10^7$ GNF) values of off-farm income and remittances were higher than that obtained by SM and IMR farmers.

The overall education level of surveyed peasants remains low, with an average of three years of schooling. However, it is important to note that the mean education level (Table 7.7) of traditional mangrove rice farmers is above the average of the overall sample. This result confirms the findings in Chapter VIII. This can be explained as there are highly educated farmers among traditional mangrove rice farmers who were formally employed at SAKOBA shrimp farm. After the closure of this industrial farm, these educated persons engaged in mangrove rice farming.

The average distance (10.33 km) from the mangrove rice field to the homestead of SM farmers exceed the overall average value of 6.70 km (Table 7.7). With respect to the IMR and TMR farmers, the mean distances were 1.08 and 1.98 km respectively. These IMR and TMR farmers were found living in *Bentya* and *Makinsy* districts respectively. The locations are almost around the plains adjacent to the mangrove forest. Both average values of farming experience of IMR (31.78 years) and TMR (28.70 years) farmers have exceeded the pooled sample mean of 22.77 years.

The mean of farm tools cost per farm area shows higher values for SM and TMR farmers being 78,927 and 59,961 GNF respectively (Table 7.7). This result confirms again the significant role of income from salt production obtained by SM farmers and the off-farm income from the civil servants belonging to the TMR farmers discussed above. The average of seed quantity of the pooled sample is 74.20 kg/acre, which is less than the mean seed quantity (96.24 kg/acre) used by the SM farmers.

The overall sample shows that only 36 % of farmers used improved rice varieties. This poor adoption of improved rice varieties confirms the result reported by SNSA (2004a), which indicated that 94 % of the cultivated land area utilized local seed in traditional farms, and about 99 % of the plots had no application of pesticides. Sall et al. (1998) stated that the West African agriculture is characterized by high agro-ecological and cultural diversity, limited labor availability and access to agrochemicals, and a strong tradition of self-sufficiency. Consequently, farmers in many areas of West Africa have rejected "modern" varieties of rice developed by formal, science-based institutions for use with inputs such as fertilizer and irrigation water since their local varieties often outperform them.

The research on the development of mangrove rice in West Africa is carried out by the West Africa Rice Development Association (WARDA). Starting in 1976, WARDA maintained a regional rice improvement program in Sierra Leone, targeting approximately 200,000 ha of mangrove swamps cultivated with rice in West Africa. The mangrove rice ecologies, located on tidal estuaries that are near the ocean, are important rice growing environments for six countries in West Africa: Guinea, Guinea Bissau, Senegal, Gambia, Sierra Leone and Nigeria.

Seeds of the modern varieties (e.g. ROK-5, ROK-10, etc.) were diffused to Guinea (Zinnah et al., 1993). One of the varieties, ROK-5, has been increasingly adopted. In the Coyah prefecture, it was estimated that the percentage of farmers cultivating ROK-5 increased from 1 % in 1989 to 15 % in 1990 (Adesina & Zinnah, 1993). On-farm tests conducted from 1982 to 1985 showed that these modern mangrove rice varieties consistently out-yielded the best local varieties by more than 30 %

(Agyen-Sampong, 1990).

Mainly, there are two seed systems in Guinea: informal and formal seed systems. (a) The informal seed system supplies the bulk of seed to farmers. From the previous harvest, farmers and local seed dealers to save seed for the next cropping season, and pass it on through barter, gift or sale. The informal seed system provides inexpensive seed thanks to its low production cost. Seed is produced and stored as part of crop production (Richards, 1986). However, a few farmers specialize in seed production (Okry et al., 2011). In Guinea the informal seed system supplies more than 90 % of farmers' seed (SNPRV, 2001). (b) The formal seed system focuses exclusively on improved varieties and commercial crops, such as cotton and cocoa. As the seed production units are located near cities, farmers in remote areas are discouraged from accessing quality seed. Moreover, many are reluctant to pay more than the grain price to buy seed as they are not sure whether the source can be trusted or if they are unaware of the added benefits of the quality seed. From production to sale, formal seed is broken into discrete activities, done by different stakeholders rather than a single farmer, and it is fully regulated by the government.

The extension services provided by the government of Guinea (GOG) shows that among the pooled sample only 22 % of farmers have been assisted. The TMR farmers stated they did not benefit from these services provided by the GOG. But 25 % of these TMR farmers have been assisted by their highly educated neighbors. Access to credit remains extremely low, only 13 % farmers (IMR) stated of having access to credit. A significant fraction of credit transactions in developing countries still takes place in the informal sector, in spite of serious government efforts to channel credit directly via its own banks, or by regulating commercial banks (Hoff & Stiglitz, 1993). This is largely because poorer farmers lack sufficient assets to put up as collateral, a usual prerequisite for borrowing from banks [Note 7.3]. Numerous case studies and empirical analyses in a variety of countries have revealed that informal credit markets often display patterns and features not commonly found in institutional lending.

7.12. Stochastic frontier production and estimation of technical inefficiency

The stochastic frontier production function and the technical inefficiency estimates of the surveyed mangrove rice farmers in the coastal area of Koba are presented in Table 7.8. Overall, the production elasticity of mangrove rice production is positive and significant as expected. The stochastic frontier model revealed that only the coefficients of farm area, depreciation cost of farm tools and hired labor cost have the expected positive signs. This implies that these variables have positive influence on mangrove rice production efficiency. Bringing more farm land under mangrove rice cultivation with more investment on farm tools and hiring labor has the tendency of increasing the technical efficiency of mangrove rice farmers. The coefficient of farm area is positive and significant at the 5 % level. Our results confirm findings from previous studies (Idiong, 2007; Ologbon et al., 2012; Athipanyakul et al., 2014), who also highlight the positive effect of the farm size on the technical efficiency of rice production. The depreciation cost of farm tools is also positive and significant. Despite, the outdated farm tools, the investment on farm tools during one season of rice production has revealed a positive influence on the mangrove rice production efficiency. The implication of this finding suggests that the adoption of machinery could enhance the technical efficiency of mangrove rice production in Guinea. This is in line with a previous study (Akanbi et. al., 2011) highlighting the machine use as an important contributor to the improvement of technical efficiency in rice production.

The coefficient of hired labor cost is positive, but not statistically significant. This implies that the investment in labor forces in the mangrove rice production in Koba (Boffa prefecture) does not bring improvement in productivity. Therefore, the previous part A in this present chapter VII related to the technical efficiency measurement in the same study area found that the investment in labor could bring a significant improvement in performance of salt production. In addition, Chapter V on mangrove rice production in the coastal area of Dubreka prefecture, in Guinea also found that among all inputs included under the average variable costs (fertilizer cost, pesticide cost, herbicide cost, hired labor cost, local and improved varieties cost), the hired labor per hectare represented the highest variable input in terms of cost (77 to 97 % of variable cost according the different type of rice varieties under consideration). In Nigeria, where the mangrove rice production is called swamp rice production; Idiong (2007) found that labor use has a positive and significant effect on technical efficiency in this farming system.

Fertilizer and pesticide cost indicated a significant negative value of -0.90 (Table 7.8). This implies an inverse relationship between these inputs and the output obtained from the mangrove rice production i.e. an increment of the input by 1 % will reduce the total output by 90 %. Previous studies (Okoruwa & Ogundele, 2006; Akanbi et. al., 2011) explained the negative value of the fertilizer input as the result of over utilization of this input. Contrarily to their explanations; as regards to our field investigation conducted in the study area, this current research argues that the significant negative value of fertilizer and pesticide could be explained through the poor quality of these inputs. Surveyed farmers stated that the poor quality of these inputs could be attributed to the poor storage system. The main types of inorganic fertilizer were triple 17 and urea. The pesticide was “Roundup”. It is also important to highlight that the accessibility of modern farm inputs (fertilizer, agrochemical, improved seed varieties etc.) in the mangrove rice farming system in Guinea remains insignificant. This is well known in the coastal area of Guinea where this mangrove rice production is mainly practiced by small-scale farmers. This is in line with previous studies conducted in the Guinean coastal area. Chapter V revealed a very low use of the inorganic fertilizer i.e. 92 % of respondents did not apply the inorganic fertilizer. In general, farmers were satisfied with the organic matter, debris brought to the rice plots by the seawater intrusion under the influence of the tides. In addition, Chapter IV which examined the role of land use transitions on improving the livelihood of local farmers growing mangrove rice has also revealed the insignificant usage of fertilizer (i.e. 90 % of surveyed farmers did not apply it). This result (Table 7.8) also confirms the finding by Abdulai & Huffman (2000) that a negative relationship between the use of fertilizer and the level of profit inefficiency in the Northern region of Ghana.

Both seed quantity and active family labors also indicated negative insignificant coefficients. The coefficient of seed quantity and family labors of -0.049 and -0.051 signifies about 5 % decrease in the revenue of mangrove rice production output for every 1 % increase in the quantity of seed and family labor, respectively. However, Ologbon et al., 2012, found that quantity of planted seeds was positively significant depicting an increase in rice output as seeds use is increased.

The maximum likelihood estimates (MLEs) for parameters of the technical inefficiency model are also presented in Table 7.8. The estimated coefficients of the explanatory variables in the model for the technical inefficiency effects are of interest and have important implications as shown in Table 7.8. A negative sign on a parameter explaining inefficiencies means that the variable is improving technical efficiency, while for a positive sign, the reverse is true. The results indicated that age of household's head, household size, farming experience and off-farm income coupled and remittance are significant determinants of the technical efficiency (negative impact on the technical inefficiency) in the mangrove rice production. However, variables such as education level, usage of improved seed, extension service provided by the Government of Guinea (GOG) and credit, despite their statistical significance levels, impact negatively to the technical efficiency (positively to the technical inefficiency, i.e. Table 7.8) in mangrove rice production.

The impact of age of the household's head is negatively significant implying that the older mangrove rice farmers were more productive than the younger ones. This finding confirms the results of previous studies conducted by Idiong (2007), Tijani (2006). However, part A, Chapter VII conducted in the same site focusing on the technical efficiency of salt production found that younger salt producers were more efficient than the older ones. With respect to education level, it is significant but has a negative impact (positive impact on the technical inefficiency) to the technical efficiency of the mangrove rice production. This implies that less educated mangrove rice farmers are more efficient than better educated rice farmers. The result is consistent with the study of Idiong (2007); who also found that education level was significant and positively affecting to the technical inefficiency of rice production in Nigeria. This means being an educated mangrove rice farmer was not enough to significantly attain higher levels of efficiency.

The variable household size has a positive and highly significant impact on efficiency of mangrove rice production. This implies that farmers with more household members perform better than those with fewer members. This result confirms the findings of Rahman et al (2012), who found that family size had negative and significant impact on technical inefficiency of rice production. The estimated coefficient of years of experience in mangrove rice farming is negative, conforming to our priori expectation, and it is statistically significant. The implication is that farmers with more experience in rice production are more efficient than the inexperienced ones in the study area. The result is consistent with the work of Bravo-Ureta (1994) who observed positive relationship between economic efficiency and experience in a study of dairy farms. The result also confirms findings from Yiadom-Boakye et al., 2013, who indicated that rice farmers in the Ashanti region of Ghana tend to use the knowledge acquired through experience on soil, and crop management in their farm operations.

The use of improved mangrove rice seed varieties has a negative and significant impact on technical efficiency (positive impact on the technical inefficiency) estimate. This result is in corroboration with the finding of Adesina & Baidu-Forson (1995). They reported that in the case of mangrove rice varieties in Guinea and Sierra Leone, the extension had very little to do with technology diffusion: this occurred mainly through farmers' self-experimentation, evaluation, exchange and transfer. The farmer's self-experimentation is in line with our finding regarding the extension supported by neighboring farmers (discussed below). Extension services from government are significantly and positively related to technical inefficiency. This confirms the results of Muhammad-Lawal et al., (2009), who stated that extension information received by youth participation in agriculture programme in south western Nigeria was positively related to technical inefficiency. Our results are also in line with Raphael (2008) who observed that extension contact has a negative effect on the efficiency of farmers in cassava production. Muhammad-Lawal et al., (2009) argued that this was due to the lack of trust among the participants on the potency of the information received from the extension agents. Moreover, Raphael (2008) was of the opinion that this may be due to bureaucratic inefficiency and some generic weaknesses in information dissemination in the civil service. This weakness of extension services was revealed by Zinnah et al., (1993), who indicated that the researcher-extension-farmer linkages are extremely weak in Guinea and that most of the mangrove rice varieties currently grown by farmers were obtained via farmer-farmer contacts.

The poor effect of agricultural extension programs in farming systems is not surprising. Similar results have been reported in past analyses of the productivity of agriculture in developing countries (Feder et al., 2004). Although agricultural extension and farmer-education programs are key policy instruments for the government seeking to improve the productivity of agriculture, while protecting the environment, yet, many observers document poor performance in the operation of extension and informal education systems, due to bureaucratic inefficiency, deficient program design, and some generic weaknesses inherent in publicly operated, staff-intensive, information delivery systems. One deficiency highlighted by researchers and practitioners is the tendency of many public officers dealing with the transmission of knowledge to conduct their assignment in a ‘‘top-down’’ manner. Often, the information conveyed is presented as a technological package comprising recommended practices. This is perceived as a less effective method for improving knowledge. In this case, more participatory approaches are suggested to extend science-based knowledge and practices **(**Braun et al., 2002**)**.

Networking with neighbors for farming advice is insignificant and negatively related to the technical inefficiency. This result corroborates with the finding of Adesina & Baidu-Forson (1995), who stated that farmers are important as sources of technology information and agents of technology transfer. When farmers assess the characteristics of new technologies and find them to match their preferences, they often give the technologies to other farmers to test and evaluate thereby setting into motion an endogenous process of technology diffusion.

Access to credit is significant but has a negative impact on the technical efficiency on mangrove rice production. In the other hand, it means that a positive and statistical significance is found between access to credit and technical inefficiency. This implies that accessibility and availability of credit relaxes the production constraints and hence makes it easier for timely purchase of resources thereby increasing productivity through efficiency. This indicates that farmers who have access to credit tend to exhibit higher levels of inefficiency. This is contrary to a priori expectations that the more credit the farmers use, the more efficient they become. It might be as a result of the credit received being misused (or diverted to other uses). The result agrees with the findings of Etim & Okon (2013), Baruwa & Oke (2012) and Aye & Mungatana (2010). The negative impact on the technical efficiency of the variable credit mentioned above explained its constraint to farmers. This was also highlighted by Komicha & Öhlmer (2007), who stated credit constraint not only affects the purchasing power of farmers to procure farm inputs and cover operating costs in the short run, but also their capacity to make farm-related investments as well as risk behavior in technology choice and adoption. These, in turn, have influence on the technical efficiency of the farmers. Although the credit constraint problem has been recognized in the economics literature, especially in those dealing with developing countries, little emphasis has been given to its effect on productive efficiency of farmers.

The overall technical inefficiency effects are evaluated in terms of the parameters associated with $\sigma^2$and γ (Table 7.8). The estimate for the variance parameters σ is significantly different from zero at one percent level (Table 7.8). This indicates statistical confirmation of our presumption that there are differences in Technical efficiency (TE) among the mangrove rice farmers.

Table 7.8: Estimates of the stochastic frontier and technical inefficiency models of mangrove rice production

Variables	Parameters	Coefficient	t-ratio
Stochastic frontier model			
Constant	β_0	49.409 (3.661)	13.495***
X_1 = Ln(Fertilizer and pesticide cost)	β_1	-0.900 (0.215)	-4.187***
X_2 = Ln(hired labor cost)	β_2	0.882 (1.849)	0.477
X_3 = Ln(depreciation cost on farm tools)	β_3	0.478 (0.195)	2.454**
X_4 = Ln(seed quantity)	β_4	-0.049 (0.221)	-0.220
X_5 = Ln(active family labors)	β_5	-0.051 (0.058)	-0.869
X_6 = Ln(farm area in acres)	β_6	4.119 (1.918)	2.147**
Technical inefficiency model			
Constant	δ_0	3.478 (2.292)	1.518
Z_1 = Age of household head	δ_1	-0.000 (0.000)	-2.328**
Z_2 = Education level	δ_2	12.654 (4.043)	3.130***
Z_3 = Origin (1= native; 0= migrated)	δ_3	2.054 (1.390)	1.478
Z_4 = Household size	δ_4	-7.893 (3.368)	-2.343**
Z_5 = Distance to rice field	δ_5	2.054 (1.390)	1.478
Z_6 = Farming experience	δ_6	-10.341 (6.061)	-1.706*
Z_7 = Usage of improved seed	δ_7	6.657 (3.833)	1.737*
Z_8 = Off-farm income and remittance	δ_8	-4.796 (2.563)	-1.871*
Z_9 = Extension from GOG	δ_9	8.966 (4.702)	1.907*
Z_{10} = Extension from NGOs	δ_{10}	0.739 (1.294)	0.571
Z_{11} = Networking with neighbors for farming advice	δ_{11}	-3.746 (2.863)	-1.308
Z_{12} = Credit	δ_{12}	14.876 (7.613)	1.954*
Variance parameters			
Sigma squared	σ^2	79.962 (2.252)	35.504***
Gamma	γ	0.464 (0.161)	2.876***
Likelihood ratio (LR) test	χ^2	9.931	
Log likelihood function		-230.974	

*** = significant at 1 %, ** = significant at 5 % and * = significant 10 %

Table 7.9: Generalized likelihood ratio (LR) tests

Null hypotheses	Log likelihood	LR (λ)	Critical value	Decision
1.H_0: $\gamma = \delta_0 = \ldots \delta_{12} = 0$	-0.104	-461.74	16.07	Accept H_0
2.H_0: $\gamma = 0$	-241.95	21.95	25.55	Accept H_0
3.H_0: $\delta_0 = \ldots \delta_{12} = 0$	-0.104	-461.74	5.41	Accept H_0
4.H_0: $\delta_1 = \ldots \delta_{12} = 0$	48.96	-559.87	16.07	Accept H_0

The gamma value (γ) of the MLEs of stochastic frontier production model is 0.464 (Table 7.8). This value is statistically significant at the 1 % level, implying that 46 % of variability of revenue from mangrove rice production is attributed to technical inefficiency. And the rest (54 %) is due to random noises. This also confirms that the application of the stochastic frontier function model is appropriate for this study.

Moreover, the presence of technical inefficiency was tested by the Likelihood Ratio (LR) test. The null hypothesis (H_0) implies that gamma value is equal to zero. In other words, variations of mangrove rice production revenue are due to random noises or stochastic frontier model is inadequate. Alternative hypothesis (H_1) implies that gamma value is different from zero or the application of the stochastic frontier model is adequate. LR test has a mixed chi-square (${x^2}_R$) distribution with R equal to restrictions in the model. According to statistic principles, the null hypothesis (H_0) will be rejected if LR test is greater than critical chi-square value table. Table 7.8 shows that LR value is 9.93; and the critical chi-square value (${x^2}_{(1\%,R)}$) is equal to 16.07 (obtained from Kodde & Palm, 1986). Hence, LR test is less than critical chi-square value. Therefore, the null hypothesis (H_0) is accepted. Tests of null hypotheses associated with the models were carried out using the likelihood ratio (LR) statistics and the results are presented in Table 7.9. The first null hypothesis ($H_0\colon \gamma = \delta_0 = \cdots = \delta_{12} = 0$) that inefficiency is absent from the model, is strongly accepted. This implies that the mean response function is an adequate representation of the data for the mangrove rice production. The second null hypothesis ($H_0\colon \gamma = 0$) which specifies that the inefficiency effects are not stochastic, is accepted. So, we do accept the null hypothesis that there was technical inefficiency. The parameter γ is estimated to be 0.464 (Table 7.8) indicating that 46.4 % of inefficiency is due to the mangrove rice farmer's own decision and the remaining 54 % is due to the factors outside the control of the farmers. The parameter γ also reflects that the inefficiency effects are highly significant in the analysis of mangrove rice production (Table 7.8).

The third null hypothesis considered in the model ($H_0: \delta_0 = \cdots = \delta_{12} = 0$) that the coefficients of the explanatory variables in the inefficiency models are simultaneously zero, is also accepted. This indicates that all twelve explanatory variables considered in the model (Equation 2) did not make a significant contribution in the explanation of inefficiency effects associated with the value of output. The last null hypothesis considered ($H_0: \delta_1 = \cdots = \delta_{12} = 0$) that the coefficients of the variables in the model for inefficiency effects are zero, is also accepted. It reflects that all the coefficients of the explanatory model are not significantly influenced by the variables (Equation 2 or Table 7.8).

7.13. Technical efficiency distribution in mangrove rice production

The result derived from the ML estimates show technical efficiency (TE) indices range from 0.00 to 1.00 with a mean value of 0.23 (Table 7.10). This means that for an average efficient mangrove rice farmer to achieve the technical efficiency level of its most efficient counterpart he should realize about (1.00 – 0.23/1.00) savings in cost or increase in production. This gives about 77 % increase in production or cost saving. The least efficient mangrove rice farmer can now save a cost or increase in production of 100 %. (1.00 – 0.00/1.00) to achieve the required technical efficiency of the most efficient producers in the study sample. The variation in technical efficiency (0.00 to 1.00) of these mangrove rice farmers might arise from managerial decisions and specific-farm characteristics that affect the ability of the farmer to adequately use the existing technology. This explains the reason why three farmers (4.35%) have very high technical efficiencies.

To provide a better indication of the distribution of TE, a frequency distribution of the predicted TE is presented in Table 7.10. Among the mangrove rice farmers 91.31 % are producing at less than 41 % efficiency level while only 4.35 % of farmers have TE of above 81 %, which is an indication that most of mangrove rice farmers (TMR, IMR and SM) still remain inefficient. Efficiency is one of the main factors determining competitiveness. The higher the degree of efficiency the lower will be the unit cost of production and as a result, mangrove rice farmers would be able to produce at lower prices. Consequently, more efficient mangrove rice farmers would have better chances of surviving and prospering in the future than less efficient ones. Along these lines, analysis of efficiency would provide information about the potential sources of inefficiency. In addition, measures of potential cost savings that can be achieved from improvements in technical and allocative efficiencies could be derived and used by mangrove rice farmers as a benchmark to improved competitiveness.

Table 7.10: Frequency distribution of technical efficiency estimates

Efficiency level (%)	Frequency of mangrove rice farmers	Percentage of mangrove rice farmers
00 – 20	33	47.83
21 – 40	30	43.48
41 – 60	3	4.35
61 – 80	0	0.00
81 – 100	3	4.35
Total	69.00	100.00
Mean efficiency	0.23	
Minimum	0.00	
Maximum	1.00	

7.14. Loss due to inefficiency and potential output of mangrove rice production

In order to measure the loss due to inefficiency, both actual output and potential outputs were calculated first (Mor & Sharma, 2012). The potential output as well as loss of output is estimated by dividing the actual output by the mean technical efficiency, whereas the output forgone (loss due to inefficiency) is the difference between the potential output and the actual output (Mor & Sharma, 2012). Table 7.11 presents an account of the potential as well as the output forgone in mangrove rice production in the study area. Mangrove rice farmers on average loose output worth of 8,838,762 Guinean francs per acre (GNF/acre) seasonally solely due to the technical inefficiency. This can be regained by way of better utilization of resources which are at the disposal of the mangrove rice farmers.

As highlighted in this Chapter VII, part A, there are three possible ways to increase mangrove rice production in the coastal area of Guinea. Firstly, by allocating more land, secondly by developing and adopting new technologies and thirdly by utilizing the available resources more efficiently. The third option of using available resources more efficiently is the most viable approach. This implies that increased mangrove rice growing hinges upon the improvement of productivity, i.e. yield per unit area. According to Abedullah et al. (2007), it is generally believed that resources in the agricultural sector, especially in the developing countries are being utilized inefficiently. Farmers are mainly concerned with profitability of farming business which directly or indirectly depends on resource use efficiency.

Productivity growth can be achieved either through technological change (development and adoption of new technologies) or improvement in technical efficiency (ability to obtain maximum output from a given input mix and the existing technology) but the most cost-effective strategy depends on the magnitudes of the inefficiencies (Dey et al., 2000). When producers are highly efficient, the former is applicable, however if inefficiencies are large the latter is likely the most cost-effective means of raising productivity.

Table 7.11: Estimated potential output and output for mangrove rice production

Technical efficiency	Mangrove rice producers
Actual output (GNF/acre)	2,640,149.54
Potential output (GNF/acre)	11,478,911.04
Loss due to inefficiency (GNF/acre)	8,838,761.50

7.15. Summary

In Guinea, the national rice consumption exceeds rice production, leading to concerns about food security. Thus, recent governmental measures have been directed towards promoting rice production, particularly in the coastal areas, the only zone where the mangrove rice production is practiced. Rice is the most important food crop and its production is the most organized food production system in the country. Therefore, it’s of interest to examine the efficiency of mangrove rice production, in this study an attempt is made to determine the technical efficiency of mangrove rice production by using the stochastic frontier model. The study used primary data collected through a field survey. The analysis revealed that farm area and depreciation cost of farm tools contribute to significantly enhance the mangrove rice productivity. The inefficiency model revealed that age of household head, household size, farming experience, off-farm income and remittance significantly influenced the technical efficiency. The mean level of the technical efficiency was estimated at 23 %, while the efficiency ranged from 0.0 % to 100 %. Furthermore, the analysis indicated that the loss due to the inefficiency was significant with a value of 8,838,762 Guinean Francs per acre. Policy recommendations and strategies for improving the efficiency of mangrove rice production are advocated based on the findings.

Notes

[Note 7.1] Stephen Carr has spent sixty years working with small-scale farmers in a range of African countries, both at the village level and in senior positions with African governments and internationally.

[Note 7.2] It refers to the second Agricultural Census in Guinea, conducted during the year 2000/2001. Prior to this one, Guinea had conducted another census during the year 1988/1989. The Census was organized by the National Service of Agricultural Statistics (Ministry for the Agriculture, Livestock, Water and Forest), with assistance from FAO, USDA and World Bank. The preparatory phase for census lasted during 1999/2000. Fieldwork for data collection was carried out during 2000/2001. The data were processed during March-December 2003. Reports on *Recensement National de l'agriculture, Campagne agricole 2000-2001* were published by the National Service of Agricultural Statistics (Ministry for the Agriculture, Livestock, Water and Forest, Republic of Guinea), on May 2004.

[Note 7.3] Banks, in turn, have to rely on such guarantees because the impersonal nature of institutional lending reduces the ability to select or monitor borrowers effectively.

CHAPTER VIII

EFFECTS OF RURAL LIVELIHOOD ACTIVITIES ON INCOME INEQUALITY AND POVERTY REDUCTION

8.1. Introduction

In Guinea, coastal lands play a key role in national food security in terms of agricultural production focused on rice, salt production, etc., and over one-third of the country's population who live in coastal lands. Income inequality is one of the major contributing factors of poverty and food security in developing countries, while leaving a substantial proportion of their populations to languish in poverty and suffer from problems associated with chronic malnutrition (Peters & Shapouri, 1997). Inequality also matters to the pace of poverty reduction that is achieved at any given rate of growth (Ravallion, 2001). Since 2003; Guinea has experienced a serious economic crisis, which has exacerbated the poverty. Poverty was decreased significantly between 1994/95 and 2002/03, falling by more than 13 percent. However, the incidence of poverty at the national level has gone up from 53% in 2007 to 55.2% in 2012 (INS, 2012). In addition, the number of poor increased very significantly from 4 million to over 6.2 million over the past two decades, due to the aggravation of poverty and high population growth associated with high fertility.

Demographically, Guinea is characterized by rapid population growth and marked by strong regional disparities. In fact, total population grew from 9.7 million inhabitants in 2007 to about 11.3 million in 2012, at an average annual growth rate of 3.1% (equivalent to doubling every 22.5 years), and is made up mostly of women (52%). An age breakdown shows a high proportion of youth. In fact, 22% of women and 23% of men are aged 15-19 years. About 18% of women and 17% of men belong to the 20-24 age groups. This demographic growth rate remains worrisome and prejudicial to the economic development of the country, as it leads to strong social demand (specifically for education, health care, housing, employment and transport) to which social policy must respond. The Synthetic Fertility Index (ISF) remains high, 5.1 children per woman, according to Demography and Health Study [EDS4-2012, reported by IMF, (2013)]. This Total Fertility Rate (TFR) level is putting more and more pressure on social services and employment. It can be explained by, among other things, the precarious socioeconomic status of women, especially by their low level of education, generally low standard of living in the household, weak economic power and lack of knowledge about their own reproductive system.

The development of indicators of poverty and some social indicators show that Guinea will not reach the Millennium Development Goals by 2015 (INS, 2012). The current economic situation is very different from the one which prevailed between 1994 and 2002, a period during which the country's economy has experienced strong growth in GDP per capita. A comparative analysis of surveys conducted in 1994/95 and 2002/03 showed a decline in poverty from 62.6 % in 1994 to 49.1% in 2002. Nowadays, there is an ongoing and increasing interest in measuring and understanding the level, causes and development of income inequality (Heshmati, 2004).

An improved understanding of the sources of income and income distribution provides instructive insights into poverty and helps policy makers in the developing world to formulate new strategies for its mitigation. In the perspective of inclusive growth strategies, it is important to undertake analysis of the dynamics of poverty, analysis of inequality in income distribution and the effects of these changes on dynamics of poverty. Hence, the present chapter aims to investigate the effect of livelihood activities on the income inequality and poverty in the coast of Guinea.

8.1.1. Literature review on poverty and inequality

Poverty and inequality depends on the household earning capacities. Recently, there has been a growing recognition that rural households receive their income from a diverse portfolio of activities (Castagnini et al., 2004). Income levels and its distribution had attracted many researchers. The focus in these researches is on finding the welfare levels of households and to compare their situation. Thus, poverty and inequality are the keywords for development researchers. Poverty exists in a given society when one or more persons do not enjoy a level of material well-being deemed to constitute a reasonable minimum by the standard of that society (Sen, 1999). Inequality is closely related to the definition and conceptualization of poverty. The close link between poverty and inequality is partly supported by the fact that the latter has been defined or measured in the context of the former (Sen, 1976; Foster et al., 1984). In practice, the association between the two developmental issues has moved in varied directions in different countries, suggesting an intriguing relationship (Bourguignon, 2004). More interesting to this discourse is the characterization of the two concepts: that is, the degree of aggregation (unit of analysis) and whether what is being considered for measurement (income, consumption, wealth, etc.) is the same or varies between poverty and inequality. While inequality deals with the entire distribution, poverty either reflects the proportion below the poverty line (absolute poverty) or is measured based on the characteristics of other units in the sample (relative poverty). The variations in the characterization of both poverty and inequality partially account for the depth of the discussion that is taking place on these developmental issues. In sum, the conceptual difference between poverty and inequality is nuance.

Also, the discourse on poverty and inequality has deepened in recent times based on the outcomes of empirical studies that seek to evaluate the ability of the developing countries to achieve the MDG1 target of halving poverty by 2015. Imai et al. (2010) assert that while globally the goal of halving poverty is on course, many individual countries and regions are struggling to achieve this goal. Also, Fosu (2011) argues that even if all countries grow at a desired rate (such as the purported seven per cent growth rate) necessary for achieving the first Millennium Development Goal (MDG1), this criterion will not be sufficient for all developing countries, given their idiosyncratic factors such as inequality. On the nature of inequality, one dimension currently being explored in the literature is spatial disparity. This is because there is a growing sense across much of the developing world and other transitional economies that spatial and regional inequality of income, consumption, economic activities and other social indicators is on the increase (Kanbur & Venables, 2003; McKay & Aryeetey, 2007; World Bank, 2009). More importantly, the trend towards increased regional inequalities comes within the context of positive economic growth in several parts of the developing world in recent times, especially in previously poorly performing regions, such as sub-Saharan Africa (Aryeetey et al., 2009).

Both poverty and inequality have increasingly become multi-disciplinary, given their multi-dimensionality and dynamism. For instance, economists have explored the growth–poverty nexus based on the role of inequality (Fosu, 2011; Bourguignon, 2004; Ravallion, 1997), while sociologists, among other theories, have argued that poverty and inequality are outcomes of social categorization and identity that self-perpetuate themselves within a society (Mosse, 2010). Another twist to this discourse is the relationship between poverty and inequality – that is, whether they are dependent or independent, or whether they both mutually cause the occurrence of other outcomes. Barber (2008) suggests that the relationship between poverty and inequality is either pragmatic, that is, inequality exacerbates poverty, or moral, that is, inequality is a form of poverty.

8.1.2. Poverty and inequality in Guinea

Poverty is a multidimensional phenomenon characterized by weak consumption of goods, malnutrition and bad living conditions, as well as by difficult access to public and basic social services (education, health care, safe drinking water and sanitation, etc.).

It is also the result of loss of autonomy and of exclusion. It should be perceived not only as a lack of material goods and possibilities, such as, for example, employment and property, but also as the absence of physical and social assets, such as healthcare, corporeal sovereignty, shelter from fear and violence, a sense of belonging, cultural identity, ability to have political influence and the possibility of living with respect and dignity.

The poverty threshold is fixed at 3,217,305 Guinean Franc (GNF) per capita and per year at 2012 prices, or nearly 8815 GNF per capita, per day. This threshold was determined on the basis of a 2002/03 survey, updated in 2007 and 2012 to reflect inflation. According to results of the two surveys, the incidence of poverty at the national level has gone from 53% in 2007 to 55.2% in 2012, an increase of 2.2 percentage points (Table 8.1). The trend shows that the number of individuals living below the poverty line increased from 5.1 million in 2007 to 6.2 million in 2012. This increase in the number of poor poses a real challenge in terms of access to basic social services, employment and land development planning. On the other hand, the extent and severity of poverty have worsened between the two periods, moving, respectively, from 17.6% to 18.4% and from 8.2% to 8.4%. This reflects a widening of the gap between average spending by the poor and the poverty threshold.

Furthermore, the extent and severity of poverty are greater in rural areas than in urban areas, along with the incidence of poverty itself. Gini inequity coefficients calculated with data from the 2007 and 2012 ELEP (Small-Scale Surveys for the Evaluation of Poverty) conducted by the National Institute of Statistics (INS) reveal that inequity of income distribution increased over the period. In fact, the Gini index increased from 0.312 to 0.317 (Table 8.1). This increase is most strongly felt in urban areas (0.290 in 2007 to 0.315 in 2012). In rural areas, by contrast, there was a slight decline, with the Gini index moving from 0.295 in 2007 to 0.290 in 2012.

Table 8.1: Trends of Poverty and Inequality

Indicators	**2007**			**2012**		
	Urban	Rural	Total	Urban	Rural	Total
Incidence	30.5	63.0	53.0	35.4	64.7	55.2
Extent	7.7	22.0	17.6	9.6	22.6	18.4
Severity	3.0	10.5	8.2	3.8	10.5	8.4
% Population	30.7	69.3	100	32.1	67.9	100
% Poor	17.7	82.3	100	20.8	71.2	100
Number of poor	907519	4224191	5131710	1285039	4927703	6212742
Gini	0.290	0.295	0.312	0.315	0.290	0.317

Source: INS, (2012); IMF, (2013)

8.2. Characteristics of surveyed peasants

Table 8.2 illustrates some socio-demographic variables of peasants with respect to the surveyed districts. The average and percentages of these variables are also presented. It indicates that the average age of the improved mangrove rice and salt marsh producers was higher than other respondents. This confirms findings from Mignouna et al., (2011), who indicated that the older the household head, the greater the chances of adopting the improved technology in Western Kenya. Adoption of improved agricultural technologies has become a critical avenue for increasing productivity in developing countries, but is subject to serious limitations. The overall education level of surveyed peasants remains low, with an average of three years of schooling. However, it is important to note that the mean education level (Table 8.2) of traditional mangrove rice farmers is above the average of the overall sample. This can be explained through the presence of highly educated farmers who previously were working in SAKOBA [Note 8.1] shrimp farm. After the closure of this industrial farm, these highly educated persons went for the mangrove rice farming. In terms of family size, the sample size indicated an average of 11 members. The sample shows that gender represents 79 % and 21 % for male and female respectively.

The traditional salt production (TSP/GS) shows that 76.7 % of females involve in salt extraction. This significant involvement of women in traditional salt production was also reported by Serbin, (2000), who stated that women represent 80 % of salt producers in the Maritime Guinea region so called Guinean coastal zone. Once women are released from agricultural activities that last three to five months a year, they moved to the campsite of salt extraction where they extract salt which demands physical strength, thus compromising the health. The marital status was 99 % married and 1 % as single. Table 8.2 shows a higher migration among salt marsh producers representing 68 %. This significant number of migrant salt producers is not surprising since salt extraction is only limited to the Guinean coastal belt. Balde and Liagre, (2008) suggested that an estimate of migrant traditional salt producers is important. The overall sample represents 69 % and 31 % of native and migrant farmers respectively.

Table 8.2: Socio-demographic profile of respondents

	Balessourou		**Taboria**	**Makinsi**	**Bentya**	**Overall**
	TSP/GS	SM	WE	TMR	IMR	
Age (years)	41.3 (11.9)	48.7 (6.96)	45.8 (6.7)	44.4 (10.7)	49.9 (10.3)	45.6 (10.6)
Education level (years)	2.4 (3.2)	2.7 (2.9)	3.9 (3.8)	5.1 (5.5)	2.9 (3.8)	3.3 (4.1)
Family size (persons)	9.9 (3.5)	12.5 (4.1)	11.6 (4.2)	10 (5.2)	11.3 (3.9)	10.9 (4.3)
Gender (dummy)						
1=male (%)	23.3 (0.06)	100 (0)	95.0 (0.1)	100 (0)	100 (0)	78.6 (0.03)
2=female (%)	76.7 (0.06)	0	5.0 (0.1)	0	0	21.4 (0.03)
Marital status (dummy)						
1=married (%)	100 (0)	100 (0)	100 (0)	94.0 (0.03)	100 (0)	98.6 (0.01)
2=single (%)	0	0	0	6.0 (0.03)	0	1.4 (0.01)
Origin (dummy)						
1=native (%)	75 (0.06)	32.5 (0.08)	75 (0.1)	82 (0.1)	76.0 (0.1)	69.1 (0.03)
2=migration (%)	25 (0.06)	67.5 (0.08)	25 (0.1)	18 (0.1)	24.0 (0.1)	30.9 (0.03)

Values in parentheses are standard errors. IMR = improved mangrove rice; TMR = traditional mangrove rice; WE = wood extractors; SM = salt mash producers; TSP/GS = traditional salt producers/Guinean saline.

8.3. Situation of income sources in Koba

Table 8.3 presents different income sources in respect to each district. A significant proportion (40 %) of average per capita income of salt marsh (SM) producers was derived from improved salt production technique in the district of Balessourou. The next significant proportion (23 %) of average per capita income of mangrove rice producers was also derived from improved mangrove rice production (IMR) in Bentya district. Therefore, traditional salt and mangrove rice producers are considered as the poorest because their overall incomes indicated 17 % and 15 % respectively (Table 8.3).

Table 8.3: Contribution to total income from different income sources

	Districts					Overall districts
	Balessourou		Taboria	Makinsi	Bentya	
	TSP/GS	SM	WE	TMR	IMR	
Respondents	60 (27.3)	40 (18.2)	20 (9.1)	50 (22.7)	50 (22.7)	220
1. Mangrove rice production	0	934517		1066391	2213909	4214817 (26.10)
2. Lowland rice production	0	0	0	88641	71064	159705 (0.99)
3. Vegetables production	0	0	0	167652	295391	463043 (2.87)
4. Perennial crop prod.	0	0	0	120208	54982	175190 (1.08)
5. Seasonal crop prod.	0	0	0	192714	157839	350553 (2.17)
6. Salt production	2634079	5417060	0	0	0	8051139 (49.85)
7. Wood extraction	0	0	763205	0	0	763205 (4.73)
8. Non-farm income	103003	56299	93642	428852	425270	1107066 (6.85)
9. Remittance	34864	33854	23452	24888	42923	159981 (0.99)
10. Livestock	0	13739	54573	256472	380212	704996 (4.37)
Overall income per district (GNF)	2771946 (17)	6455469 (40)	934872 (6)	2345818 (15)	3641590 (23)	16149915

IMR = improved mangrove rice; TMR = traditional mangrove rice; WE = wood extractors; SM = salt mash producers; TSP/GS = traditional salt producers/Guinean saline. GNF = Guinean Franc. Values in parentheses are percentages.

These figures prove that poorer farmers get excluded from improved livelihood activities. This is very common in Africa and it is not different in Guinea. Based on the components of income, Table 8.3 revealed that the salt production income was significant, representing 50 % followed by the income from the mangrove rice production (26 %). The contribution from non-farm income and wood extraction to total income represents 7 % and 5 % respectively. The agricultural income sources such as lowland rice, vegetables, perennial and seasonal crop production except mangrove rice production, contributes 7 % to total income.

8.4. Effects of livelihood activities on income inequality

The estimates of the Gini decomposition analysis are presented in Table 4. The overall Gini coefficient (Table 8.4, column 3) of the total income of respondents is 0.3799. This result is comparable to the Gini coefficients of 0.38; 0.38; 0.39; 0.39; 0.38 and 0.39 that were derived respectively, for Cote d'Ivoire in 1995, Djibouti in 1996, Burkina Faso in 1995, Mauritania in 1995, Tanzania and Uganda in 1993 (Dollar & Kraay, 2002). A Gini coefficient of 0.40 was also derived for Guinea (Dollar & Kraay, 2002) which was a higher inequality compared to the Gini coefficient 0.38 (Table 8.4). Therefore, our Gini coefficient also presented higher inequality than Gini coefficients reported by IMF, (2013), in poverty reduction strategy paper (PRSP) in Guinea in 2007 (0.31) and 2012 (0.32).

The share of total income (S_k) (Table 8.4) indicates the contribution of particular income sources to the overall income. Hence, Table 8.4 shows that salt production contributes to 50 % or half of the total income, while the income from the mangrove rice production contributes 27 %. These figures confirm results relative to the contribution to the total income from different income sources as earlier discussed as per Table 8.3. The contribution to the total income from non-farm income and livestock represent 7 % and 5 % respectively. The overall Gini coefficient of 0.3799 (Table 8.4) represents the difference in incomes of households. Since the mean value of the total income of the sample is 16,149,915 GNF (Table 8.3), the expected difference in the incomes of randomly selected households is 37.99 % of the mean income of 16,149,915 GNF, or 6,135,353 GNF. This result of expected difference is lower than the one (46.7 %) found by Omilola, (2009) in Nigeria. In our results and when considering the expected difference (37.99 % of mean income), salt production income, mangrove rice income, non-farm income and wood extraction income (Table 8.3), their corresponding values become 3,058,628 GNF; 1,601,209 GNF; 420,574 GNF and 289,942 GNF respectively.

The third column (Table 8.4) represents the Gini coefficient (G_k), which indicates equity in income distribution from each source of income. The Gk from different sources of income as a proportion of total Gk gives the contribution of each source of income to total inequality. For salt production income, the Gini coefficient dropped by 32.12 % (from 0.7011 to 0.3799).

Table 8.4: Gini Decomposition by income source

Income source	Share in total income (Sk)	Gini coefficient for income source (Gk)	Gini correlation with total income rankings (Rk)	Absolute contribution to Gini Coeff. of total income (Sk*Gk*Rk)	Share in total income inequality	Percentage change in overall Gini
1. Salt production	0.5046	0.7011	0.7590	0.2685	0.7068	0.2022
2. Non-farm income	0.0714	0.7443	0.2464	0.0131	0.0345	-0.0369
3. Remittance	0.0098	0.5975	0.0668	0.0004	0.0010	-0.0088
4. Livestock	0.0451	0.7989	0.2493	0.0090	0.0236	-0.0214
5. Wood extraction	0.0206	0.9270	-0.7714	-0.0147	-0.0387	-0.0592
6. Mangrove rice production	0.2712	0.5903	0.4703	0.0753	0.1982	-0.0730
7. Lowland rice production	0.0108	0.9409	0.0261	0.0003	0.0007	-0.0101
8. Vegetables production	0.0312	0.9658	0.6959	0.0210	0.0552	0.0240
9. Seasonal crop prod.	0.0236	0.8726	0.2397	0.0049	0.0130	-0.0106
10. Perennial crop	0.0118	0.9114	0.2008	0.0022	0.0057	-0.0061
Total income		0.3799				

Despite the highest contribution of salt production to total income, it is unequally distributed as indicated by the value of G_k (0.7011). Generally, the distribution of income by different income sources shows a high inequality ranging from 0.59 to 0.97 much higher than the overall Gini coefficient of 0.38.

The share in total income inequality (Table 8.4, column 6) indicates that salt production was the most important contributor to income inequality (71 % contribution). This inequality in salt production can be explained through the fact that when a new technology is introduced only peasants being organized into a group enjoy the benefits, whereas the poorer (non-organized peasants) get excluded which is a dilemma in Guinean rural areas. For example, among salt producers, only SM producers (93 %) belonging to an organized group, were found to receive tarpaulins (canvas or plastic sheets). These tarpaulins were provided by NGOs (*e.g. La Charente Maritime*) on a credit refundable basis after the salt harvesting. With respect to overseas training, only leaders from SM producers were offered this opportunity. Mangrove rice production was the second most important contributor (20 % contribution) to income disparity. This uneven distribution arose due to the mangrove rice farming types (improved and traditional). Furthermore, the difference related to farm size, inputs (type of seed varieties, fertilizer, agrochemical, labors, etc.) usage and output (productivity levels).

Wood extraction was the only source of income contributing to income equality (Table 4.4). This can be attributed to the easy access to the mangrove forest resources in Kito and Keregnon Islands. Based on the field investigation, wood loggers stated that "there were no worries of replenishment because there is a quick regeneration of almost

98 % of logged mangrove areas”. Wood loggers revealed that this regeneration is accelerated thanks to the significant presence of marshy areas. The regeneration of mangroves and the remoteness of these islands from the main inland of Koba probably indicate the reason why all interviewed wood loggers mentioned that there is no ban on extraction from mangrove forest in the above mentioned islands. However, the ban of mangrove logging was imposed in the Balessourou district (located in the main inland of Koba) where salt production is conducted.

The effect on income inequality when there is a small change in a particular source of income can be observed in the last column. The estimates showed that a 1 % increase in salt production income and vegetable production will increase the overall inequality by 20.22 and 2.4 % respectively. However, a 1 % increase in mangrove rice production, assuming other sources of income are constant, will reduce the overall inequality by 7.3 %. Similarly, the estimates indicated that 1 % increase in non-farm income, remittance, livestock, wood extraction, lowland rice production, seasonal and perennial crop production, assuming other sources of income are constant, will reduce the overall disparity by 3.7 %; 0.9 %; 2.1 %; 6 %; 1 %; 1 % and 0.6 % respectively.

The role of non-farm income on income inequality is reported by many researchers (De Janvry et al., 2005; Elbers & Lanjouw, 2001).

Table 8.5: Bootstrap statistics

Variable	Reps	Observed	Bias	Std. Err.	[95% Conf. Interval]		
Salt production	50	0.2022	-0.0036	0.0385	0.1249	0.2795	(N)
					0.1161	0.2539	(P)
					0.1161	0.3085	(BC)
Non-farm income	50	-0.0369	0.0007	0.0106	-0.0583	-0.0156	(N)
					-0.0562	-0.0108	(P)
					-0.0606	-0.0108	(BC)
Remittance	50	-0.0088	-0.0001	0.0020	-0.0128	-0.0048	(N)
					-0.0127	-0.0060	(P)
					-0.0139	-0.0060	(BC)
Livestock	50	-0.0214	0.0005	0.0060	-0.0335	-0.0094	(N)
					-0.0312	-0.0082	(P)
					-0.0333	-0.0090	(BC)
Wood extraction	50	-0.0592	0.0004	0.0125	-0.0844	-0.0341	(N)
					-0.0898	-0.0376	(P)
					-0.0951	-0.0376	(BC)
Mangrove rice production	50	-0.0730	0.0013	0.0235	-0.1202	-0.0257	(N)
					-0.1168	-0.0234	(P)
					-0.1168	-0.0234	(BC)
Lowland rice production	50	-0.0101	-0.0002	0.0031	-0.0162	-0.0039	(N)
					-0.0145	-0.0043	(P)
					-0.0145	-0.0032	(BC)
Vegetables production	50	0.0240	0.0003	0.0148	-0.0058	0.0538	(N)
					0.0015	0.0529	(P)
					0.0044	0.0564	(BC)
Seasonal crops production	50	-0.0106	0.0005	0.0056	-0.0220	0.0007	(N)
					-0.0208	0.0002	(P)
					-0.0247	-0.0001	(BC)
Perennial crops production	50	-0.0061	0.0002	0.0042	-0.0145	0.0023	(N)
					-0.0143	0.0007	(P)
					-0.0151	0.0007	(BC)

N = normal; P = percentile; BC = bias-corrected

Idowu et al., (2011); Buchenrieder, (2003); Knerr & Winnicki, (2003) reported that non-farm rural employment can reduce poverty by generating alternative income sources and it can stimulate agricultural growth and mitigate rural to urban migration and the findings of De Janvry et al., (2005); Zvyagintsev et al., (2008) too supported this outcome. The Gini decomposition analysis allows the estimation of bootstrapped standard errors and confidence intervals. To guarantee reproducibility of the results of the Gini decomposition analysis (Table 8.4), bootstrap statistics were produced as shown in Table 8.5.

8.5. Effects of livelihood activities on poverty reduction

Both Table 8.6 and Table 8.7 show three different poverty measures by using FGT (Foster-Greer-Thorbecke) index. Firstly, the poverty headcount index (P0), set at 3,217,305 Guinean Franc (GNF) per person per year, indicating the poverty line in Guinea as of 2012 (INS, 2012). Next, the depth of poverty represents the amount by which the average per capita income of the poor falls short of the poverty line. This poverty measure reports the poverty gap index (P1), which is measured in percentage terms how far the average income of the poor falls short of the poverty line. For instance, a poverty gap of 10% means that the average poor person’s income is 90% of the poverty line income. The third poverty measure is the squared poverty gap index (P2), indicates the severity of poverty. This squared poverty gap index possesses useful analytical properties, because it is sensitive to changes in distribution among the poor.

In order to determine the effect of salt production and mangrove rice production on poverty reduction, these two economic activities were associated with the other activities (Table 8.6). All the poverty measures (P0, P1 and P2) in respect to each combination show that the incorporation of salt production (SP) and mangrove rice production (MRP) into other activities could reduce the level, depth and severity of poverty in the study area. The size of the poverty reduction depends very much on how poverty is measured. Table 8.6 shows that when poverty is measured in terms of the headcount measure by associating the mangrove rice to salt production income, level of poverty is reduced by 5.52 %. Therefore, poverty is reduced much more when it measured by the depth and severity of poverty, such as the poverty gap and squared poverty gap.

Hence, the squared poverty gap measure indicates that inclusion of mangrove rice production (MRP) and other agricultural income (OAI) reduce poverty by 50% and 18% respectively. According to poverty headcount measure (Table 8.6, column 6); coupling each of the following income sources (salt production (SP), other agricultural income (OAI), non-farm income (NFI) and livestock (L) to mangrove rice production, the poverty level is reduced by 27.7 %, 3.76 %, 3.29 % and 2.82 % respectively. Table 8.6 shows that in respect to the headcount measure, the inclusion of remittance and animal rearing to the salt production income does not make any effect on the poverty reduction. Similarly, the inclusion of remittance (RE) to income from mangrove rice production does not produce any effect on the poverty reduction.

Table 8.6: Effect of salt and mangrove rice production incomes on poverty reduction

Livelihood activities	PLI/α			Livelihood activities	PLI/α		
	P0	P1	P2		P0	P1	P2
1.Salt production (SP)	0.7409	0.6423	0.6051	1.Mangrove rice (MRP)	0.9682	0.7232	0.6109
2.SP+MRP	0.7	0.4162	0.3021	2.MRP+SP	0.7	0.4162	0.3021
3.SP+OAI	0.7273	0.5715	0.4966	3.MRP+OAI	0.9318	0.6757	0.5661
4.SP+NFI	0.7318	0.574	0.4971	4.MRP+NFI	0.9363	0.6613	0.5438
5.SP+RE	0.7409	0.6347	0.5923	5.MRP+RE	0.9682	0.713	0.5965
6.SP+L	0.7409	0.5958	0.5249	6.MRP+ L	0.9409	0.6869	0.5796
$[[2-1]/1]*10^2$ (%)	-5.52	-35.20	-50.07	$[[2-1]/1]*10^2$ (%)	-27.70	-42.45	-50.55
$[[3-1]/1]*10^2$ (%)	-1.84	-11.02	-17.93	$[[3-1]/1]*10^2$ (%)	-3.76	-6.57	-7.33
$[[4-1]/1]*10^2$ (%)	-1.23	-10.63	-17.85	$[[4-1]/1]*10^2$ (%)	-3.29	-8.56	-10.98
$[[5-1]/1]*10^2$ (%)	0	-1.18	-2.12	$[[5-1]/1]*10^2$ (%)	0	-1.41	-2.36
$[[6-1]/1]*10^2$ (%)	0	-7.24	-13.25	$[[6-1]/1]*10^2$ (%)	-2.82	-5.02	-5.12

PLI= poverty line index; P0=poverty headcount index; P1=poverty gap index; P2=squared poverty gap index.

Table 8.7: Effect of wood extraction income on Poverty reduction

Livelihood activities	PLI/α		
	P0	P1	P2
1.Wood extraction (WE)	1	0.9784	0.9627
2.WE+NFI	0.9955	0.9059	0.8418
3.WE+RE	1	0.9681	0.9425
4.WE+ L	1	0.9311	0.8819
$[[2-1]/1]*10^2$	-0.45	-7.41	-12.56
$[[3-1]/1]*10^2$	0	-1.05	-2.10
$[[4-1]/1]*10^2$	0	-4.83	-8.39

PLI= poverty line index; P0=poverty headcount index; P1=poverty gap index; P2=squared poverty gap index.

In Table 8.6, the three poverty measures (P0, P1 and P2) show that the extent of poverty reduction varies with respect to the type of activity integrated into the salt and mangrove rice production. For example, when mangrove rice production is incorporated in salt production income, the effect on the poverty reduction is significant.

The reduction in headcount ratio, depth of poverty and squared gap index are 5.52 %, 35.20% and 50.07% respectively. The reduction with respect to these three measures is 27.7 %, 42.45 % and 50.55 % respectively, when the salt production and mangrove rice income are combined. Table 8.7 shows the effect of wood extraction income when incorporated into other income sources, except income from mangrove rice and salt production. These two activities were not associated with wood extraction. Table 8.7 indicates that when the wood extraction income is incorporated into non-farm income, the effect on poverty reduction is high. The reduction in headcount, depth of poverty and squared gap indices are 0.45 %, 7.41 % and 12.56 % respectively. However, based on the depth of poverty and squared gap ratio, the effect on poverty reduction is low when wood extraction income is included to remittance and livestock. There is no effect when it is estimated based on headcount ratio or poverty line (Table 8.7).

Reardon & Taylor, (1996), used Gini and Foster-Thorbecke-Greer decompositions of income inequality and poverty in the Sahelian zone of Burkina Faso before and after the severe drought of 1984. They revealed that in 1983, the poverty level was higher in the Sudanian zone (0.12, compared with 0.02 in the Sahelian zone and 0.01 in the Guinean zone). Our results relative to poverty indices (Table 8.6 & Table 8.7) revealed a higher poverty level compared to their findings. Reardon & Taylor, (1996), stated that understanding the links between income inequality and poverty is particularly important in Africa, where poverty is widespread and where, given low per-capita incomes, the poverty consequences of changes in the income distribution are likely to be significant.

8.6. Household assets, Access to housing and energy consumption

In order to justify the inequality among surveyed peasants, variables related to household assets, access to housing and energy consumption were examined. Among household assets, items such as refrigerator, TV, bicycle, bike, car, radio, mobile phone, stove charcoal and rocket stove and tripod were considered. Access to housing considered the state of the wall and the floor. With respect to access to energy consumption, respondents rely on charcoal, kerosene, gas/batteries, fuel wood from mangrove and upland forest. Rakodi, (1999) reported that improved access to physical or produced capital (basic infrastructure and the production equipment and means which enable people to pursue their livelihoods) is an essential element of strategies to reduce household poverty.

Ndambiri et al., (2012) stated that series of livelihood outcomes had emanated from the economic ways of life of farm households in Kenya. These outcomes lead to increased financial ability of the households to: (1) acquire more land for farming, (2) starting businesses, (3) hire more land for cultivation, (4) put up toilets, (5) roof houses with iron sheets, (6) put up stone walls in their houses, (7) pay cooperative fees and (8) improve floor material of their houses.

Table 8.8 indicates that access to housing relative to wall and floor indicated a significant difference among respondents. Access to thatched and wooden walls was only found in campsites of the traditional salt producers. Despite the significant availability of wall with bricks (72.3 %) more than 50 % of walls were without cement layers. The brick walls with cemented layers represent a sign of decent housing. However, thatched, muddy and wooden walls indicate a sign of household living in poverty. In addition, floor with soil and cowpat is an indication of peasants living in poverty. The cemented floor (56.4 %) is an indication of better off peasants.

In Guinea, IMF, (2013) reported that in terms of inequity of access to decent housing, the percentage of individuals who have shelters with permanent walls grew nearly 9 % in the countryside between 2007 (22.6%) and 2012 (31.5%).

Table 8.8: Household assets and Access to housing and energy sources in the household

Variables				WE (%)	TSP/GS (%)	SM (%)	TMR (%)	IMR (%)	Total (%)	p-value
Access to housing	Wall	Thatched	No	9.1	1.8	18.2	22.7	22.7	74.5	0.000***
			Yes	0	25.5	0	0	0	25.5	
		Wooden	No	9.1	5.5	18.2	22.7	22.7	78.2	0.000***
			Yes	0	21.8	0	0	0	21.8	
		Mud	No	9.1	17.3	18.2	19.5	16.4	80.5	0.000***
			Yes	0	10.0	0	3.2	6.4	19.5	
		Brick©	No	0	23.6	0	2.3	1.8	27.7	0.000***
			Yes	9.1	3.6	18.2	20.5	20.9	72.3	
	Floor	soil	No	3.2	1.8	16.4	12.7	14.5	48.6	0.000***
			Yes	5.9	25.5	1.8	10.0	8.2	51.4	
		cowpat	No	9.1	24.5	18.2	20.0	20.9	92.7	0.133
			Yes	0	2.7	0	2.7	1.8	7.3	
		cement©	No	4.5	23.6	1.4	10.5	3.6	43.6	0.000***
			Yes	4.5	3.6	16.8	12.3	19.1	56.4	
Household assets	Refrigerator©		No	9.1	27.3	18.2	22.7	22.7	100	a
			Yes	0	0	0	0	0	0	
	Television©		No	9.1	26.4	17.7	21.4	20.9	95.5	0.531
			Yes	0	0.9	0.5	1.4	1.8	4.5	
	Bicycle		No	5.9	8.6	2.7	12.7	8.6	38.6	0.000***
			Yes	3.2	18.6	15.5	10.0	14.1	61.4	
	Motorbike©		No	9.1	20.0	5.9	13.6	7.7	56.4	0.000***
			Yes	0	7.3	12.3	9.1	15.0	43.6	
	Car©		No	9.1	25.5	15.0	22.7	22.7	95.0	0.001***
			Yes	0	1.8	3.2	0	0	5.0	
	Radio		No	0.9	3.2	1.4	7.7	10.0	23.2	0.000***
			Yes	8.2	24.1	16.8	15.0	12.7	76.8	
	Mobile phone		No	1.8	25.0	0.9	8.2	8.6	44.5	0.000***
			Yes	7.3	2.3	17.3	14.5	14.1	55.5	
	Stove charcoal©		No	9.1	12.3	11.4	11.8	22.7	67.3	0.000***
			Yes	0	15.0	6.8	10.9	0	32.7	
	Rocket stove efficient wood cooker©		No	3.6	23.6	4.5	14.1	6.8	52.7	0.000***
			Yes	5.5	3.6	13.6	8.6	15.9	47.3	
	Tripod		No	2.3	4.5	13.2	11.4	15.9	47.3	0.000***
			Yes	6.8	22.7	5.0	11.4	6.8	52.7	
Access to energy consumption	1.Firewood from mangrove forest		No	0	25.9	18.2	4.1	11.8	60.0	0.000***
			Yes	9.1	1.4	0	18.6	10.9	40.0	
	2.Firewood from upland forest		No	0	0	0	8.6	0.9	9.5	0.000***
			Yes	9.1	27.3	18.2	14.1	21.8	90.5	
	3.Charcoal		No	7.7	5.9	10.9	9.1	22.7	56.4	0.000***
			Yes	1.4	21.4	7.3	13.6	0	43.6	
	4.Electricity©		No	9.1	27.3	18.2	22.7	22.7	100	a
			Yes	0	0	0	0	0	0	
	5.Kerosene		No	9.1	27.3	18.2	21.8	10.0	86.4	0.000***
			Yes	0	0	0	0.9	12.7	13.6	
	6.Gas/batteries		No	5.5	27.3	12.3	20.5	5.0	70.5	0.000***
			Yes	3.6	0	5.9	2.3	17.7	29.5	

© = convenient household resources mostly owned by wealthiest peasants; a = no statistics are computed because the variable is a constant. *** = statistically significant at 1 % level.

There are also problems of access to property ownership. Of 77.4% homeowners, about 32% own their houses in urban areas. The rate of house rent remains high, in Conakry (about 54%) as well as in other cities in the country (about 55%). Access to home ownership is hampered by various factors [Note 8.2].

Household asset ownership revealed the difference among respondents, indicating that most of them are poor since nobody owned a refrigerator. In addition, only 5 % reported having a car. Respondents using tripod (52.7 %) are vulnerable to poverty. Vulnerability to poverty can first be defined as a probabilistic concept: it is the risk of falling into poverty when one's income or consumption falls below a predefined poverty line. This calls for a quantitative approach to vulnerability that implies estimating a probability as well as selecting a poverty line [Note 8.3] (Echevin, 2013). Echevin, (2013) measured the vulnerability to asset-poverty in Sub-Saharan Africa using an asset-based index. Among household assets, Echevin, (2013), considered liquid assets such as: radio, television, refrigerator, bicycle and car. He also considered more durable assets such as housing. This encompassed tap water, surface water, flush toilet, no toilets, electricity and finished floor. Those households owning television, refrigerator, or car are among the wealthiest, whereas those declaring only a radio or a bicycle are among the poorest. In addition, households with access to electricity; tap water and flush toilet are among the wealthiest (Echevin, 2013).

Access to energy consumption is also an important indicator for evaluating the level of poverty among surveyed peasants. Table 8.8 shows that electricity was not available for all peasants. Energy consumption comes mainly from firewood of upland forest (90.5 %), charcoal (43.6 %) and firewood of mangrove forest (40 %). These figures indicated that the majority of surveyed peasants rely on the natural resources. The natural resources on which the rural poor most depend may, because of their lack of access to private assets, be common pool resources (Rakodi, 1999).

IMF, 2013 reported that Guinean households barely use clean energy (gas and electricity) because of low income. Rather, they have access to wood and its by-products. More than 74% of households (ELEP, 2012) use firewood for cooking and more than one household in five (23.9%) use charcoal. This, on the one hand, adds to the burden of women and girls, notably in rural areas, when they have to walk long distances to fetch wood for cooking. And, this situation leads to the degradation of resources, especially because of strong pressure from the poor population that depends on these resources (especially on the outskirts of Conakry), along with deforestation and deteriorating soil fertility, which could reduce agricultural productivity.

In terms of unequal access to electricity, the percentage of individuals benefitting from this source of lighting grew slightly in the countryside between 2007 (1.4%) and 2012 (2.6%). On the other hand, in urban areas, there has been a strong decline of access to electricity by 10.2 % between 2007 (65.7%) and 2012 (55.5%). In 2012, one out of five households at national level used electricity as an energy source for lighting, mainly in urban areas. In rural areas, the service was virtually unavailable. All regions, with the exception of Conakry, find it difficult to access this source of energy because the supply is weak, and poverty has worsened, especially in the towns.

8.7. Summary

This chapter investigated the influence of portfolio of livelihood activities on income inequality and poverty reduction in the Guinean coastal area. The study used primary data collected through a survey of salt producers, mangrove rice farmers and wood loggers along the Guinean coast in Koba. The survey used a questionnaire to collect data on peasants' characteristics and their income sources. To examine the effects of livelihood activities on income inequality and poverty reduction, Gini decomposition analysis and poverty decomposition techniques such as Foster-Greer-Thorbecke (FGT) index were used.

The results revealed that salt production and vegetable production give rise to income inequality. Therefore, by enhancing the share of income from mangrove rice production, wood extraction, non-farm income, livestock, seasonal crop production, lowland rice production, remittance and perennial crop production has the potentials to reduce income disparity among the peasants. Poverty measures also revealed that the degree of poverty reduction largely depends on the extent to which livelihood activities of the peasants can be diversified. The government could remedy the income inequality arising from salt production and reduce poverty by providing machineries and tools to poorer farmers to ensure their participation in salt production. Further, this chapter also highlights the need to put more emphasis on mangrove rice production due to its high potential to reduce income inequality in the region.

Notes

[Note 8.1] The *SAKOBA* shrimp farm was established in 1995 and the production was shut down in 1999. This industrial farm built by the Guinean Government included 400 hectares of ponds with a processing plant and hatchery which did not produce more than 250 tons. Among the serious problems of poor management and the choice of an inadaptable site- production has never been operational to date. A large scale hatchery was located on the isolated island of Tamara, offshore of Conakry, while the farm was located over two hours by road up the coast of Guinea in the region of Koba. From its inception, the project was plagued by cost over-runs and poor management. These problems were compounded by logistical issues (proximity of the two integral facilities), and unmanageable technical problems (acid soil, and silted water on the farm).

[Note 8.2] (i) the lack of a suitable financing mechanism, (ii) the inexistence of a Bank dedicated to housing (especially social) and the lack of credit channels specific to housing in classic banking and financial networks; (iii) weak support for a wide-scale do-it-yourself construction system; (iv) a high level of poverty that deprives a large segment of the population from access to housing; (v) the absence of public-private partnerships and the weak performance of the Guinean private sector in the development of real estate; (vi) women's lack of access to property ownership.

[Note 8.3] An intuitive threshold is when the probability of being poor in the future exceeds 50%; people should be considered vulnerable in this case since they are more likely to fall into poverty than not to be poor in the future (Pritchett et al., 2000).

CHAPTER IX

IMPACTS OF HOUSEHOLD ENERGY CONSUMPTION AND LIVELIHOOD ACTIVITIES ON COASTAL FORESTS IN GUINEA

9.1. Introduction

The coastal ecosystems are always the most exploited because most of the world's population inhabits the coastal regions (Pernetta, 1993). Mangroves play a crucial role in the ecology and the economy of coastal communities (Ellison, 1997; Naylor and Drew, 1998; Dahdouh-Guebas et al., 2000). In the coastal areas, mangroves provide the only source of energy for domestic uses as well as for fish smoking activities (Chong, 1987). They are also an important source of charcoal. Throughout the entire West African region fuel wood provides the main source of energy for rural households and the main source of cooking fuel in urban areas. Fuel wood and charcoal provide the predominant source of energy for small-scale processing enterprises such as palm oil production and fish smoking. Estimates of fuel wood consumption are available for most urban centers in the region, especially for fuel wood consumption in arid regions (Davidson 1985, Njomgang 1987, Oguntala 1986, Energy Initiatives for Africa 1986). Population pressure is typically greatest along the coast, so it is no surprise that human influences on the world's mangrove forests are significant and growing. Mangroves have been cleared and degraded on an alarming scale during the past four decades (Valiela et al., 2001; Wilkie and Fortuna, 2003; Duke et al., 2007), yet they remain an important source of wood and food products and provide vitally important environmental services for coastal communities throughout the tropics (Balmford et al., 2002).

In Sub-Saharan Africa, biomass accounts for about 80–90 % of the primary energy consumption of private households. In the developing nations of sub-Saharan Africa, providing households with modern energy services is a critical step towards development. A large majority of households in the region relies on traditional biomass fuels for cooking, which represent a significant proportion of domestic energy use. The disadvantages of these fuels are many: they are inefficient energy carriers and their heat is difficult to control; they produce dangerous emissions; and their current rate of extraction is not sustainable for forests. Increasingly, the unsustainable harvesting of trees for fuel wood and charcoal is contributing to deforestation especially in Africa. Almost 90% of the wood removals are used for fuel. Soil erosion and water loss can be of further consequences (FAO, 2007; The World Bank, 2009). In the absence of affordable modern fuels and electricity, 90% of the Sub-Saharan African population relies on traditional fuels for cooking, heating and lighting (Brew-Hammond and Kemausuor, 2009; Karekezi et al., 2008; Wolde-Rufael, 2009). The use of biomass fuels for cooking has a range of adverse consequences.

In Guinea, households barely use clean energy (gas and electricity) because of low income. Rather, they have access to wood and its by-products (IMF, 2013). More than 74% of households (ELEP, 2012) use fuel wood for cooking and more than one household in five (23.9%) use charcoal. This, on the one hand, adds to the burden of women and girls, notably in rural areas, when they have to walk long distances to fetch wood for cooking. On the other hand, this situation leads to the degradation of resources, especially because of strong pressure from the poor population that depends on these resources (especially on the outskirts of Conakry), along with deforestation and deteriorating soil fertility, which could reduce agricultural productivity. In terms of unequal access to electricity, the percentage of individuals benefitting from this source of lighting grew slightly in the countryside between 2007 (1.4%) and 2012 (2.6%). On the other hand, in urban areas, there has been a decline in access to electricity by 10.2 % between 2007 (65.7%) and 2012 (55.5%). In 2012, one out of five households at national level used electricity as an energy source for lighting, mainly in urban areas. In rural areas, the service was virtually unavailable. All regions, with the exception of Conakry, find it difficult to access this source of energy because the supply is weak, and poverty has worsened, especially in the towns. Electricity production capacity in Guinea is too low to meet the needs of the country and achieve accelerated growth objectives. Guinea’s level of energy performance is among the weakest in the world. Consequently, energy consumption per inhabitant is less than the equivalent to half a ton of petroleum (TEP), with 80% coming from biomass, 18% from hydrocarbons and 2% from electricity. Fuel wood for cooking and wood coal are the main fuels used by households.

According to WEO (2006), the use of biomass is not in itself a cause for concern. However, when resources are harvested unsustainably and energy conversion technologies are inefficient, there are serious adverse consequences for health, the environment and economic development (WEO, 2006). A variety of factors related to human pressure over coastal areas cause degradation of mangrove forests, namely cutting and clearing for lumber and fuel wood, agriculture and coastal development, and replacement with aquaculture (Valiela et al., 2001). Without strong new policies to expand access to cleaner fuels and technologies, the number of people in developing countries relying on traditional biomass as their main fuel for cooking will continue to increase as the global population increases. According to PDO-ICZMP, (2004), the coastal livelihood analysis provides a better understanding of coastal livelihood conditions at present and in future. This understanding has been instrumental in preparing a meaningful coastal zone policy, and would guide the formulation of a pragmatic coastal development strategy and a feasible investment program for enhancement of livelihoods of the coastal people, particularly the disadvantaged groups.

In this backdrop, the objective of this paper is to examine the impact of household energy consumption on both mangrove and upland forests in the Guinean coastal area; to describe scenarios of livelihood activities and household energy consumption over these forests and to provide some policy prescriptions for improving the livelihood and sustainable coastal forests management.

9.2. Household energy consumption

The assessment of household energy consumption among the surveyed peasants is tested using binary qualitative questions. These questions included two types of household energy consumption: (1) the consumption of traditional fuels comprising the following biomass such as fuel wood from mangrove forest, fuel wood from upland forest and charcoal. (2) The consumption of modern fuels included kerosene, batteries and electricity. With respect to the consumption of traditional biomass, the pooled sample indicated that 91 %; 44 % and 40 % of peasants relied on the fuel wood extracted from the upland forest, charcoal and fuel wood collected from the mangrove forest respectively (Table 9-1). These results corroborate with findings from ESMAP (1994), indicating that charcoal and fuel wood account for more than 95% of the total household energy consumption.

It was found that all wood loggers (Table 9-1) to be using the mangrove wood as a source of household energy consumption. This is due to their close proximity to the mangrove forest and the fact that mangrove wood extraction is their main activity. Moreover, they stated that there is no restriction on the mangrove wood extraction in their area. On the contrary, SM producers mentioned the remoteness of the mangrove forest to their homestead. And they also reported close proximity of their operating sites of salt production to the mangrove forest. Despite, this closeness a ban on mangrove wood logging was imposed in *Balessourou* district where salt producers (SM and TSP/GS) are operating. The use of fuel wood from mangrove forest by TSP/GS was purchased from wood sellers from other areas. The consumption pattern of modern fuels (Table 9-1) revealed that 30 %, 14 % of peasants used batteries, kerosene and none electricity in these rural areas.

Table 9-1: Source of household energy consumption

Variables		WE	TSP/GS	SM	TMR	IMR	Overall	p-value
Firewood from mangrove forest (%)	No	0	25.9	18.2	4.1	11.8	60.0	0.000***
	Yes	9.1	1.4	0	18.6	10.9	40.0	
Firewood from upland forest (%)	No	0	0	0	8.6	0.9	9.5	0.000***
	Yes	9.1	27.3	18.2	14.1	21.8	90.5	
Charcoal (%)	No	7.7	5.9	10.9	9.1	22.7	56.4	0.000***
	Yes	1.4	21.4	7.3	13.6	0	43.6	
Electricity (%)	No	9.1	27.3	18.2	22.7	22.7	100	a
	Yes	0	0	0	0	0	0	
Kerosene (%)	No	9.1	27.3	18.2	21.8	10.0	86.4	0.000***
	Yes	0	0	0	0.9	12.7	13.6	
Batteries (%)	No	5.5	27.3	12.3	20.5	5.0	70.5	0.000***
	Yes	3.6	0	5.9	2.3	17.7	29.5	

a = no statistics are computed because the variable is a constant.

9.2.1. Monthly expenditures on household energy consumption

The estimation of monthly expenditures on household energy consumption is shown in Table 9-2. Overall, the mean expenditure is statistically significant indicating a difference among peasants. The pooled sample shows that the average monthly expenditure on fuel wood collected from the upland forest is greater than other expenditures, representing 122,077 Guinean Franc (GNF). This is followed by the mean expenditure (56,000 GNF) of fuel wood from the mangrove forest (Table 9-2). The monthly expenditure on the charcoal represents 22,886 GNF. Normally, the charcoal is made from the fuel wood from the upland forest. This shows that in the study area most of the fuel wood used for the household energy consumption is extracted from the upland forest. This could be justified due to the partial restriction imposed in the mangrove forest (section 9-3) particularly in some districts such as Balessourou and Bentya.

In Balessourou district, the restriction on mangrove forest logging was imposed by the local government, while in Bentya district, it was decided by farmers belonging to the Darabo union. The average monthly expenditure on the consumption of traditional fuel wood was almost collected from the upland forest (Table 9-2). Chapter IV based on the spatial analysis, conducted to the coastal area of Guinea, revealed that 41.7% of the 5,099 ha studied has undergone changes during the period of 20 years (1990 to 2010), where the upland forest has increased by 448.2%. This increase on the upland forest was attributed to factors such as local population growth, whose annual growth rate is estimated to be 54% and immigration of farmers (55%).

The average monthly consumption of modern household energy (kerosene, electricity and batteries) is low (Table 9-2). This low consumption of modern fuel can be explained because the majority of surveyed peasants rely most more on the consumption of traditional fuel (Table 9-1 and 9-2). Osei (1993) indicated that for many developing countries, fuel wood constitutes the cheapest and most accessible source of household fuel for the majority of the population, especially those living in rural areas.

Table 9-2: Monthly expenditures on household energy consumption based on their sources

Districts		Taboria	Balesourou		Makinsi	Bentya	Overall	p-value
Source of energy consumption		WE	TSP/GS	SM	TMR	IMR		
Firewood from mangrove forest (GNF)	Mean	250,000	22,667	0.00	67,760	55,600	56,945	0.000***
	Std. error	13650	14710	0.00	10063	12307	7069	
	Minimum	160000	0.00	0.00	0.00	0.00	0.00	
	Maximum	370000	800000	0.00	270000	300000	800000	
Firewood from upland forest (GNF)	Mean	272600	123667	235500	41360	49940	122,077	0.000***
	Std. error	10020	13272	9352	8794	4899	7346	
	Minimum	189000	60000	130000	0.00	0.00	0.00	
	Maximum	360000	800000	360000	230000	150000	800000	
Charcoal (GNF)	Mean	4,000	48,000	19,200	26,140	0.00	22,886	0.000***
	Std. error	2224.27	3434.62	5150.21	4599.29	0.00	2083.17	
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	
	Maximum	30,000	75,000	150,000	120,000	0.00	150,000	
Electricity (GNF)		0.00	0.00	0.00	0.00	0.00	0.00	a
Kerosene (GNF)	Mean	0.00	0.00	0.00	620	6480	1,614	0.000***
	Std. error	0.00	0.00	0.00	445	1191	338	
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	
	Maximum	0.00	0.00	0.00	19000	30000	30000	
Batteries (GNF)	Mean	13900	2500	15575	13620	5400	9,100	0.057*
	Std. error	4091	1477	5410	5992	606	1794	
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	
	Maximum	45000	60000	200000	180000	15000	200000	

a = no statistics are computed because the variable is a constant. *** = statistically significant at 1% level, * = statistically significant at 10% level.

9.2.2. Other household monthly expenditures and perception on food security

Table 9-3 presents the household monthly expenditures on food and other household expenditure such as contribution to ceremonies, transportation, children education and health care. 99 % (218) of surveyed peasants indicated that they don't secure food (Table 9-3). The average monthly expenditure (479,091 GNF) on food is the highest and then followed by the one (129,395 GNF) from the health care. The significant monthly average expenditure on food (Table 4) could have a significant effect on the household energy consumption. This is in line with Reddy (2004), who indicated that energy consumption increases due to increase of dishes prepared. Also supplementary items like vegetables, milk, meat etc., are added to food grains and more energy is required to cook the additional food. This results in the increasing use of energy. As the majority of surveyed peasants relies on the traditional biomass fuels cooking, this could cause some health problems to the household members and may increase the health care (Table 9-3). According to Schlag and Zuzarte (2008), the disadvantages of these traditional fuels are many: they are inefficient energy carriers and their heat is difficult to control; they produce dangerous emissions; and their current rate of extraction is not sustainable for forests. Transition to clean cooking fuels such as liquefied petroleum gas (LPG) or ethanol would resolve many of these issues as they do not produce dangerous particulate emissions, and are commercially viable, offering a number of socio-economic advantages over traditional options.

Table 9-3: Other household expenditure and perception on food security

Food and social factors		WE	TSP/GS	SM	TMR	IMR	Overall	p-value
Foods (GNF)	Mean	380000	599833	373625	540500	396800	479,091	0.000***
	Std. error	26388	31080	32367	68220	24111	20470	
	Minimum	200000	360000	190000	100000	30000	30000	
	Maximum	600000	1800000	1575000	2500000	630000	2500000	
Food security	Not enough	20	60	40	48	50	218	0.143
(dummy)	Enough	0	0	0	2	0	2	
Children	Mean	91750	70583	73200	125760	83700	88,505	0.014**
education	Std. error	12994	5130	2932	23067	9100	6073	
(GNF)	Minimum	30000	0.00	30000	0.00	0.00	0.00	
	Maximum	240000	200000	120000	800000	360000	800000	
Contribution to	Mean	65400	71817	104375	60660	90600	78,886	0.001***
ceremonies	Std. error	3585	2366	6114	13406	6403	3757	
(GNF)	Minimum	30000	40000	40000	5000	30000	5000	
	Maximum	86000	120000	300000	450000	200000	450000	
Health care	Mean	125000	73000	153875	206620	102020	129,395	0.000***
(GNF)	Std. error	12107	8040	14617	34139	5988	9238	
	Minimum	30000	30000	50000	25000	50000	25000	
	Maximum	200000	400000	600000	950000	210000	950000	
Transportation	Mean	85650	51333	99000	128200	92400	89,923	0.005***
(GNF)	Std. error	10850	1817	15973	23724	14223	7197	
	Minimum	30000	30000	40000	12000	15000	12000	
	Maximum	210000	80000	660000	960000	400000	960000	
Others (GNF)	Mean	0.00	167	0.00	14960	0.00	3,445	0.000***
	Std. error	0.00	167	0.00	4200	0.00	1038	
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	
	Maximum	0.00	10000	0.00	150000	0.00	150000	

9.2.3. Type of cooking devices

The previous section indicated that surveyed households don't rely on the modern energy which is supposed to limit the threats on mangrove and upland forest from deforestation. Hence, it is necessary to present the situation of cooking devices for the investigation of their impacts on the household and forest levels. As presented in Table 9-4 the traditional cooking device, the open three-stone stove (tripod) is the common device (53%) in use. Such significant usage could impact negatively on the household health.

The adoption of improved cooking devices (Table 9-4) such as rocket stove and charcoal stove for the household energy consumption represents 47.3% and 32.7%, respectively. These improved cooking devices (improved cookstoves) that burn biomass more cleanly and efficiently, and could thus help mitigate health and environmental problems (Hulscher, 1998; Masera et al., 2007). These above figures related to the improved burning cookers (cooking devices) indicated that the promotion of improved stoves in the study area remains insignificant. This confirms findings of ESMAP (1994), which indicated that in Guinea, since 1983, the *Secrétariat d'État aux Energies* (SEE) has run a program (Improved Stove Project [PFA]) to disseminate improved household stoves in Conakry, capital city of Guinea. Yet in 1990, less than 2% of households in

Conakry possessed an improved stove. During the same period, improved stove programs in Burkina Faso and in Niger achieved a penetration rate of 30-40% in the urban households. In Guinea, a prototype for an improved stove for fish smoking was tested, but rejected by the end users because of claims that its use led to a change in the taste of the fish products. In 1989, a project was initiated to disseminate improved charcoaling techniques among professional charcoalers in the prefecture of Dubreka. But because of a ban on charcoaling by the prefectural authorities, the same year, the program had to be stopped without results.

Table 9-4: Traditional and improved cooking devices

Type of burning cookers		WE (%)	TSP/GS (%)	SM (%)	TMR (%)	IMR (%)	Overall (%)	p-value
Charcoal stove ©	No	9.1	12.3	11.4	11.8	22.7	67.3	0.000***
	Yes	0	15.0	6.8	10.9	0	32.7	
Rocket stove© (efficient wood cooker)	No	3.6	23.6	4.5	14.1	6.8	52.7	0.000***
	Yes	5.5	3.6	13.6	8.6	15.9	47.3	
Tripod (open three-stone fire)	No	2.3	4.5	13.2	11.4	15.9	47.3	0.000***
	Yes	6.8	22.7	5.0	11.4	6.8	52.7	

© = convenient household resources mostly owned by wealthiest peasants; *** = statistically significant at 1% level.

9.3. Scenarios on mangrove and upland forests related to household energy consumption and livelihood activities

Figure 9-1 describes the scenarios related to the use of the biomass from both mangrove and upland forest. These scenarios are classified into three groups (scenarios A, B and C). Each scenario presents the flux of biomass used as household energy (HE) consumption and other usage regarding livelihood activities such as wood extraction (WE), salt production (SP) and mangrove rice (MR) cultivation. All scenarios indicated that the household energy (HE) consumption is coming from both mangrove and upland forests. In contrast, the access to these forests differs according to the purpose of the livelihood activities (WE, SP and MR) conducted. Peasants could be directly or indirectly implicated to the fuel wood collection from these forests. They are acting directly when members from the household are collecting fuel wood from mangrove and/or upland forests. The indirect action happens when the household is purchasing bundle of fuel wood from a lumberman (woodcutter). The remoteness of the mangrove forest from homestead leads to the purchase of fuel wood consumed as household energy. This corroborates with the findings of Adesina and Baidu-Forson (1995) who mentioned that farmers are obliged to travel several kilometers to search for fuel wood in the mangrove areas in Guinea.

9.3.1. The "Scenario A"

This scenario represents the situation where no restriction or ban was imposed to the access of the mangrove forest. Before any restriction or ban was imposed to the wood exploitation on mangrove forest, wood loggers (WE) were extracting natural resources (poles, chopped wood, etc.) and sold them to: (1) owners of building sites, (2) fish smokers practicing *bonga* smoking in *Taboria* port, and (3) wood sellers of fuel wood for cooking. One of the most common uses of mangroves is as a source of wood (e.g. Ewel et al., 1998; Spalding, 2004; Walters et al., 2008; Spalding et al., 2010). The two most widespread uses of mangrove wood are for fuel and construction. As mangrove wood is strong, durable and rot-resistant, they are well suited for construction purposes. The extraction of poles is mostly for the construction of houses and fishing stakes. Mangrove poles are in great demand as piles for building.

For fish smoking, mangrove wood is preferred because of its high calorific value and its combustion imparts a golden brown color to the smoked fish, enhancing their marketability (Feka et al., 2008). In addition, smoke from burning mangrove wood has antimicrobial properties. Large quantity of wood is used for fish smoking, chiefly due to the low fuel efficiency of the traditional smoke system (Feka et al., 2008, 2009). In the coastal area of Guinea, fish smoking is a popular method of fish preservation. ESMAP (1994) reported that the drying and fish smoking consumes an estimated 54,000 tons of fuel wood per year, most of which comes from the mangroves. Fuel wood and charcoal are the major source of energy in Guinea.

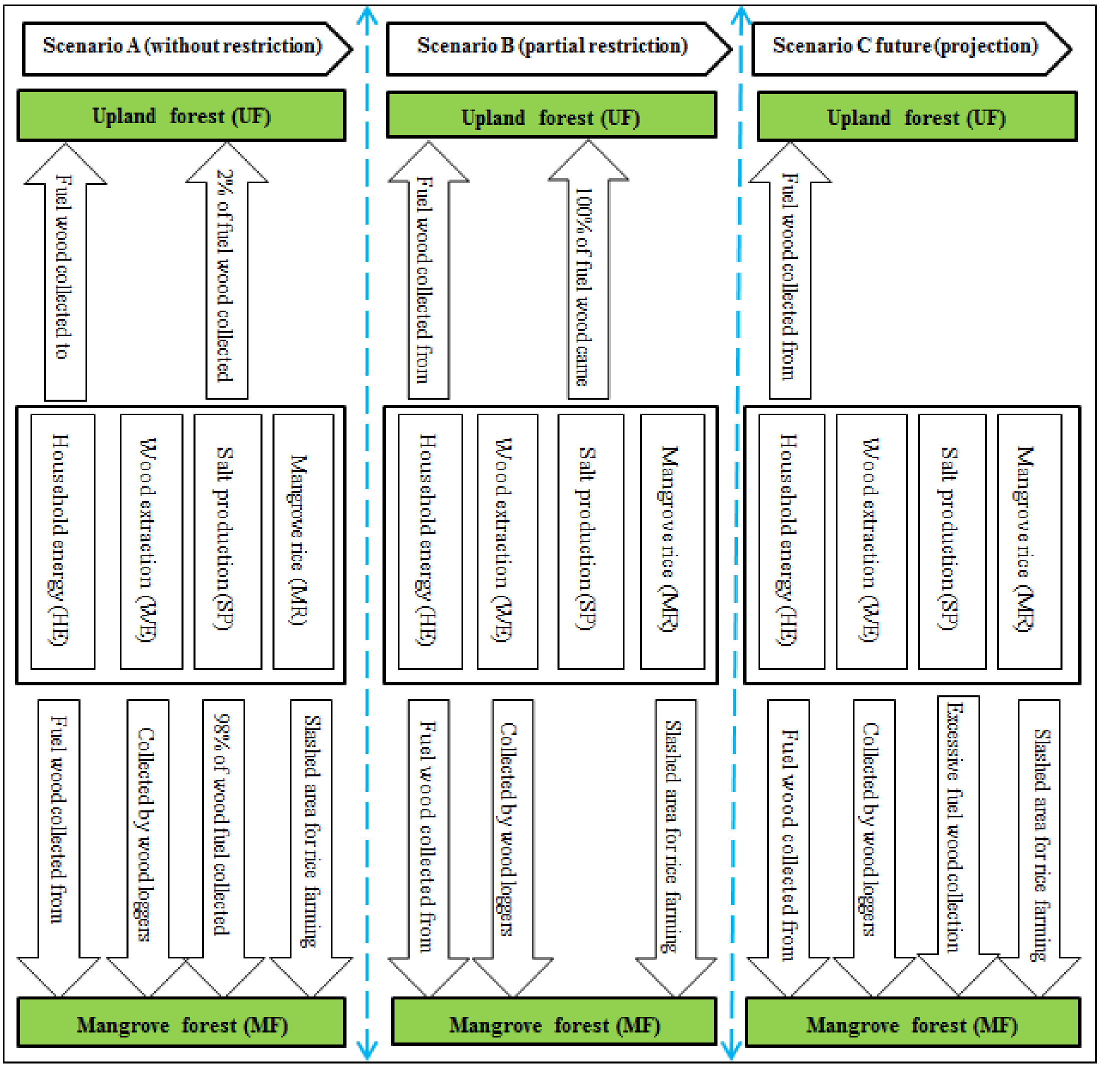

Figure 9-1: Scenarios of household energy (HE) and livelihood activities (WE, SP and MR) over the coastal forests (MF and UF) in Guinea

That is used by 99 % of households (ESMAP, 1994). In 1990, the energy demand of the household and informal sector amounted to 0.95 million toe or 61 % of final energy demand in Guinea. Wood fuels cover more than 90% of this demand. Rural and urban residents use mostly fuel wood; in Conakry, the consumption of charcoal is important as well. The scenario A also indicated that salt production (SP) relies more on wood harvested from the mangrove forest. The traditional salt production is characterized by a preparation of the brine. This brine obtained by filtering the salty earth is poured into the pan. Its utilization is conditioned by the usage of wood gathered from the mangrove or upland forests. Before the ban on mangrove wood cutting was imposed to salt producers in *Balessourou* district, more than 95 % of firewood was collected into the mangrove forest. The significant use of mangrove wood is due to its higher quality. This corroborates with findings of Chapter VI, that traditional salt producer's usage of mangrove wood could provide a better quality salt compared to the usage of fuel wood collected from the upland forest as the mangrove wood smokes less than fuel wood extracted from upland forest.

ESMAP (1994) indicated that salt is produced in the mangroves in a very energy inefficient way and consumed an estimated 93,000 tons of fuel wood in 1990. From an economic point of view, the national benefits from the production can hardly justify the economic cost of the consumed wood. But salt extraction is economically important for the villages along the coast, and provides subsistence for more than 8,000 households. The mangrove rice (MR) production, as shown in the "scenario A", contributes to the mangrove forest logging. We observed in the *Makensi* district that there is conversion of land uses. The regenerated mangrove forest from the abandoned shrimp farming area was slashed for practicing mangrove rice cultivation. In the *Bentya* district, farmers indicated that before the implementation of the irrigation system, mangrove forest was converted into rice farms. This land use conversion was reported by Chapter IV, indicating that the main land use types that have been transformed into paddy fields include mangrove forest (37.0 % of paddy field) and slashed area (26.0 % of paddy field). The study based on the spatial analysis revealed that about 41.7% of the 5,099 ha studied has undergone changes between 1990 and 2010. These changes indicate an increasing human pressure on natural resources in the Guinean coastal belt, mainly exerted by the migrant farmers and the growing local population. The mobility of farmers into the mangrove forest could result in embankment subsidence, to factors related to the management at the plot level, to the reduce use of modern farm technologies.

9.3.2. The "scenario B"

This scenario corresponds to a partial restriction imposed to certain surveyed areas. For example, in *Balessourou* district, salt producers indicated that a ban on wood extraction in the mangrove forest was imposed in 2004 by the local government of the Koba sub-prefecture. This ban comes to reduce the consequences due to the mangrove forest logging in this area. Salt producers reported that the area was flooded as results; the flood damaged the campsite and shortens the season of salt production. According to different salt producers, this restriction on wood extraction from the mangrove forest presents positive and negative effects. Both traditional and improved salt producers agreed that the ban limited the flood as there is a regeneration of the mangrove forest. The season of salt production is not disturbed by the flood. Due the ban of mangrove wood cutting, traditional salt producers depend much more on the upland fuel wood (Figure 9-1) where their costs are relatively significant (Chapter VI). Furthermore, traditional salt producers also invested significantly on the transportation of upland fuel wood. These producers moved to the upland forest for fuel wood collection. Therefore, the travelling distance from salt production campsite increased thereby increasing the firewood costs.

In *Bentya* district, after the irrigation development undertaken in 1999, the improved mangrove rice farmers reported that a ban on the mangrove forest cutting was decided by owners of the irrigated perimeters. Most of these land owners belong to the Darabo union. One of the objectives of this union is the protection of the mangrove forest band between irrigated perimeters and inlets of seawater. Farmers believe that the protection of this band of mangrove forest may ensure the food security and save their community from the inundation due the flood which could damage the rice fields. They stated that when mangrove forest is cut down, this could limit the rainfall and lead to droughts.

On the contrary to both above mentioned districts (*Balessourou* and *Bentya*), the restriction on the mangrove forest logging was not imposed in Keregnon according to the surveyed peasants in *Taboria*, as well in *Makinsi* district indicated traditional mangrove farmers. Surveyed wood loggers operate at two sites, Keregnon and Kito (Main Island) accessible only by canoes from Koba, the main inland. These wood loggers live in Kito, but mangrove woods are marketed in Taboria, principal port in Koba. The remoteness and difficult access (only by canoes) to these sites (Keregnon and Kito) of wood extraction from Koba could explain the reason that the local government did not impose any restriction on the mangrove forest logging. Based on the field investigation, wood loggers stated that "there were no worries of replenishment because there is a quick regeneration of almost 98% of logged mangrove areas". Wood loggers revealed that this regeneration is accelerated thanks to the significant presence of marshy areas. The regeneration of mangroves and the remoteness of these islands from the main inland of Koba probably indicate the reason why all interviewed wood loggers mentioned that there is no ban on extraction from mangrove forest in the above mentioned islands. However, the ban of mangrove logging was imposed in the Balessourou district (located in the main inland of Koba) where salt production is conducted.

In *Makinsi* district where the traditional mangrove rice cultivation is practiced, it was found that the abandoned area of shrimp farming is slashed for the purpose of the mangrove rice farming. The shrimp firm was established in 1995 and the production was shut down in 1999. This industrial farm built by the Guinean government included 400 ha. Before 1995, this area was under mangrove rice cultivation. In Chapter IV, I found that in Guinea mainly slashed area targeted for the mangrove rice farming came under the traditional mangrove rice farming (TMRF). Around this TMRF, farmers slashed over larger extents because the mangrove forests are controlled by the farmers themselves.

9.3.3. The "scenario C"

This scenario represents just a projection to the near future based on the previous scenarios (A and B). All scenarios show that the household energy consumption is coming from both mangrove and upland forests. The fuel wood is harvested by family members or by professional wood loggers in mangrove and upland forests. But this present study was limited to those harvesting from mangrove forest. It did not focus to upland charcoal makers and woodcutter or lumberjack. Based on the field investigation we conducted in the study area, it was found that the irrigated perimeters in Balessourou and Bentya are not maintained because farmers lack the means to perform such tasks requiring huge investment. Following this situation, if actions are not undertaken to maintain the irrigated perimeters, this will impact negatively on the mangrove forest when these perimeters become unproductive (e.g. due to salinity, acidification, etc.) merely because a decrease in the crop yield leads to land use transition. A previous study (Chapter IV) conducted in this coastal area, particularly in Doboro and Dofily districts (Dubreka prefecture) show that when yield decreases, farmers need more land to attend to their food requirements. The yield is mainly affected by sea water intrusion into the rice plots during the cultivation season, mainly due to the destruction of the dike constructed to prevent sea water intrusion into the rice plots.

In Guinea, salt production is a major driving force behind the loss of mangrove. As the traditional salt production causes increasing deforestation, the intensive exploitation of mangrove resources has now reached a critical threshold. With respect to salt production, it was found that only traditional salt producers rely on wood for the brine preparation. They reported that the cost of wood for the salt production is too expensive because the upland forest is located far from their campsite of salt extraction. This long distance increases the cost of wood transportation to the campsite. The salt produced by the improved techniques was of high quality due to fewer impurities. However, the salt produced by the traditional salt extraction technique had many impurities resulting from the usage of fuel wood collected from the upland forest. The improved salt production techniques do not require the usage of fuel wood. Traditional salt producers reported that the usage of mangrove wood could provide a better quality salt compared to the usage of fuel wood collected from the upland forest as the mangrove wood smokes less than fuel wood extracted from upland forest. In addition to the above mentioned factors (cost of wood, its transportation from the upland forest and poor quality), when a depletion of biomass from the upland forest occurs in the near future, this will push traditional salt producers to fetch the wood from the mangrove forest (Figure 9-1).

Despite the regeneration of logged mangrove areas as stated by wood loggers, a particularly attention is necessary because this regeneration occurred in the marshy areas. The poles, chopped wood, etc. extracted from the mangrove forest are marketed to owners of building sites, fish smokers, retailer of wood sellers, bakers etc. Hence, this means that the mangrove wood extraction is under commercial exploitation. This corroborates with findings of Alongi (2002), reporting that commercial practices are being increasingly adopted in developing nations due to strong pressure to increase wealth and living standards of people living in coastal areas. Commercial exploitation is commonly forced from outside the local community, and is nearly always on a scale much larger than the local forests can sustain. This exactly confirms the situation in the coastal area of Guinea because the majority of biomass extracted from the mangrove forest is drained to the urban cities where the main household energy consumption still remains the traditional fuel wood fuels such as the chopped wood and the charcoal.

9.4. Discussion

The household energy consumption pattern indicates that the surveyed peasants rely mainly on the consumption of traditional biomass resources derived from both mangrove and upland forests. However, utilization of mangrove biomass in some areas was limited due the remoteness of locations to the mangrove areas in one hand and one the other hand due to the partial restriction imposed in some areas especially where the traditional salt production was practiced. The areas, in which traditional salt production is conducted, were found near the mangrove forests. In these areas following to the ban against the mangrove wood logging, traditional salt producers depend on the upland forest. This dependence of peasants on traditional biomass consumption may impacts negatively on both coastal (mangrove and upland) forests because access to improved sources of energy was limited. ESMAP, (1994) mentioned that as the rural population in Guinea comprises two thirds of the total population, and rural per capita energy consumption is higher than the urban average. As a result, rural households account for 70% of final energy consumption in the household and informal sector. The urban household and informal sector accounts for the remaining 30% of the sectorial consumption. Fuel wood extraction has been identified as one of the most significant causes of forest degradation in many developing countries. According to one estimate, firewood accounts for over 54% of all global harvests per annum, suggesting a significant and direct role of fuel wood in forest loss (Osei, 1993).

Results of monthly expenditures of household energy consumption confirmed the dependence of peasants on the coastal forests. The overall monthly expenditure on firewood from upland forest was more than twice compared to the one from the mangrove forest. This difference arises due to the restriction of the mangrove wood extraction in some locations and the remoteness of mangrove forest from villages.

Mostly settlements found in areas where salt production was extracted are campsites of salt extraction. However, monthly expenditures on the modern household energy consumption such as kerosene and batteries were insignificant. Overall peasants did not access to electricity consumption. The consumption of electricity by households is negligible in Guinea. Even in Conakry, only 20 % of households have access to electricity. PAR (2010) reported that in 2009, Guinea's electrification rate was 12 % at the national level and 3% in rural areas. The current limited network as well as low investment in network rehabilitation and maintenance, partly explain the very low contribution of electricity to the country's energy needs.

In general, surveyed peasants utilized the traditional cooking devices. These devices may have major impacts on the mangrove and upland forests resources. They are economically inefficient due to the need for large quantities of wood for household cooking. They could also impact negatively on household health conditions as people are exposed to the smoke when using the traditional devices. Hence, the frequent use of the woods leads to deforestation of coastal forests that affects the climatic conditions. Therefore, a sustainable management of these coastal (mangrove and upland) forests is needed in order to bring a balance between coastal communities and these forests. The use of unsafe, inconvenient and inefficient of traditional cooking devices will not help to solve such problems. A more efficient and saving improved cooking devices would indeed go a long way to saving resources and promoting good environmental conditions for most coastal communities. Previous study (IEA, 2009) indicated that burning of biomass in traditional stoves is associated with a host of ills among the estimated 2.5 billion people around the world who lack access to modern fuels. According to estimations from the World Health Organization (WHO, 2006), very often biomass is burnt inefficiently in open three-stone fires, which causes severe health problems in women and children and affects the environment. Every year, smoke from open fires and traditional stoves causes death of approximately 1.5 million people (WHO, 2006).

The results of the scenario analysis indicated that partial restrictions on the mangrove forest exist in Balessourou and Bentya districts. In the first district, the traditional salt production leads to the ban of mangrove forest cutting. Some locally improved salt production techniques were adopted by NGOs and disseminated to salt producers belonging to a given producers association or group. A significant number of traditional salt producers are still adopting the traditional methods of salt production while collecting wood from the upland forest in order to prepare the brine. In Bentya district, the implementation of the irrigation scheme, supported by the Guinean government and its partners, has enabled mangrove rice farmers to be trained on the protection of mangrove forest. Based on this training, a ban of the mangrove forest slashing for rice cultivation was enforced by members of the Darabo union.

Therefore, the restriction or ban of mangrove forest logging was not reported in Makinsi and Kegneron areas. In Makinsi district, the abandoned shrimp farms were slashed and converted into traditional mangrove rice farming. In Taboria port where the lead author has surveyed wood loggers who have reported the exploitation of the mangrove forest resources in Kegneron and transporting them to the main port of Koba located in Taboria. However, no ban on mangrove forest exploitation was imposed.

9.5. Implications for livelihood improvement and forest sustainability

Based on the above discussion on the mangrove and upland forests; the current sub-section calls for implications for the improvement of livelihood of communities and forest sustainability in the coastal area of Guinea. Table 9-5 discusses the process which should be adopted by stakeholders for mitigating the negative impacts of household energy (HE) consumption and livelihood activities (wood extraction [WE], salt production [SP] and mangrove rice [MR] cultivation) on the mangrove and upland forests.

The negative impact of the household energy (HE) consumption and wood extraction (WE) could be overcome throughout the provision of the modern cooking fuels (MCF) such as kerosene, LPG (liquefied petroleum gas), biogas, electricity, etc. for limiting the traditional biomass cooking fuels. As results, this action may generate a better livelihood improvement and forests sustainability from both mangrove and upland areas (Table 9-5). According to Reddy (2002), scaling up modern energy services in developing countries will boost efforts to reach the Millennium Development Goals (MDG) targets for poverty and hunger reduction, education, health, gender equality and environmental sustainability. Access to modern energy services will also increase the quality of life as measured by the Human Development Index (HDI).

The negative impact of salt production over the mangrove and upland forest can be avoided through the adoption of improved salt production (ISP) techniques. In Chapter VII, part A, it is reported that improved salt production techniques requiring the sunlight as the source of energy need to be popularize as an alternative to the traditional salt production techniques which consumes a significant amount of mangrove wood. This will reduce the over-exploitation of both mangrove and upland forest leading to the improvement of livelihood and forest sustainability (Table 9-5). In Chapter VI, it is revealed that salt producers under the improved techniques have more access to convenient household assets and better housing. It also pointed out that an improved living condition could limit the deforestation of mangrove and upland forests. The adoption of the improved salt production techniques resulted in the minimization of the total variable cost related to the salt production which led to higher profits.

Table 9-5: Implementation for livelihood improvement and forest sustainability

Targeted determinants of coastal forests		Policy intervention (PI)	Without policy intervention (WPI)
1.Energy consumption	Household energy (HE) consumption	➢ Provision of modern cooking fuels (MCF) (kerosene, LPG, biogas, electricity, etc.)	➢ Traditional cooking fuels (TCF) such as fuel wood from mangrove and upland forests, charcoal, etc.
2.Livelihood activities	Wood extraction (WE)	➢ Provision of improved cooking devices (ICD) such as rocket stove (efficient wood cooker), charcoal stove, etc.	➢ Traditional cooking devices (TCD) [open three-stone stove or tripod]
	Salt production (SP)	➢ Adoption of improved salt production (ISP) techniques	➢ Traditional salt production (TSP) requiring huge wood resources extracted from coastal forests (mangrove and upland).
	Mangrove rice (MR) farming	➢ Implementation of improved irrigation system for the improved mangrove rice (IMR) production	➢ Traditional mangrove rice (TMR) farming techniques
Expected outcome		With regulation: Sustainable coastal forests (mangrove and upland) and livelihood improvement	Without regulation: Unsustainable coastal forests and vulnerable livelihood conditions

Thanks to the use of tarpaulin (plastic sheet) instead of fuel wood, improved techniques also shorten the daily working time. This time saving on working hours has a significant impact on income generated from a secondary activity as it enables improved salt producers to be involved in the improved mangrove rice production thereby earning an additional income. Salt producers under these improved techniques produced high quality salt which led to fetch a better price for their produce.

With respect to the mangrove rice production, its negative impact on the mangrove forest degradation can be reduced through the implementation of improved irrigation system (Table 9-5). Improved irrigation system plays a significant role by maintaining farmers stable with less accrochment over slashing a new stand of mangrove forest for the expansion of paddy areas. Irrigation schemes are a sustainable alternative which can contribute preserving the fragile mangrove ecosystem through deforestation.

9.5. Summary

This chapter examined the situation of household energy consumption and explores the impact of scenarios relative to the livelihood activities and household energy consumption on the mangrove and upland forests in the coastal area of Guinea.

The results revealed the dependence of the coastal communities on the traditional fuels extracted from both mangrove and upland forests. Hence, peasants were found heavily relying significantly on the traditional cooking devices, which may impact negatively on forest degradations and peasants' health. The paper also presented three scenarios leading to the degradation of both mangrove and upland forests threatened by the unsustainable household energy consumption and the livelihood activities (salt production, wood extraction and mangrove rice production) practiced in the coastal area of Guinea. In order to limit the degradation of these forests and achieve forest sustainability and livelihood improvement, some policy implications are advocated based on our findings. It is proposed to provide coastal communities access to modern fuels and improved cooking devices that are believed to burn biomass more cleanly and efficiently in order to mitigate environmental and health problems. For limiting the negative impacts of the livelihood activities on the mangrove and upland forests, improved technologies for livelihood activities should be introduced to these coastal communities.

CHAPTER X

CONCLUSION AND POLICY RECOMMENDATIONS

10.1. Introduction

The main objective of this study was to analyze the socio-economic status and livelihood patterns of coastal communities dependent on mangrove forest resources in the littoral Guinea. The reason behind focusing on this objective is based on the improvement of coastal communities and sustainable management of coastal forests in Guinea, particularly the mangrove forest. This was achieved through examining some specific objectives as early indicated in the first chapter. Overall, these objectives were realized by addressing the following questions:

1. What are the role of understanding land use change analysis and their determinants, in a given area which sufficiently lacks of statistical data, for the purpose of improving livelihood of local mangrove rice farmers?
2. What are the present statuses and determinants of mangrove rice production?
3. Which of the small-scale salt production techniques may contribute for improving livelihood status and sustainable mangrove forest management?

4. How technically efficient are small-scale improved salt producers and mangrove rice farmers in the Guinean coastal zone?
5. How significant is the loss due to the inefficiencies? What are the factors determining the inefficiency of both small-scale salt production and mangrove rice production in the Guinean coastal zone?
6. What are the effects of livelihood activities on income inequality and poverty reduction?
7. What are the impacts of both household energy consumption and livelihood activities on coastal forests in Guinea?

Hence, in this current Chapter X, I discussed the answers to these research questions in the next section.

10.2. Main findings

10.2.1. Land use change analysis and their determinants in livelihood improvement

The study examined the role of land use change in improving the livelihood of local farmers in the Guinean coastal zone. This objective was achieved by determining the land use change that occurred in this area from 1990 until 2010, using satellite data, and identifying the factors influencing land use change via field survey. The study revealed that family size and migrant farmers are significant determinants of land use change. The majority of farmers in the study area own less than one hectare. Despite a significant number of farmers being members of the farmers' organization, access to credit and use of modern farm technologies (improved seed varieties, fertilizer and agrochemical usage) remained negligible.

The study based on the spatial analysis revealed that about 41.7% of the 5,099 ha studied has undergone changes during this period. Paddy fields, build up, slashed and upland areas have notably increased in extent, while mangrove forest, savannah forest and palm trees have decreased. These changes indicate an increasing human pressure on natural resources in the Guinean coastal belt, mainly exerted by the migrant farmers and the growing local population. The mobility of farmers into the mangrove forest could result in embankment subsidence, to factors related to the management at the plot level, to the reduce use of modern farm technologies. Therefore, an increase in the use of modern farm technologies will have a positive effect on food supply through increasing agricultural production. The binary logistic regression results indicated that yield and membership in farmers' organizations are two important factors determining land use change.

10.2.2. Determinants of mangrove rice production

The study has revealed that the main purpose of this mangrove farming in the study area remains for the self-consumption. The low level of improved seed varieties, fertilizer and agrochemical usages indicated the non-adoption of new technologies. The significant selection of local varieties pointed out despite the high yield that can provide improved seed varieties, some farmers prefer the local one for some reasons such as: their resistance to the salinity, easy threshing and above that, once cooked, these local varieties are kept more than 24 hours without rotting unlike improved varieties. The reason for the use of different local varieties for a single farmer in a given season is to avoid the overlapping of activities he claims to run, especially for those who have other activities, also taking into account the availability of family labor. The study indicated the availability of cultivated area, increasing number of family labor and farming experience as main factors leading to the combination of local and improved rice varieties. Interestingly, the access to the extension service, which is highly correlated to the farm size, pointed out that more farmers are receiving the extension more their average yield increases.

The hypothesis was that using all the inputs will have effect on the mangrove rice productivity as well as on the farm net profit. Regression analysis was used to determine the effect of these inputs. Thus, findings from the multiple regression analysis revealed that the cultivated area, off-farm income per family members, agrochemical, farmers' opinion on the type of irrigation systems, improved seed variety usage and combination of both local and improved rice varieties as factors determining the mangrove rice productivity in the study area.

10.2.3. Small-scale salt production techniques

The research study focuses on the analysis of small-scale salt production techniques in the coastal area of Guinea. Among three groups of salt producers (traditional salt, Guinean saline and salt marsh), the analysis shows that salt producers under the improved techniques (Guinean saline and salt marsh) have more access to convenient household assets and better housing. An improved living condition could limit the deforestation of mangrove and upland forests. The adoption of the improved salt production techniques resulted in the minimization of the total variable cost related to the salt production which led to higher profits. Thanks to the use of tarpaulin instead of firewood, improved techniques also shorten the daily working time. This time saving on working hours has a significant impact on income generated from a secondary activity as it enables salt marsh producers to be involved in the mangrove rice production thereby earning an additional income. Salt producers under these improved techniques produced high quality salt which led to fetch a better price for their produce.

The empirical results reveal that the results of OLS and quantile regression share common characteristics but differ in some aspects. The results of quantile regression (QR) provide a complete picture of the factors affecting the revenue of salt production. The QR results demonstrate that origin of salt producers, family size, total variable cost of salt production, land rent and unit price per salt bag and profit from mangrove rice cultivation influence significantly the revenue from salt production. Furthermore, graphical results provided detail picture of the revenue of salt production determinants over quantiles. The gross marginal analysis indicated that improved salt production techniques are highly profitable than the traditional technique. The convenient household assets and better living conditions (household resources endowments) are outcomes of this high profit. Hence, the improved salt production techniques could be considered as an alternative for enhancing the livelihood status and sustainable mangrove forests management.

10.2.4. Technical efficiencies of salt production

The study measures the technical efficiencies of small-scale improved salt production techniques practiced in the coastal area of Koba in Guinea through the application of stochastic frontier production functions. The production frontiers incorporate labor cost, materials cost (tarpaulin and other equipment) and dimension of basins. Among these inputs, results indicated that only labor cost and dimension of basins contribute to the performance for salt production revenue. There are still rooms for improvement in technical efficiency that can be achieved by salt producers to fully utilize existing resources. Results from the model for the inefficiency effects in the production frontier show that explanatory variables such as land rent, family size; producer's participation in activities and membership in salt production contribute to production efficiency. Overall, the study revealed a wide variation in the level of technical efficiency of salt producers with an average of 27 %. Thus, the salt production in the coastal area of Koba has a potential to be increased by 73 %, if prevailing inefficiencies are overcome, without increasing the level of inputs. Furthermore, the loss due to the inefficiency was enormously significant at 601,024 Guinean francs per basin for the whole season of salt extraction.

10.2.5. Technical efficiencies of mangrove rice production

The study used stochastic frontier production function to measure technical efficiency of mangrove rice farmers in the coastal area of Koba sub-prefecture in Guinea. Among the inputs incorporated into the Cobb-Douglas production function, results revealed that only the farm area and the depreciation cost of farm tools have contributed to the performance of the mangrove rice production. The farm-specific variables used to explain inefficiencies indicate that elderly mangrove rice farmers with farming experience, significant household size and access to off-farm income and remittance tend to be more efficient. However, education level, improved seed use, extension services provided by the government and access to credit have a negative influence on technical efficiency in this mangrove rice farming system. Overall, this study revealed a wide variation in the level of technical efficiency of mangrove rice farmers with an average of 23 %. Thus, the mangrove rice production in the coastal area of Koba has a potential to be increased by 77 %, if prevailing inefficiencies are overcome, without increasing the level of inputs. Furthermore, the loss due to the inefficiency was enormously significant at 8,838,762 Guinean Francs per acre for the whole season of mangrove rice production.

10.2.6. Effects of rural livelihood activities on income inequality and poverty reduction

The study examines the effect of livelihood activities on the income inequality and poverty reduction based on a survey conducted in four districts (Balessourou, Taboria, Makinsi and Bentya) of Koba located in the Guinean coastal area. Income inequality is considered as one of the major contributing factors to poverty and food security in developing countries. Understanding the key sources of inequality in the coastal zone of Guinea could provide a framework for generating useful information for development policy on how policy makers could rectify or remedy the income inequality in order to bring about poverty reduction. With respect to the socio-demographic variables, the study indicated that surveyed peasants' level of education was low while they had large families. The study revealed that the proportion of income is higher in Balessourou and Bentya districts where improved salt and mangrove rice production are practiced respectively. Overall, salt production and mangrove rice cultivation contribute to the total household income by 50 % and 26 % respectively; followed by non-farm income and wood extraction by 7 % and 5 % respectively.

The Gini decomposition analysis revealed that increasing the income share of mangrove rice production, wood extraction and non-farm income could alleviate poverty and reduce income inequality among peasants in the study area. Although increasing the income share of salt production would not decrease inequality, it remains one of the most important sources of income and benefits more rich peasants. This implies that salt production has the potential for increasing inequality. Moreover, decomposition carried out on poverty index indicated that the extent of poverty reduction varies with respect to the type of combination of livelihood activities.

In this research, household assets, access to housing and household energy consumption confirm the poverty level and the income distribution inequality among surveyed peasants. Analysis of household capital assets and livelihood strategies needs to be both dynamic and differentiated (Rakodi, 1999). An advantage of capital assets is that it places the reality of domestic groups (generally conceptualized as households) at the centre of analysis and policy, without ignoring the contextual economic, political and social factors which determine their ability to construct sustainable livelihood strategies. It provides a more adequate multi-dimensional understanding of poverty, impoverishment and increased well-being than analysis of income or consumption alone. Rakodi, (1999), also reported that there is some evidence of the beneficial impacts of policies for increasing the assets available to poor households and relieve constraints on their ability to cope with impoverishment or take advantage of opportunities to enhance their livelihood.

10.2.7. Impacts of household energy consumption and livelihood activities on coastal forests

The study explored the impacts of household energy consumption and livelihood activities on the mangrove and upland forests in the coastal area of Guinea. In terms of household energy consumption, the results indicated that peasants depend more on the traditional fuels collected from upland and mangrove forests. The consumption of certain modern fuels (kerosene and batteries) was highly negligible and the consumption of electricity was unavailable for surveyed peasants.

The results also revealed that the use of the traditional cooking devices (e.g. open three-stone fire or tripod) was highly significant. The traditional cooking devices such as open three-stone may cause severe health problems to different household members and affects the environment. The improved cooking stoves (rocket stove and charcoal stove), that burn biomass more cleanly and efficiently, and even mitigate health and environment problems, were insignificantly adopted. Hence, the less adoption of the improved cooking stoves could bring various negative impacts on both mangrove and upland forests.

The study described three scenarios over the mangrove and upland forests threated by household energy consumption and by livelihood activities such as wood extraction, salt production and mangrove rice cultivation. These scenarios indicated that the household energy (HE) consumption is coming from both mangrove and upland forests. The fuelwood is harvested by family members or by professional wood loggers in mangrove and upland forests. However, scope of this paper is limited to those harvesting from the mangrove forest. It did not focus to upland charcoal makers and woodcutters. The first scenario was where no restriction was imposed to the mangrove forest logging for the purpose of traditional salt production, wood extraction and mangrove rice production. The second scenario described the situation when partial restriction is imposed in some areas (Balessourou and Bentya districts). The restriction on the mangrove forest logging was twofold: in the Balessourou district, it was imposed by the local government and in the Bentya district by Darabo union. The third scenario is a projection for the upcoming years based on the awareness over the uncontrolled natural resources depletion occurring in the mangrove and upland forests in the coastal area.

10.3. Policy recommendations

10.3.1. Land use change analysis and their determinants in livelihood improvement

The three most important policy implications of this study for mitigating rapid land use change in the Guinean coastal belt are: (1) the pressing need to improve mangrove rice productivity, (2) the need to strengthen and maintain strong dikes to prevent sea water intrusion into the rice fields, and (3) the need to strengthen the farmers' organizations to enhance farmer participation.

The mechanisms for strengthening the participation in farmers' organizations include the diffusion of modern farm technologies, the reconstruction of the embankment, training related to natural resources management, etc. The maintenance of the embankment could limit the intrusion of sea water in the rice plots leading to higher yield. It could also mitigate plot abandonment and farmers' encroachment on the mangrove forest. This strategy will contribute to the increase in land productivity and the improvement in farmer's livelihood. Moreover, it will reduce human pressure on the mangrove forest, thereby enabling a balance between livelihoods and the exploitation of natural resources.

As with any research, this study too had certain limitations. Overall accuracy and kappa coefficient were not relatively high (e.g., for 1990). Since the empirical results are based on relatively limited sample size, the findings should not be generalized. To generalize the findings further scrutiny through spatial and empirical studies would be required. A cross-county comparison of the entire Guinean coastal zone can be useful to improve the relevance of the findings of this study.

10.3.2. Determinants of mangrove rice production

Towards increasing the mangrove rice productivity, the government is required to identify traditional farmers by providing them new technologies (agrochemical, improved seeds, etc.), to adopt measures for improving irrigated perimeters in order to avoid the abandonment of plots. Irrigation schemes are a sustainable alternative which can contribute preserving the fragile mangrove ecosystem through deforestation.

10.3.3. Small-scale salt production techniques

The findings highlight the need for the government authority to encourage the participation of more local and international NGOs for providing improved materials (e.g. tarpaulin) to salt producers. Such efforts can contribute to preserve mangrove and upland forests against deforestation and to enhance the livelihoods of the coastal communities through the adoption of improved salt production techniques. As with any research, this study too had certain limitations. Due to the lack of data related to salt production over the years in the coastal zone of Guinea, this paper did not focus on the detail background of salt production. Since the empirical results are based on relatively limited sample size, the findings should not be over-generalized. To enhance the generalizability of the results, further scrutiny through theoretical and empirical studies is required. A cross-country comparison of the entire Guinean coastal zone can be made to broaden the usefulness of the results.

10.3.4. Technical efficiencies of salt production

The findings advocate strategies such as encouraging producers' participation in activities organized by local and/or international NGOs for the purpose of sharing knowledge and experience of salt producers, sharing latest information on salt production techniques, being informed about latest government policies and learn to take a balanced approach on salt production and environmental conservation particularly the mangrove ecosystem. This would feasible if more producer groups are formed to mobilize collective efforts of the producers. This study also suggests coating of basins or ponds for limiting the significant loss of salt occurring seasonally. This loss also can be mitigated by improving the quality of tarpaulin (plastic sheet) used.

As with any research, this study too had certain limitations. Studies on the technical efficiency of salt production were not available for the purpose of comparison and discussions with our results. Due to the lack of data related to salt production over the years in the coastal zone of Guinea, this paper did not focus on the detail background on salt production in the study area. Since the empirical results are based on relatively limited sample size, the findings should not be over-generalized. To enhance the generalizability of the results, further scrutiny through theoretical and empirical studies is required. A cross-country comparison of the entire Guinean coastal zone can be made to broaden the usefulness of these results.

10.3.5. Technical efficiencies of mangrove rice production

Based on the findings, policy implications are advocated. The technical efficiency can be improved by focusing on farm area and farm tools. Higher technical efficiency can be achieved through the irrigation which leads to boost the productivity of mangrove rice and preserve the mangrove forest from slashing new stand of it for the extent of farm area. The restoration of abandoned rice fields favors farmers with less farm area to increase their extents. The role of farm tools in increasing efficiency of mangrove rice production suggests a possibility for a small-scale mechanization in this farming system. The government is required to facilitate the public investment in physical infrastructure (irrigation including embankments, dikes, etc.) which is crucial for improving mangrove rice farmers' efficiency, and then, earnings. Irrigation schemes are a sustainable alternative which can contribute to preserving the fragile mangrove ecosystem through deforestation.

In addition, age of household head, family size, off-farm income and remittance as well as farming experience are important policy variables and determinants of efficiency, which can be considered in formulating agricultural policy in Guinea in order to raise the current level of technical efficiency and hence the level of productivity in the mangrove rice sector. This could be possible if the government involves in creating job opportunities directly or indirectly in order to improve the revenue from off-farm income. As the remittance is almost transferred by family members living in cities or abroad, this creation of job opportunities could also stabilize the household members from migration. The people of West Africa have a long tradition of mobility. Evidence suggests that one in three individuals no longer resides in their place of birth (De-Haan, 2000). Migration has been described as the history of peoples' struggle to survive and to prosper, to escape the insecurity and poverty, and to move in response to opportunity (DFID, 2004). The findings also advocate strategies for the reduction of inefficiency in this farming system by enhancing the farmers' education level through extension programs and providing enough inputs (credit, improved seed varieties, fertilizer and pesticide). These recommendations will pave the way to mitigate the significant loss due to the inefficiency occurring seasonally in the mangrove rice production system.

As with any research, this study too had certain limitations. Studies on the technical efficiency of mangrove rice production in Guinea were not available for the purpose of comparison and discussions with our results. Due to the lack of empirical data related to mangrove rice production in the coastal zone of Guinea, this paper did not focus on the background detail of mangrove rice production in the study area. Since the empirical results are based on relatively limited sample size, the findings should not be generalized. To enhance the generalizability of the results, further scrutiny through theoretical and empirical studies is required.

10.3.6. Effects of rural livelihood activities on income inequality and poverty reduction

Findings from this research suggest that policy makers, interested in remedying income disparities and reducing poverty in the Guinean coastal area, need to pay more attention on technology transfer and extension services to improve mangrove rice production as it accounts for 27 % of the share of total income. Furthermore, the relative marginal effect indicates that 1 % increase in mangrove rice production will reduce poverty by 7.3 %. This implies that mangrove rice production exerts the highest impact on poverty reduction from among all the livelihood activities. The government could remedy the income inequality arising from salt production and reduce poverty by providing machineries and tools to poorer farmers to ensure their inclusion in the salt production. NGOs and other organizations should come forward to support the government financially, teach farmers about advanced techniques of salt production and give due recognition to producers. In addition, the government should provide subsidies and/or credits to poorer farmers for rectifying income inequality and alleviate poverty because salt production is capital intensive.

Policy makers and different actors involved in the Guinean coastal area are requested to take further efforts to rectify income inequality and poverty alleviation through the provision of extension programs and credit services to rural areas until improved access to market opportunities created a demand for technology and inputs. This strategy could lead to the improved household assets, access to better housing and modern energy consumption. The latter one could play a significant role with respect to the sustainable management of natural resources including the mangrove and upland forests. These recommendations will pave the way to improve rural livelihoods and conserve natural resources and biodiversity.

10.3.7. Impacts of household energy consumption and livelihood activities on coastal forests

The study highlighted some policy implications for the livelihood improvement and coastal forests (mangrove and upland) sustainability. For limiting the negative impacts of the HE consumption and wood extraction on these forests, stakeholders (local government, NGOs, peasant organizations, etc.) acting into the coastal area of Guinea are required providing modern cooking fuels and improved cooking devices to peasants. The provision of modern cooking fuels and improved cooking devices could limit significantly the threat over the mangrove and upland forests and then improve the peasants' livelihood. The negative impact of traditional salt production (TSP) techniques on the mangrove and upland forests could be mitigated through producers' motivation for the adoption of improved salt production (ISP) techniques. These ISP techniques used sunlight as the source of energy instead of the TSP techniques requiring a significant amount of both mangrove and upland wood collected in these forests. Hence, the adoption of ISP techniques could enhance the livelihood improvement and contribute to the sustainability of both mangrove and upland forests. With respect to the mangrove rice production, livelihood improvement and sustainable mangrove forest could be achieved through the implementation of improved irrigation systems. Irrigation schemes are a sustainable alternative which can contribute to preserving the fragile mangrove ecosystem through deforestation.

The ways to put policies into practices are based on the feasibility in terms of the country's economic condition. Of course, what is useful for a particular country depends on its own economic, social, resource, and governmental circumstances and may not be easily applicable to another (Sinton et al., 2004). With this caveat, this study suggests some lessons experienced to some Africans countries. These are based on dissemination approaches and public sector investment. According to Kees and Feldmann (2011), since 2005, around 500,000 households in Uganda have started to use the energy saving rocket stoves; a rate of dissemination that has not been reached previously in any African country in such a short period of time. The reasons for this success can be summarized as follows: (1) the technology is convenient, modern, and (most importantly), it is affordable. (2) The dissemination approach - training local artisans, using local material, employing local service providers and NGOs for training and promotion campaigns – strengthens local value chains. (3) An intensive monitoring system from the beginning guarantees product quality. (4) The political system acknowledges the relevance of efficient and modern cookstoves and supports a massive scaling-up by setting clear targets.

10.4. Future research directions

In developing countries like Guinea, both coastal and inland populations rely on the natural resources for their livelihood. This present study deals only with coastal communities and focused on some major livelihood activities (e.g. salt production, mangrove rice production and mangrove wood exploitation such as firewood and logging) in the littoral Guinea. This study analyzed the socio-economic status and livelihood patterns of coastal communities dependent on mangrove forest resources in order to bring an improvement of local livelihood peasants and sustainable mangrove forest management. The research indicated that an improved living condition could limit the deforestation of mangrove and upland forests. The study discovered scenarios leading to the degradation of both mangrove and upland forests threatened by the unsustainable household energy consumption and the livelihood activities (salt production, wood extraction and mangrove rice production) practiced in the coastal area of Guinea. Overall, the research study provides basic information regarding some determinants of the mangrove forest in the coastal area of Guinea.

Hence, owing to the significant interrelationship between livelihoods of coastal communities and their environment (mangrove ecosystem), an appropriate balanced approach between them is required. It is pertinent to examine the most suitable and environmentally sustainable practices contributing to the livelihood improvement and conservation of mangrove forest. Further studies shall specifically address:

1) The present status of the mangrove and upland wood markets in the coastal area.
2) The sustainable management of natural resources towards the perceptions of stakeholders in the coastal area of Guinea.
3) The peasants' perceptions and attitudes towards mangrove forest management in the Guinean coastal area.
4) The peasants' perceptions on the community participation to the mangrove forest management and its sustainable use,
5) The role of the food production expansion process in household food security, poverty reduction, livelihood improvement and sustainable coastal forest management.
6) Furthermore, addressing the improvement of traditional salt production techniques in Guinea based on the Japanese experience in salt production

industry. Through the Japanese International Cooperation Agency (JICA), Guinea experienced and benefitted many developmental programs in many sectors as well as research (e.g. infrastructures such as roads, schools, irrigation facilities, research on NERICA upland rice varieties, etc.). This proposal would also bring to Guinea a new approach and meaningful insights through the Japanese salt production industry and management of coastal environment. Overall, it will provide new findings to developing countries like Guinea with the help of Japanese modern technology and hence save vulnerable coastal communities.

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Appendix I

Field Survey Questionnaire (March – April 2011)

1. Identification of the household farmer

(1) Administrative region, (2) Prefecture, (3) Sub-prefecture/ Urban commune, (4) District, (5) Village/sector, (6) Name of respondent, (7) Interviewer, (8) Date of interview, (9) Latitude/longitude

2. Marital status and citizenship of the head of the household:

(1) Nationality ……….? (2) Ethnic group ………? (3) Religion ………? (4) Marital status (1= Married; 2 = Single; 3= Widower and 4= Divorced), (5) Age………?

Section 1: Basic Household Data

1. How many people live in this household …………?

2.Number of people working in the farmland …………..?

3. Table 1: Household composition

	Name	Age (year)	Gender 1- Male 2- Female	Relationship to the Head of Household[a]	Reached Education level	Part or Full time farmer[b]	Main Occupation[c]	Living	
								At home	out
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									

Codes: (a): 1- Husband, 2- Wife, 3- Son, 4- Daughter, 5- Sister, 6- Mother, 7- Father, 8- Worker, 9- Grandmother, 10- Grandfather, 11- Other. (b): 1-Part time, 2- Full time. (c): 1- Mainly crops farmer, 2- Mainly Livestock farmer, 3- Self-employee, 4- Formal employee, 5- Informal employee, 6- Student, 7- Other (specify)

4. Did you moved from Upland field to the mangrove area? No ……..Yes……… When ……? If yes, how many time ……..? What were the reasons (choose from 1 to 6 below) …………?

[1- Low yield, 2- Land degradation (erosion), 3- Livestock problems, 4- Conflict (detail it), 5- Access to off-farm income to the Coastal area, 6- Other (specify)]

5. Regarding to the mangrove farming area, how many time did you changed the plots …………?

6. What were the reasons of plot shifting (choose from 1 to 8 below) …………?

[1-Salinity intrusion to the plot, 2-Acidification (soil), 3-Biological factors problem (crabs, etc.), 4-Conflict under land tenure, 5- Government policy, 6- Accessibility conditions to plots, 7- Lack of Labor force, 8- Other (specify)]

Section 2: Land, Land Use and Farm Management

1. Field and Plots Characteristics

Table 2: Inventory of the Household Farm (Farm size, Field and Plots Number and other characteristics)

Landscape type (landform) and Field Location			Field and Plot Identification: Number of Fields	Field and Plot Identification: Number of Plots	Farm Size/ Area (ha)	Farming experience (Years)	Management type of plots 1- Individual 2- Collective	Acquisition Mode[a]	Property Status[b]	Cultural History of the plot 1- Cultivated 2- Fallow	Culture system (crops) 1- Single 2- Mixed	Irrigation type used in the mangrove and plot size (ha): Traditional	Semi-traditional	Government Support
	Upland Field													
	Mangrove Farming	Upper Estuaries												
		Middle Estuaries												
		In Front of Sea												
	Lowland field	Rainfed												
		Irrigated												

Codes: **(a)**: 1- Heritage, 2- Purchase, 3- Tenant farming (tenancy) or Sharecropping, 4- Lend, 5- Gift, 6- Other (specify). **(b)**: 2- Ownership with Title, 2- Property untitled, 3- Rental, 4- Lending, 5- Other

Table 3: Tenure Status of land managed by the Household (Details of Area)

	Tenure status	Area (ha)
1	Area leased/certificated of ownership	
2	Area owned under customary law	
3	Area bought from others	
4	Area rented from others	
5	Area borrowed from others	
6	Area share-cropped from others	
7	Area under other forms of tenure	
Total area		

Was all land available to the household used from 2010 to 1990? (Yes=1, No=0)	
Do you consider that you have sufficient land for the household? (Yes=1, No=0)	

2. Accessibility of Fields used by the Household

Table 4: Access and use of land resources

Field Number	Sex of the field manager	Distance (km) from field to:			Accessible By[a]	Main crop	Second crop in intercropping	Used crops in the following years					Any idea for?	
		Homestead	Nearest road	Nearest market				2010	2009	2008	2007	2006	2000	1990
1														
2														
3														
4														
5														
6														
7														
8														

Code (a): 1- Road, 2- Track, 3- Footpath, 4- Waterway, 5- Other (specify)

Table 5: Erosion Control and Water harvesting structures on the field

Type of erosion control/ Harvesting structures	Tick whether structure was carried out	Number of structures	Year of construction	Cost of construction
1- Terraces				
2- Erosion control bunds				
3- Gabions/ Sand bags				
4- Grass/ leguminous plants				
5- Tree belts				
6- Water harvesting bunds				
7- Drainage ditches				
8- Dam				
9- Other (specify)				

Land map

[1-Plots (non-irrigated, irrigated), 2-Acreage, 3-Crops, 4-Land tenure, 5-River or stream, 6-Road, 7-Railway, 8-Market, 9-Homestead, 10-Plantations, 11-Forest, 12-Mining zone, 13-Salt extraction area]

Table 6: Land Use Change by Plot and Crops during the last 5 years

Plot	Latitude/ Longitude	2010	2009	2008	2007	2006	Do you keep land use record?	
							2000	1990
1								
2								
3								
4								
5								
6								
7								
8								

Table 7: Plots characteristics and other observations

Plot	Problems	Advantages	Production[(a)]	Technology	Soil conservation[(b)]	Future improvement
1						
2						
3						
4						
5						
6						
7						
8						

Codes: (a): 1- High, 2- Medium, and 3- Low. (b): 1- Crop rotation, 2- Organic fertilization, 3- Lime application, 4- other (specify).

If there is land not used for farming, what are the main reasons? (Choose below from 1 to 8)………………

[1-Salinity intrusion, 2-Soil acidification, 3-Lack of labor, 4-Lack of capital, 5-Fallow, 6-Theft of crops/ animals, 7-Conflicts over ownership, 8-Other (specify)**]**

Do you have enough land for agricultural activities? No ……..Yes …… (Explain the reason)……………

1- Crop and Animal Enterprises

Cropping Calendar

Table 8: ***Agricultural activities by crops***

Agricultural activities		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Crop 1	1																								
	2																								
	3																								
	4																								
	5																								
	6																								
	7																								
	8																								
	9																								
	10																								
Crop 2	1																								
	2																								
	3																								
	4																								
	5																								
	6																								
	7																								
	8																								
	9																								
	10																								
Crop 3	1																								
	2																								
	3																								
	4																								
	5																								
	6																								
	7																								
	8																								

Codes: 1- Nursery preparation, 2- Land clearing 3- bedding out, 4- Plowing/ Tilling, 5- Sowing/ Transplanting, 6- Weeding/Treatment, 7- Harvesting, 8- Threshing, 9- Husking, , 10- Dikes reparation, 11- Other (specify).

Table 9: Animal Enterprises beginning with the most important

	Animal	Numbers	Type[a]	Years of rearing
1				
2				
3				
4				
5				

Code (a): 1- Indigenous, 2- Exotic, 3- Crossbreed.

Section 3: Economic Information (Farm inputs and outputs)

Subsection 3-1: Inputs (Fixed and Variable)

Access to Agricultural Implements, Assets and Technologies

2- Table 10: Use of farm implements and assets

Equipment/Asset	Equipment status		Number		Purchase year	Price per item	Source of Equipment[a]	Source of Finance[b]	Reason for not using[c]
	Property	Co-property	Owned	Rented					
Hand hoe									
Hand powered sprayer									
Oxen									
Ox plough									
Ox seed planter									
Ox cart									
Tractor									
Tractor plough									
Tractor harrow									
Threshing machine									
Other…									

Codes:

(a): 1- Government Extension Service, 2- Local farmers group, 3- Cooperative, 4- Local market/ trade store, 5- Secondary market, 6- Development Project,7- Crop buyers, 8- Large scale farmers, 9- Locally produced by household, 10- Neighbor, 11- Other (specify), 12- Not applicable.

(b): 1- Sale of farm products, 2- Other income-generating activities, 3- Remittances, 4- Bank loan/ Credit, 5- Produced on farm, 6- Other, 7- Not applicable.

(c): 1- Not available, 2- Prices too high, 3- No money to buy, 4- Too much labor required, 5- Do not know how to use, 6- Input is of no use, 7- Locally produced by household, 8- Other, 9- Not applicable.

3- Access to Agricultural Inputs

Table 11: Use of variable farm inputs during the last year

Variable farm inputs		Inputs name	Used (Yes=1 No=0)	Field Number (treated)	Plot Number (treated)	Source of input[(a)]	Distance to the source	Source of finance[(b)]	Reason for not using[(c)]	Quality of input[(d)]	Quantity bought	Unit price	Total cost	Treated area (ha)
Seed	Traditional													
	Improved													
Chemical fertilizer														
Farm yard manure														
Compost														
Pesticide														
Herbicide														
Other…														

Codes:

(a): 1- Government Extension Service, 2- Local farmers group, 3- Cooperative, 4- Local market/ trade store, 5- Secondary market, 6- Development Project, 7- Crop buyers, 8- Large scale farmers, 9- Locally produced by household, 10- Neighbor, 11- Other (specify), 12- Not applicable.

(b): 1- Sale of farm products, 2- Other income-generating activities, 3- Remittances, 4- Bank loan/ Credit, 5- Produced on farm,6- Other, 7- Not applicable.

(c): 1- Not available, 2- Prices too high, 3- No money to buy, 4- Too much labor required, 5- Do not know how to use, 6- Input is of no use, 7- Locally produced by household, 8- Other, 9- Not applicable.(d): 1- Excellent, 2- Good, 3- Average, 4- Poor, 5- Does not work, 6- Not applicable.

4- Table 12: Farm Labor Remunerations

Labor status	Agricultural Activities[(a)]	Period of activity	Dairy Wages						Number of Labor employed	Length of employment	Total labor cost	For each crop below, please indicates the corresponding agro-ecological zone (1- Mangrove farming, 2- Lowland and 3- Upland)					
			Male		Female		Children										
			Cash	Kind[(+)]	Cash	Kind[(+)]	Boy	Girl				Maize (M)	Peanut (P)	Cassava (C)	Fonio (F)	Local Rice (LR)	Imp. Rice Variety (IRV)
							Cash	Kind[(+)]									
Casual/ Temporary (seasonal paid worker																	
Permanent paid workers																	
Neighbors																	
Paid partners/ Shareholders																	
Mutual Aid/ Peasant org./Village association																	
Family																	

Codes: (+): Indicate the monetary value of the products or goods received. (a): 1- Nursery preparation, 2- bedding out, 3- Plowing/ Tilling, 4- Sowing/ Transplanting, 5- Weeding, 6- Harvesting, 7- Threshing, 8- Husking, 9- Land clearing, 10- Embankment (Dikes)/ Bunds rehabilitation, 11- Other (specify).

5- Irrigation (water use and price) ………………………per hectares.

6- Table 13: Estimation of Marketing expenditures for major enterprises

Product	Marketing Activity a- Individual b- collective	Expenditure	Product	Marketing Activity a- Individual b- collective	Expenditure
1			4		
2			5		
3			6		

Subsection 3-2: Outputs (production for marketing (sell) and Self-consumption)

7- Table 14: Destination or Share of Production

			Product (Commodity)	Harvested Area (ha)	Total production[a] (T)	Self-consumption	Marketing: Quantity	Marketing: Sold to[b]	Marketing: Price per Unit	Marketing: Total price	Gift (kg)	Quantity reserved for future seed (kg)	Other uses[c] (specify)
Agro-ecology type	Upland field												
	Mangrove farming	Upper estuaries											
		Middle estuaries											
		Front of sea											
	Lowland field	Rainfed											
		Irrigated											

Codes: (a): 1- Number of bag……x.……Kg …..T. 2- Number of basket……x.…..Kg …....T. Yield ………Kg/ha …….T/ha. (b): 1- Local market/ trade store, 2- Farmer association, 3- Trader at farm, 4- Village/ Contact partner, 5- Large-scale farm, 6- Mining Companies, 7- Project/ Program,8- Peasant Organization (OP), 9- Cooperative, 10- Other (specify). (c): 1- Baby's giving name, 2- Wedding, 3- Other social event (specify).

8- Non-agricultural Sources of Income

Table 15: Income from people in the household for a period of one year (2010)

Person[a]	Type of work[b]	Frequency of payment[c]	Amount per period	How many periods?	Income earned

Codes: (a): 1- Husband, 2- Wife, 3- Son, 4- Daughter, 5- Other (specify). (b): 1- Self-employment, 2- Formal employment, 3- Informal employment. (c): 1- Daily, 2- Weekly, 3- Monthly.

9- Table 16: Remittances in the past year

Sender[(a)]	How much?	How often [(b)]?	Total

Codes: (a): 1- Husband, 2- Wife, 3- Son, 4- Daughter, 5- Other (specify). (b): 1- Monthly, 2- Quarterly, 3- Twice a year, 4- Once a year.

Section 4: Social Information

Attitude towards changes in Land Use

10- How would you respond to Government instructions on land use based on land use suitability and planning evaluations? (Choose the reason below)

[1-Highly receptive, 2-Receptive, 3-Receptive under conditions, 4-No receptive If no, please give reasons: …………………………………………..]

11- What will be your product (crop) preferences for future farming activities? ……………………..

Table 17: Access to Extension Services (Training programs, Inputs and Farm implements Tools)

Extension provider	Payment Status[(a)]	Cost per year	Contact farmer/ group member (Yes=1/ No=0)	Frequency of contact over the past 4 years[(b)]	Relevance (quality) of service[(c)]	Training program/ Implementation of extension message[(d)]	Did you receive any Inputs or farm implements from the Extension provider?	
							Inputs (Kg)	Number of tools
Government extension service								
NGO/ Development project								
Cooperative								
Large Scale Farmer								
Private practitioners								
Agro-Industrial Company								
Religious group								
Other (specify)								

Codes:

(a): 1- Free, 2- Paid. (b): 1- Rising, 2- Falling, 3- Constant. (c): 1- Very good, 2- Good, 3- Average, 4- Poor, 5- Not good. (d): 1- Spacing, 2- Use of agro-chemicals, 3- Erosion control, 4- Organic fertilizer use, 5- Inorganic fertilizer use, 6- Use of Improved seed, 7- Mechanization practices, 8- Irrigation Technology, 9- Crop storage, 10- Agro-processing, 11- Agro-forestry, 12- Fish farming, 13- Other (specify)

Access to credit at holding level

12- Have you or a member of your family borrowed money for farming purposes in the past 5 years?

Yes …….. No ……..

If yes, please give the source and purpose of the credit.

Table 18: Source and Purpose of Credit

		Source of credit[(a)]	Borrowed year	Amount borrowed (value of credit)	Repayment period	Value of repayment	Guarantee (surety)/ (Nature of bond) [(b)]	Actual situation	Use (purpose) of credit[(c)]
Credit type	Campaign								
	Equipment								
	Other (specify)								

Codes: (a): 1- Commercial bank, 2- Family/ Friend or Relative, 3- Cooperative, 4- Saving and Credit Society, 5- Trader/ Trade store, 6- Private Individual [Moneylender (Usurer)], 7- Religious Organization/ NGO/ Project, 8- Other (specify). (b): 1- Land, 2- House, 3- Plantation, 4- Livestock, 5- Other (specify). (c): 1- Input purchase, 2- Labor cost (pay), 3- Marketing fee, 4- Equipment purchase, 5- Other (specify)

If no, which are reasons, for not receiving a loan or credit? (Choose from 1 to 10 below)

[1-No need for loans, 2-Complicated formalities or procedures, 3-Unavailability of lending facility, 4-Lack of collateral, 5-Interest too high, 6-Not profitable, 7-Already paid, 8-Ignorance, 9-Negative past experience, 10-Other (specify)]

Migration

13- Are you native of this community? Yes …………No……………

If no, where is your native land? …………. When did you move here? …………….

14- Besides your native land, did you live in any other community before moving here?

If yes, where? …………. No ……………

If non-native, choose the following reasons below ……………….

[1-Attempting to find better lands, 2-Seeking better employment opportunities, 3-Food availability (ensure household surveillance), 4-Personal or family decision, 5-Other (specify)]

Membership of Agricultural/ Farmers' Organization (OP)

15- Is it here, in your area (district) any Agricultural Organization/ Peasant Organization?

Yes …….. . No …..….

If yes, are you member of any organization or group? Yes.…... No ……..

16- Table 19: Type of farmers' organization, provided services their activities and level of involvement.

		Type of farmers organization	Assistance received	In case of loan		Activities did by farmers' group	Any Mutual Aid (activity between members)	Created year	Number of members			
				Specify the amount	Specify purpose				Year 1	Year 2	Year…	Year n
Upland field												
Mangrove farming	Upper estuary											
	Middle est.											
	Front of sea											
Lowland	Rainfed											
	Irrigated											

Appendix II

Field Survey Questionnaire (March – April 2013)

Section 1: Mangrove Rice, others Crops and Livestock Production

Code		Respondent name:	
Prefecture			
Sub-prefecture/ Urban Commune		Interviewer	
District		Date of interview	
Village/ sector			

Personal details		Resident household members by gender and productivity in the farm							House building materials circle the corresponding number related to these materials below	
Age of respondent										
Gender (1=male; 2=female)		Age category	Total		Active[1] male	Non-active[2] male	Active[1] female	Non-active[2] female	Roof	1=thatched; 2=tiled; 3=corrugated iron; 4=cement
Ethnicity			male	female						
Marital status (1=married; 2=single; 3=divorced)		children							Wall	1=thatched; 2=wooden; 3=cowpat; 4=brick
Education level (years)		Adults								
Origin (1=native; 2=migration)		Total							Floor	1=soil; 2=wooden; 3=cement; 4=samel-brick ; 5=enameled brick
Persons in the household (total)		*1=able to work on farm, 2=not able to work on farm*								

<u>Non-farm household assets:</u> Which of the following items do you have? Please encircle the corresponding numbers. 1=Refrigerator; 2=TV; 3=bicycle; 4=bike; 5=car; 6=radio; 7=mobile phone; 8=Rocket stove (efficient wood cooker); 9=other (specify)
Please indicate the main sources of energy consumption in your household? Encircle the number. 1=Fuel wood from mangrove forest; 2=Fuel wood from other forest; 3=Charcoal; 4=Electricity; 5=Kerosene; 6=Gas
How much do you spend monthly for the following cases? Indicate the amount. 1=Charcoal (….); 2=Fuel wood from mangrove forest (….); 3= Fuel wood from other forest (…..); 4=Electricity (…….); 5=Kerosene (……..); 6=Gas (…………..)
Would you replace the mangrove wood resource you use as fuel wood by another? ……… (1=yes; 0=No). By what……………………………? Any condition for that……………………………………………………?
Please for the following points indicate your monthly expenses? 1=Foods (…………..); 2=Children education (…………..); 3=Contribution for ceremonies (…………..); 4=Health (……………); 5=Transportation (………..); 6=other (specify)
Indicate the household food security? ………………………………………………. (1=enough; 0= not enough).

Table 2: Characteristics of land use allocation, plots abandonment, mangrove forest and membership in community-based organization

Land use types			Area (ha)	Number of plots	When did you get it? (year)	Land tenure system: 1=Under customary law; 2= state; 3= Rental; 4= borrowed; 5= Share-cropping; 6= Other form (specify)	Distance from field to			Land use allocation during			Do you have enough land? (1=yes; 0=No)
							Home	Market	Nearest road	2010	2000	1990	
Agricultural areas	Mangrove rice area												
	Upland rice area												
	Lowland rice area												
	Home gardening												
	Vegetables	Pepper											
		Eggplant											
		Okra											
		Other, specify											
	Palm tree area												
	Kola tree area												
	Peanut area												
	Maize area												
	Cassava												
	Peanut												
	Fonio												
Settlement	Build-up area												
Pasture													
Forest or other plantation													
Other land use (specify)													

Did you abandoned plots where mangrove rice was grown for the following reasons? Please encircle the corresponding reasons: 1=salinity; 2=acidification; 3=conflict; 4=water management issues; 5=decreasing of production; 6=embankment or dikes sagging; 7= depletion of organic matter; 8= due to field remoteness; 9=other (specify)

Does rice growing in the mangrove area has an impact on the mangrove forest? ….. (1=yes; 2=No). If yes how? …………………………………..

Do you think that it is acceptable to cut the mangrove forest to expand the rice growing area? ………… (1=yes; 2=No). Explain your opinion based on the answer. ………………………………………

How do you see the future of these mangroves? (1= good; 2= bad). Give the reason based on your answer. ……………………

How do you see the future of the livelihood in this coastal area? (1= good; 2= bad). Give the reason based on your answer… …………………

Would you like to participate in environmental management/ protection schemes? ………….. (1=yes; 0=No). Why? ………………………

Do you think it is important to protect the mangrove forest? ……… (1=Yes; 0=No). Why? ....

Are you a member of community-based organization? …. (1=yes; 0=no). If yes, since when you become member …. What were the conditions for becoming member ………………..What is the name of your community based organization? ………… Please indicate the number of women …… and men ……. What are the main activities of your organization? …………………Why do you decide to join this organization? ………………What benefits are you getting from this community-based organization? …………………

Table 3: Variables inputs and information of local and improved mangrove rice varieties

Variables			Mangrove rice varieties (local and improved)							
			Local 1	Local 2	Local 3	Local 4	Improved 1	Improved 2	Improved 3	Improved 4
Name of varieties										
How long have you been growing these mangroves rice varieties? (years)										
Source of seed (1=purchased; 2= As future seed; 3=other)										
Seed quantity (kg)										
Sown date										
Planted area (ha)										
Number of plots										
Fertilizer quantity (kg). If not used please indicate the reason										
Fertilizer price (FG)										
Pesticide quantity (kg). If not used please indicate the reason										
Pesticide price										
Organic fertilizer quantity (kg). If not used please indicate the reason										
Organic fertilizer price										
Hired laborers in cash	Male	Workers								
		Worked days								
		Amount paid								
	Female	Workers								
		Worked days								
		Amount paid								
Hired laborers in kind	Male	Workers								
		Worked days								
		Quantity								
		Estimated cost								
	Female	Workers								
		Worked days								
		Quantity								
		Estimated cost								
Family labors	Male	Workers								
		Estimated days								
		Estimated month per season								
	Female	Workers								
		Estimated days								
		Estimated month per season								
	Childre n	Workers								
		Estimated days								
		Estimated month per season								
Number of big tree left into the mangrove field										

Table 4: variables inputs and information of some crops

Variables			Upland rice	Lowland rice	Vegetables: Pepper	Vegetables: Eggplant	Vegetables: Okra	Vegetables: Other (specify)	Cassava	Peanut	Fonio	Other (specify)
How long have you been growing these crops? (years)												
Source of seed (1=purchased; 2= As future seed; 3=other)												
Seed quantity (kg)												
Sown date												
Planted area (ha)												
Number of plots												
Fertilizer quantity (kg). If not used please indicate the reason												
Fertilizer price (FG)												
Pesticide quantity (liter). If not used please indicate the reason												
Pesticide price												
Organic fertilizer quantity (kg). If not used please indicate the reason												
Organic fertilizer price												
Hired laborers in cash	Male	Workers										
		Worked days										
		Amount paid										
	Female	Workers										
		Worked days										
		Amount paid										
Hired laborers in kind	Male	Workers										
		Worked days										
		Quantity										
		Estimated cost										
	Female	Workers										
		Worked days										
		Quantity										
		Estimated cost										
Family labors	Male	Workers										
		Estimated days										
		Estimated month per season										
	Female	Workers										
		Estimated days										
		Estimated month per season										
	Children	Workers										
		Estimated days										
		Estimated month per season										
Number of big tree left into each type of field												

Table 5: Production, marketing, production share, perceptions about selected varieties, and constraints to the non-adoption of rice varieties

Variables		Mangrove rice varieties (local and improved)							
		Local 1	Local 2	Local 3	Local 4	Improved 1	Improved 2	Improved 3	Improved 4
Name of varieties									
Date of harvest									
Total production (kg)									
Self-consumption (kg)									
Marketing	Quantity (kg)								
	Unit price (FG)								
	Total price (FG)								
	Sold to whom?								
Please indicate the farm gate price of each variety									
Please indicate the market price of each variety									
Marketing cost									
Future seed (kg)									
Other share (kg)									

Are these characteristics important to you when selecting/adopting a new rice variety? …… (1=Yes; 0=No).
If yes enter the number of characteristics under the variety's name.

Name of varieties								
<u>Agro-morphological characteristics:</u> 1=Production; 2=Drought resistance; 3=Salinity resistance; 4=Tilling; 5=Weed resistance capacity; 6=Height; 7=other (specify)								
<u>Post-harvest characteristics:</u> 1=Resistance to shedding; 2=Ease of threshing; 3=Ease of pounding (hand); 4=Damage levels; 5=Grain color (rice); 6=other (specify)								
<u>Cooking and organoleptic characteristics:</u> 1=Ease to cook; 2=Sticky grains after cooking; 3=Taste (palatable); 4=Flavor (aroma); 5=Conservation after cooking; 6=Swelling capacity; 7=other (specify)								

If improved varieties are not used, please circle the constraints corresponding to the non-adoption of these varieties: 1= Access to seeds; 2= Access to labor force; 3= Access to land; 4= Pests and diseases; 5= Soils related problems (specify……………..); 6= Access to agricultural tools; 7= Lack of capital (income); 8= High cost of inputs; 9= other (specify)……………………

Variables	Upland rice	Lowland rice	Vegetables	Cassava	Peanut	Fonio	Other (specify)

				Pepper	Eggplant	Okra	Other (specify)				
Date of harvest											
Total production (kg)											
Self-consumption (kg)											
Marketing	Quantity (kg)										
	Unit price (FG)										
	Total price (FG)										
	Sold to whom?										
Marketing cost											
Future seed (kg)											
Other share (kg)											

Table 6: Farm equipment, animal production, off-farm income, remittances, extension services, technology adoption and farmer organization

Farm equipment								Animal production			
Farm tools					Rental: In case of rental, please indicate						
Names	Number of items	Price per unit	Purchased year	Expected years for use	Daily cost paid	Number of items	From whom	Animal type	Number of head	Reason for rearing	Actual price per head
								1.Cow			
								2.Bull			
								3.Goat			
								4.Sheep			
								5.Hen and/or rooster			
								6.Duck			

Off-farm Income from household members for a period of one year						Remittances in the past year			
Person: 1-Husband, 2- Wife, 3- Son, 4-Daughter, 5- Other (specify)	Type of work 1-Self-employment, 2-Formal employ, 3-Informal employ	Frequency of payment 1.Daily, 2.Weekly, 3.Monthly	Amount per period	How many periods	Income earned	Sender 1-Husband, 2- Wife, 3- Son, 4-Daughter, 5- Other (specify)	How often? 1.Monthly, 2.Quarterly, 3.Twice a year, 4. Once a year.	How much?	Total amount

Did you get access to the extension services from Government extension workers? …. (1=yes; 0=no); from NGOs? …. (1=yes; 0=no); from neighbors ……(1=yes; 0=no)

Adoption and extension services: How many times did an extension agent contact you in the period before and during technology adoption? Before: …..time per week; …..time per month; ……time per year. During the adoption: ……time per week; ……time per month; ……time per year. What advice did you receive about the technology adoption? ……………………………………………….

Did you participate in any of these following activities prior to or during adopting the improved varieties? Please encircle the number. 1= on-farm trials; 2= seed multiplication; 3= field days; 4= demonstration plots; 5= workshops; 6= contact farmers; 7= theatre groups; 8= others (specify)

Are you a member of farmer organization? …. (1=yes; 0=no). If yes, since when you become member …. What were the conditions for becoming member ……………………………………………..
What is the name of your farmer organization? ……………… Please indicate the number of women …… and men …… What are the main activities of your organization? ……………………Why do you decide to join this farmer organization? ………………………………What kind of benefits are you getting from this organization? ………………………………

Table 7: Factors contributing to natural resource degradation and its limiting reasons to counteract this degradation

Factors contributing to natural resource degradation			
Questions	List maximal 3 factors. Use scales in column 4 to rate	Source[1]: see note below	Please rate the impact of these characteristics below using the following 5 points scales: 1=negligible; 2=little; 3=medium; 4= high and 5=very high
In your opinion, which economic aspects contribute to natural resource degradation	a. b. c.		a. Household income (poverty); b. Economic performance of agriculture; c. Off-farm income; d. Remittances; e. Market access/ trade volume; f. Credit availability; g. Infrastructure; h. Others (specify)
In your opinion, which social aspects contribute to natural resource degradation	a. b. c.		a. Inner societal disparities; b. Gender disparities; c. Social networks; d. Land use regulations; e. Land ownership; f. Migration; g. Manpower availability; h. Traditions and culture; i. Others
In your opinion, which ecological or environmental aspects contribute to natural resource degradation	a. b. c.		a. Temperature; b. Climate variation (such as rainfall); c. Soil fertility; d. Natural resource vulnerability; e. Water availability; f. Salinity; g. Acidification; g. Soil complexity; h. Others
In your opinion, which land use practices and technical aspects contribute to natural resource degradation	a. b. c.		a. Farm skills; b. Lack of land use alternatives; c. Resource conservation measures; d. Seed availability and quality; e. Crop rotation scheme; f. Natural fertilizer; g. Abandonment of plots; h. Fallow periods; i. Land use intensity; j. Small/un-ameliorated land plots; k. Irrigation practices
Limiting factors or reasons to counteract natural resource degradation in the coastal area			
Questions	List maximal 3 factors. Use scales in column 4 above to rate	Source: see note below	Please rate their impact on natural resources. 1=agree strongly; 2=agree somewhat; 3=disagree somewhat; 4= disagree strongly and 5=No opinion
In your opinion, what are the limiting reasons for individual farmers (landholders) to counteract natural resource degradation			a. Lack of skills; b. Lack of land use alternatives; c. Lack of technical/ practical knowledge; d. Insufficient of household income (poverty)
In your opinion, what are the limiting reasons for local administration to counteract natural resource degradation			a. Lack of finances; b. Little information exchange with villages; c. Lack of technical support; d. Contradicting land policies/ laws; e. Unawareness of resource situation
In your opinion, what are the limiting reasons for research centers to counteract natural resource degradation			a. Insufficient research funds; b. Different thematic focus
In your opinion, what are the limiting reasons for farmers organizations to counteract natural resource degradation			a. Lack of finances; b. Different thematic focus; c. Insufficient enforcement of regulations; d. Lack of technical/ practical knowledge

In your opinion, what are the limiting reasons for NGOs to counteract natural resource degradation			a. Insufficient project funds; b. Different thematic focus; c. Lack of technical/ practical knowledge; d. Weak cooperation with local administration; e. Missing commitment; f. Unawareness of resource degradation
In your opinion, what are the limiting reasons for religious groups to counteract natural resource degradation			a. Lack of skills related to natural resource; b. Different thematic focus
In your opinion, what are the limiting reasons for national administration to counteract natural resource degradation			a. Lack of finances; b. Lack of technical/ practical knowledge; c. Contradicting land policies/ laws; d. Unclear responsibilities in the administration; e. Unawareness of resource situation; f. Insufficient enforcement of regulations; g. Neglect of rural issues
Note: 1=observation; 2=education;3=NGOs; 4=Government;5=Oral reports; 6=Science; 7=Mass media; 8=Estimation; 9=others			

Table 8: Sustainable Management of Land utilization in the Coastal Area

Opportunities and constraints: In this section we would like to collect promising opportunities contributing to the sustainable management of renewable natural resources.				
Questions	Opportunities:	Source:	Constraining factors:	Source:
	please list some (minimum 3) After listing them, please rate each factors 1=negligible; 2=little; 3=medium; 4= high and 5=very high	1=observation; 2=education;3=NGOs; 4=Government;5=Oral reports; 6=Science; 7=Mass media; 8=Estimation; 9=others	After listing factors, please rate each of them 1=negligible; 2=little; 3=medium; 4= high and 5=very high	1=observation; 2=education;3=NGOs; 4=Government;5=Oral reports; 6=Science; 7=Mass media; 8=Estimation; 9=others
In your opinion, how can mangrove forest be used in a more sustainable way?				
In your opinion, how can mangrove rice productions "Bora Male" must be practiced in a more sustainable way?				
In your opinion, how can land use in the coastal areas be oriented in a more sustainable way?				
In your opinion, how can 'abandoned plots" in mangrove rice area be restored in a more sustainable way?				
In your opinion, how can salt production be practiced in a more sustainable way?				

In your opinion, how can fuel wood extraction be practiced in a more sustainable way?				
In your opinion, how can "upland forests" must be used in a more sustainable way?				

Role of socio-cultural networks and institutional settings: In this present section we would like to assess the role of socio-cultural networks and institutional settings on knowledge sharing with respect to agricultural activities and environment conservation.		
Questions	Answers	Characteristics
In your viewpoint, what is the role of socio-cultural networks on knowledge sharing with respect to agricultural activities		Mutual aid in farming
In your viewpoint, what is the role of socio-cultural networks on knowledge sharing for environmental conservation		Association for forest protection or conservation
In your viewpoint, what is the role of institutional setting on knowledge sharing with respect to agricultural activities		
In your viewpoint, what is the role of institutional setting on knowledge sharing for environmental conservation		

Table 9: Knowledge profile of actors from the perspective of land management practices:

In this section we would like to examine some actors' profile from the perspective of land management practices encompassing dimensions such as environmental, socio-cultural, economical and institutional/ technological.

<table>
<tr><td colspan="6">Following the different dimensions mentioned here, how can land management be practiced or utilized in order to sustain the livelihood, community in this area?</td></tr>
<tr><td colspan="2" rowspan="2">Targeted groups</td><td colspan="4">Dimensions</td></tr>
<tr><td>Socio-cultural</td><td>Institutional/technological</td><td>Economical</td><td>Environmental /ecological</td></tr>
<tr><td colspan="2">1.Landholders (individual farmers)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">2. Farmer organizations</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">3. NGOs</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">4. Research Center</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">5.Local administration</td><td>Agriculture Service</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Forestry Service</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Irrigation Service</td><td></td><td></td><td></td><td></td></tr>
<tr><td>6.Religious group</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Section 2: Salt Production in the Mangrove Area

Table 10: Key features of household involved in salt production

What are the household members involved in to the salt production? Circle the corresponding answer. (1=head of household; 2=wife; 3=children; 4=others)
Where do you practice the salt production? Circle the answer by giving the corresponding distance from the homestead. (1=campsite [distance:]; 2=in mangrove rice plots [distance:]; 3=in other village [distance:]; 4=other [distance:])
Who own the plots where salt production is realized? ……..……What kind of arrangements occurred between you and the owner? …………………………
By which means can you get the site of the salt production? Circle the corresponding answer. (1=on foot; 2=by canoe; 3=other (specify).
What are activities conducted by your household members? (1=mangrove logging; 2=transport of mangrove wood; 3=filter construction; 4=earth collection; 5= transportation of salty earth; 6=production of raw brine (unpurified salt water); 7=transportation of the salt; 8=other (specify)
When did you start the salt production campaign (indicate the corresponding month)? …………………………………..
How long the salt production campaign will take? …….. Months. How many hours a day you work in the salt production? ….hours per day

Materials and organization (group) related to salt production

During the last campaign, indicate the materials where you invested your capital?

Tools	In case as owner please indicate			In case of rental please indicate		
	Number of tools	Unit price	Total amount	Unit price per day	Number of item	Total amount
1.Can						
2.Tank						
3.Gourd (calabash)						
4.Hoe						
5.Basket						
6.Wood						
7.Bags						
8.Tray or pan						

Labor forces involved in the salt production during the last campaign

Activities	Hired labors			Family labors		
	Number of hired labors	Number of days	Cost paid to hired labors	Number of family labors	Estimated days for family labors (day)	Estimated cost spend in foods (GNF)
1.Mangrove logging;						
2.Transport of mangrove wood;						
3.Filter construction;						
4.Earth collection;						
5.Transportation of salty earth;						
6.Production of raw brine						
7.Transportation of the salt;						
8.Other (specify)						

Detail about wood collection
What is the number of mangrove wood bunch required for preparing brine by using one pan (tray)? …………………….
What is the number of other wood bunch required for preparing brine by using one pan (tray)? …………………….
What is the number of mangrove wood bunch collected for salt production per day? …………….
What is the number of mangrove wood bunch collected for salt production per week? …………..
What is the number of mangrove wood bunch collected for salt production per month? …………
What is the number of mangrove wood bunch collected for salt production per season? …………

Table 11: Credit type, membership and perceptions of salt producers

Credit type (cash or material)	Salt production output
4.3.1. Did you receive credit in cash or material for the salt production? ……… (1=yes; 0=no)	Please indicate the number of bag you produced during last campaign? ………. Kg per day Please indicate the number of bag you produced during last campaign? ………. Kg per month Please indicate the number of bag you produced during last campaign? ………. Kg per season

Type of credit							Please indicate the share of the salt production						
Cash			Material					Marketing activities					
Amount perceived	From whom	Payment method [1=cash (interest rate); 2=salt product (kg); 3=other (specify)]	Type of material (name)	Number of material	From whom	Payment method [1=cash (interest rate); 2=salt product (kg); 3=other (specify)]	Consumption (kg)	Quantity sold (kg)	Where (1=campsite; 2=home; 3=Market; 4=other (specify)	Sold to whom?	Amount per bag (GNF)	Total amount during last campaign (GNF)	Any additional cost? (specify)
			1.										
			2.										
			3.										
			4.										

Are you a member of salt production group or association? ……. (1=yes; 0=no). If yes, since when you become member …………. What were the conditions for becoming member? …………..What is the name of your group? ……..Please indicate the number of women …………… and men ………….What are the main activities of this group? ………………Why do you decide to join the group? ……………What kind of benefits are you getting from the group? ……………………
Did you participate to the activities conducted by government institutions, projects or NGOs in this area? ……. (1=Yes; 0=No). If yes, indicate the activities. ………………………....……
Did you participate to the following activities? Circle the number if any participation. 1=Reforestation of degraded areas in the mangrove zone; 2=Reforestation in upland area; 3=Solar salt production technique usage, Guinean saline (tarpaulin or large covering sheet) usage; 4=Improved preparation of brine (limiting the wood usage); 5= other (specify) ……………………………………………..
Does the salt production in the mangrove area has an impact on the mangrove forest? ……… (1=yes; 2=No). If yes how? ………………………………………………………………………………
Do you think that it is acceptable to cut the mangrove forest for the salt production? ………… (1=yes; 2=No). Explain your opinion based on the answer. ……………………………
How do you see the future of these mangroves? (1= good; 2= bad). Give the reason based on your answer. …………………………………
How do you see the future of the livelihood in this coastal area? (1= good; 2= bad). Give the reason based on your answer. ……………………………
Would you like to participate in environmental management/ protection schemes? …….. (1=yes; 0=No). Why? ………………………
Do you think it is important to protect the mangrove forest? …… (1=Yes; 0=No). Why? ....
What is your viewpoint for the future utilization and management of the mangrove forest? …………………………
How do you manage the resources in your community? …………………………………………
Are conflicts occurred in your community related to the natural resources? ……. (1=yes; 0=no). In case of conflict, how do you solve it? ………………………
How many sacred sites exist in the mangrove forest …………? Number sacred sites in the upland forest ………………?
How many protected sites exist in the mangrove forest …………? Number protected sites in the upland forest ………………?
Is here any monitoring for all loggers? ……… (1=yes; 0=no). How many times per year ………
Do you have any legal paper for the mangrove wood collection (extraction)? ……. (1=yes; 0=no). Are the mangrove forest species becoming scarce in the exploited sites? …… (1=yes; 0=no)
Does mangrove logging has an impact on the mangrove forest? ……… (1=yes; 2=No). If yes how? ………………

Section 3: Wood supply (e.g. Fuel wood extraction) in the Mangrove Area

Table 12: Key features of household involved in wood extraction

What are the household members involved in to the wood extraction? Circle the corresponding answer. (1=head of household; 2=wife; 3=children; 4=others)
Where do you extract the mangrove wood? Please indicate the traveled distance too …………………………………………………
By which means can you get the site of wood extraction? Circle the corresponding answer. (1=on foot; 2=by canoe; 3=other (specify).
What are activities conducted by your household members? (1=mangrove wood logging; 2=transport of mangrove wood; 3=unloading the wood; 4=chopping the pole (laths); 5=other (specify)
When did you start the wood extraction (indicate the corresponding month)? ……………………………………..
How long the wood extraction will take? ………….. Months
How many hours a day you work in the wood extraction? ……….hours per day

Materials and organization (group) related to wood extraction							Labor forces involved in the wood extraction						
Please indicate the materials for the wood extraction													
Tools	In case as owner please indicate			In case of rental please indicate			Activities	Hired labors			Family labors		
	Number of tools	Unit price	Total amount	Unit price per day	Number of item	Total amount		Number of hired labors	Number of days	Cost paid to hired labors	Number of family labors	Estimated days for family labors (day)	Estimated cost spend in foods (GNF)
1.Machete							1.Mangrove wood logging;						
2.Chainsaw							2.Transport of mangrove wood						
3.Canoe without engine							3. unloading the wood						
4.Canoe with engine							4. chopping the pole (laths)						
5.Boat							5.						
6.Rope							6.						
7.							7.						
8.							8.						
9.							9.						

Detail about wood collection
What is the number of mangrove wood load transported per day? ………… load ………..m^3
What is the number of mangrove wood load transported per week? ………. load ………..m^3
What is the number of mangrove wood load transported per month? ………. load ………...m^3
What is the number of mangrove wood load transported per season? ………. load ………...m^3

Table 13: Credit type, membership and perceptions of wood loggers

Credit type (cash or material)

4.3.1. Did you receive credit in cash or material for the fuel wood extraction? ……… (1=yes; 0=no)

Type of credit						
Cash			Material			
Amount perceived	From whom	Payment method: 1=cash (interest rate); 2=other (specify)	Type of material (name)	Number of material	From whom	Payment method [1=cash (interest rate); 2=other (specify)]
			1.			
			2.			
			3.			
			4.			

Wood extraction marketing

Type of wood sold	Number of pile per			Amount perceived per			Sold to whom? 1=baker; 2=fish smoking; 3=building site; 4=other (specify)
	day	week	month	day	week	month	
Pole (laths) type A							
Pole (laths) type B							
Pole (laths) type C							
Chopped-off wood A							
Chopped-off wood B							
Chopped-off wood C							

Are you a member of salt production group or association? ………. (1=yes; 0=no). If yes, since when you become member …………. What were the conditions for becoming member? ………………..What is the name of your group? ………………..Please indicate the number of women …………… and men ………….What are the main activities of this group? ……………Why do you decide to join the group? ……………What kind of benefits are you getting from the group? …………………………………………

Did you participate to the activities conducted by government institutions, projects or NGOs in this area? …… (1=Yes; 0=No). If yes, indicate the activities. …………………………………………….

Did you participate to the following activities? Circle the number if any participation. 1=Reforestation of degraded areas in the mangrove zone; 2=Reforestation in upland area; 3=Training about forest management; 4=other (specify) …………………………………..

Do you think that it is acceptable to cut the mangrove forest for fuel wood extraction? ………… (1=yes; 2=No). Explain your opinion based on the answer.………………………………

How do you see the future of these mangroves? (1= good; 2= bad). Give the reason based on your answer. ……………………

How do you see the future of the livelihood in this coastal area? (1= good; 2= bad). Give the reason based on your answer.……………………………………..

Would you like to participate in environmental management/ protection schemes? ………….. (1=yes; 0=No). Why? ……………

Do you think it is important to protect the mangrove forest? ……… (1=Yes; 0=No). Why? ....

What is your viewpoint for the future utilization and management of the mangrove forest? ………………………………

How do you manage the resources in your community? ……………………………………………………………………

Are conflicts occurred in your community related to the natural resources? ……. (1=yes; 0=no). In case of conflict, how do you solve it? ………………………

How many sacred sites exist in the mangrove forest …………? Number sacred sites in the upland forest ………………?

How many protected sites exist in the mangrove forest …………? Number protected sites in the upland forest ………………?

Is here any monitoring for all loggers? ……… (1=yes; 0=no). How many times per year ………

Do you have any legal paper for the mangrove wood collection (extraction)? ……. (1=yes; 0=no). Are the mangrove forest species becoming scarce in the exploited sites? (1=yes; 0=no)

Does mangrove logging has an impact on the mangrove forest? ……… (1=yes; 2=No). If yes how? …………………

Analyses of Socio-economic Status and Livelihood Patterns of Coastal Communities Dependent on Mangrove Forest Resources in Guinea

Abstract

In Guinea, coastal lands play a key role in national food security in terms of agricultural production focused on mangrove rice cultivation and sustainable management of natural resources. Over one-third of the country's population lives in coastal lands. In developing countries like Guinea, the population relies on the natural resources for their livelihood. Coastal communities bordering mangroves derive significant revenue from mangrove wood logging, fishing, mangrove rice cultivation, salt extraction and other activities. All these activities result in the clearing of mangrove forest for agriculture, supply of firewood, etc., and can have a negative impact on the fragile balance of the ecosystem correlatively to population growth along the coast. The current study is focused on the livelihood activities (e.g. salt production, mangrove rice production and mangrove wood logging) of coastal communities in the littoral Guinea. In Guinea, ecosystem degradation results primarily from economic activities including agriculture and logging for firewood.

From my viewpoint, there are no studies in Guinea yet conducted by integrating the socio-economic aspects and spatial analysis to identify the dynamics of mangrove forest resources affected by livelihood activities practiced by the coastal communities. In the same line, there is no study yet interested in the performance in terms of the technical efficiency of small-scale mangrove rice farmers and salt producers in Guinea. I managed also to detect complex scenarios that are the basis of the degradation of coastal forests in Guinea. To my knowledge, this study is the pioneer in these areas in the Guinean context. In addition, it applies advanced econometric models such as stochastic frontier production function, quantile regression, Gini decomposition, Foster-Greere-Thorbecke (FGT) poverty index, loss due to inefficiency, etc. In sum, I come up to diagnose the determinants of livelihood activities (mangrove rice cultivation, salt production and wood extraction) and suggest improvement of socio-economic status of coastal communities and sustainable management of mangrove forest resources.

The main objective of this study consists to analyze the socio-economic status and livelihood patterns of coastal communities dependent on mangrove forest resources in Guinea. The reason behind focusing to such analysis is based on the improvement of the socio-economic status of livelihood coastal communities in Guinea, suggesting

sustainable management of mangrove forest resources, providing sustainable balance approach between coastal communities and coastal forest management.

The study is organized into ten chapters. The first chapter presents the background of the study, defines the general and specific objectives of the current research study and its scope. The second chapter reviews the literature of livelihood activities in the Guinean coastal area dependent on the mangrove forest resources. The third chapter presents the materials and methods adopted for conducting the study. The fourth chapter determines the role of land use change analysis and their determinants in livelihood improvement in the coastal area of Guinea based on the spatial analysis and field survey. The present status and determinants of the mangrove rice production, the analysis of socio-economic status of small-scale salt production techniques for improving livelihood status and sustainable mangrove forest management are discussed in chapters five and six, respectively. The performance in terms of technical efficiency of small-scale improved salt producers and mangrove rice farmers is measured in chapter seven. The investigation on the effects of rural livelihood activities on income inequality and poverty reduction in the Guinean coastal area is presented in chapter eight. The impacts of household energy consumption and livelihood activities on coastal forests in Guinea are shown in chapter nine. Finally, the conclusion, policy recommendations and future research directions cover chapter ten.

This study is based on primary and secondary data. The primary data was conducted through field survey using structured questionnaires, GPS data collection, group discussions and field observation guided by key persons from the study sites. The secondary data was collected via remote sensing data, literature review based on published and unpublished studies. The study was conducted in Dubreka and Boffa prefectures, in the Maritime Guinea region, from March to April 2011 and 2013, where 260 peasants were surveyed. These prefectures represent the most potential zones among others in terms of mangrove rice production, salt production and mangrove wood extraction.

Mainly, the study applied three types of analytical methods. These methods are the descriptive statistics, empirical analyses and spatial analysis. The descriptive statistics refer to mean, percentage, ANOVA, cross tabulations, net profit, rate of income, benefit cost ratio and income ratio. These methods were used to describe the characteristics of surveyed peasants and different livelihood patterns. The empirical analyses refer to the Gini decomposition for measuring the income inequalities regarding the portfolio of livelihood patterns of peasants; the Foster-Greere-Thorbecke (FGT) poverty index for assessing the degree of poverty; the multiple linear regression, quantile regression and binary logistic regression were used to assess factors influencing the mangrove rice production, salt production and farmer's contribution to the land use transitions, respectively; the stochastic frontier production function measured the technical efficiencies of both salt production and mangrove rice farming. Finally, the spatial analysis refers to the post-classification comparison for producing a complete matrix of land use change directions.

The results revealed that: (1) the spatial analysis revealed that about 41.7% of the 5,099 hectares of landscape has undergone changes. The binary logistic regression results indicated that yield and membership in farmer's organizations as two important determinants of land use change. (2) The main purpose of the mangrove farming in the study area remains for the self-consumption. Thus, findings from the multiple regression analysis revealed that the cultivated area, off-farm income per family members, agrochemical, farmers' opinion on the type of irrigation systems, improved seed variety usage and combination of both local and improved rice varieties as factors determining the mangrove rice productivity in the study area. (3) The study shows that salt producers under the improved techniques have more access to convenient household assets and better housing. An improved living condition could limit the deforestation of mangrove and upland forests. The adoption of the improved salt production techniques resulted in the minimization of the total variable cost related to the salt production which led to higher profits. (4) The loss due to the inefficiency was enormously significant (8,838,762 Guinean Francs per acre) for the whole season of mangrove rice production. Results also highlighted the fact that even the best salt producers were inefficient. In addition, the estimation of the loss due to the inefficiency occurring seasonally was significant and valued at 601,024 Guinean francs per basin. (5) The salt production and vegetable production give rise to income inequality. Therefore, by enhancing the share of income from mangrove rice production, wood extraction, non-farm income, livestock, seasonal crop production, lowland rice production, remittance and perennial crop production has the potentials to reduce income disparity among the peasants. Poverty measures also revealed that the degree of poverty reduction largely depends on the extent to which livelihood activities of the peasants can be diversified. (6) The peasants were found heavily relying on the traditional cooking devices which may impact negatively on forest degradations and peasants' health. The study also presented three scenarios leading to the degradation of both mangrove and upland forests threatened by the unsustainable household energy consumption and the livelihood activities (salt production, wood extraction and mangrove rice production) practiced in the coastal area of Guinea.

Policy implications are advocated based on the findings. The three most important policy implications for mitigating rapid land use change in the Guinean coastal belt are: (a) the pressing need to improve mangrove rice productivity, (b) the need to strengthen and maintain strong dikes to prevent sea water intrusion into the rice fields, and (c) the need to strengthen the farmers' organizations to enhance farmer participation. The findings advocate strategies such as encouraging producers' participation in activities organized by local and/or international NGOs for the purpose of sharing knowledge and experience of salt producers. It also suggests coating of basins or ponds for limiting the significant loss of salt occurring seasonally.

The government is required to facilitate the public investment in physical infrastructure (irrigation including embankments, dikes, etc.) which is crucial for improving mangrove rice farmers' efficiency, and then, earnings. Policy makers and different actors involved in the Guinean coastal area are requested to take further efforts to rectify income inequality and poverty alleviation through the provision of extension programs and credit services to rural areas until improved access to market opportunities created a demand for technology and inputs. These recommendations will pave the way to improve rural livelihoods and conserve natural resources and biodiversity.

The negative impact of traditional salt production (TSP) techniques on the mangrove and upland forests could be mitigated through producers' motivation for the adoption of improved salt production (ISP) techniques. Hence, the adoption of ISP techniques could enhance the livelihood improvement and contribute to the sustainability of both mangrove and upland forests.

ギニアにおけるマングローブ林資源に依存した海岸コミュニティの社会経済的地位や生活パターンの分析

要旨

ギニアでは、海岸部の土地はマングローブ稲の栽培等の農業生産の面で、自国のフードセキュリティ上、重要な役割を果たしており、国内人口の三分の一以上がそこに居住している。ギニアのような途上国では、国民は生計のために天然資源に依存している。マングローブ林に接する海岸部の社会では、人々は燃料用の薪を得るためのマングローブの伐採、漁撈、マングローブ稲や塩の生産、その他の活動から重要な収入を得ている。これらの活動のためにマングローブ林が伐採されており、主に農業生産や薪・建設材確保等の経済活動に起因する形で生態系の劣化が進んでいる。

これまでギニアでは、社会経済的な視点と空間分析を統合して、海岸地域の住民によって行われる生計活動によって影響を受けるマングローブ林資源の動態を識別するような研究は行われていない。同様に、小規模なマングローブ稲作や製塩の技術効率に関心を持つ研究も行われていない。著者が知る限り、本研究はギニアでのこのような領域におけるパイオニアである。加えて、本研究は確率的フロンティア生産関数、分位点回帰分析、ジニ係数、FGT 貧困指数、非効率による損失等の高度な計量経済モデルを用いている。これらの手法を用いて、生計活動の決定要因を診断し、海岸地域の社会経済的地位の改善と持続可能なマングローブ林の資源管理のためのマングローブ稲作や製塩、木材製造等の生計活動の決定要因を診断した。

本研究の主な目的は、ギニア海岸部でマングローブ林資源に依存して生活する人々の社会経済的地位と生活パターンを分析することである。

本研究は 10 章から構成されている。第 1 章では、本研究の背景、本課題と小課題について論じた。第 2 章では、マングローブ林資源に依存したギニア海岸地域の生計活動に関する既存研究のレビューを行っている。第 3 章では、本研究の分析対象と分析手法について述べている。第 4 章では、空間分析とフィールド調査に基づいて、ギニア海岸地域における土地利用変化の分析を行い、生活改善におけるその決定要因を明らかにした。第 5 章と第 6 章では、マングローブ稲作の現状と生産の決定要因、生活と持続可能なマングローブ林管理を改善するための小規模製塩技術の社会経済的状況について論じた。第 7 章では、小規模改良型製塩の技術効率を測定した。第 8 章では、ギニア海岸地域における農村の生計活動が所得格差と貧困削減に及ぼす影響を論じている。第 9 章では、家庭でのエネルギー消費と生計活動の影響を論じている。最後に第 10 章で

は、結論と政策提言、将来の研究の方向性を述べている。

本研究は、一次データ、及び二次データに基づいている。一次データは、構造化された質問票を用いた農家調査、GPS、グループ調査、現地のキーパーソンのガイドによるフィールド観察により収集した。第二次データは、リモートセンシング・データ、公刊・未公刊の既存研究に対する文献レビューにより収集した。本研究では、ギニア海岸地域の Dubreka 県、Boffa 県を対象に 2011 年、2013 年の３月から４月に実施した農家調査により、260 戸の農家データを収集した。これらの県は、マングローブ稲の生産や製塩、薪生産の面で最も潜在力のある地域である。

本研究では、主として記述統計、実証分析、空間分析の３種類の分析方法を用いた。記述統計は、平均、割合、分散分析、クロス集計、純利益、所得率等を用いた。これらの方法は、調査対象とした農民の特徴と、異なる生活のパターンを説明するために用いられている。実証分析では以下の方法を用いた。農民の生計獲得方法に起因する所得の不平等を説明するためにジニ係数、そして、農民の貧困の度合いを評価するために FGT 貧困指数を用いた。多重線形回帰、分位点回帰分析、バイナリロジスティック回帰分析を用いて、マングローブ稲作、製塩に影響する要因、土地利用の遷移に対する農民の影響を評価した。確率的フロンティア生産関数を用いて、マングローブ稲生産と製塩の技術効率性を評価した。最後に、空間分析を用いて、土地利用変化の方向を検討した。

本論文の結論は以下のように要約できる。（１）空間分析の結果、(1990 年から 2010 年までの 20 年間に) 対象地域の 5,099ha の土地のうち 41.7%の土地利用が変化していた。バイナリロジスティック回帰分析の結果より、農民組織への加入、マングローブ稲の収量が土地利用の変化を引き起こす二つの重要な要因として示された。（２）調査地域におけるマングローブ林での農業生産は、主として自家消費を目的としている。重回帰分析の結果から、栽培面積、世帯員１人当たりの農外所得、農薬、灌漑方式に対する農民の意見、水稲改良品種の使用、在来品種と改良品種の組み合わせといった変数が、調査地域のマングローブ稲作の生産性を規定する要因であることが示された。（３）改良技術を用いている製塩業者は、便利な家財や良い家を所有している割合が高くなっていた。このような生活環境の改善を通じて、マングローブ林や内陸の森林の伐採を制限することができる。改良された製塩技術の採用により、製塩のための可変費用を最小化することができ、その結果、高い利益につながっている。（４）生産の非効率に起因する損失は、マングローブ稲作の全期間にわたって有意であり、884 万ギニアフラン/エーカーであった。また、最も優秀な塩の生産者も非効率であった。加えて、非効率な製塩によって発生する損失は、製塩用池単位当たり 60.1 万ギニアフランであると推計された。（５）製塩と野菜生産は、所得の不

平等を生じさせる。そのため、マングローブ稲作、木材の伐採、農外所得、家畜、季節性作物の生産、低地米の生産、家族からの送金、多年生作物生産により農家間の所得格差を減らす可能性がある。また、貧困削減の程度は、農家の生計活動を多様化することができる程度に依存していることを明らかにした。
(６)農民は、森林の劣化と農民の健康に悪影響を及ぼす可能性のある伝統的な調理器具の利用に依存している。研究では、持続不可能な家庭でのエネルギー消費とギニア海岸部で行われている生計活動（製塩、薪の伐採、マングローブ稲作）によって、マングローブ林と内陸林の劣化につながる３つのシナリオを提示した。

以上の分析結果を踏まえて、ギニア海岸部の急速な土地利用の変化を緩和するために、以下の政策提言を行った。(a)マングローブ稲作の生産性を向上させるための支援、(b)マングローブ稲を生産している水田への海水の浸入を防ぐための堤防の強化と維持、(C)農民の参加を進めるための農民組織の強化である。また、研究結果をふまえて１）塩製造者の知識や経験の共有を目的として、地方/国際 NGO が組織した活動への参加を奨励。２）季節的に発生する塩の損失を防ぐための塩田底部の被覆、等の方策を提唱する。

政府は、マングローブ稲作農家の生産効率と所得を向上させるために重要となる灌漑、堤防などのインフラストラクチャーへの公共投資を促進することが求められている。所得の不平等や貧困を緩和するためには、技術や投入材への需要を作り出す市場へのアクセスの機会が改善されるまで、政策立案者やギニア海岸地域に関わる主体は、普及サービスや農村部へのクレジットサービス等に関するさらなる努力が必要である。これらの推奨事項は、農村の生活を改善し、天然資源や生物多様性を保全するための道を開く。

マングローブ・平地林に対する伝統的な製塩技術の負の影響は、改良製塩技術を採用しようとする生産者の意欲によって軽減することができた。したがって、改良製塩技術の採用は、家計の改善に貢献し、マングローブ・平地林の持続可能性に貢献することができる。

List of Related Publications in Peer-Reviewed Journals

1. Boubacar Siddighi Balde, Hajime Kobayashi, Ichizen Matsumura, Mohamed Esham, Arif Alam and Emmanuel Tolno: Land use change and their determinants in the coastal area of Guinea: A study based on spatial Analysis and field survey. *Journal of the Japanese Agricultural Systems Society*, 30(3): 65-75, July, 2014.
   Covered in Chapter III and Chapter IV

2. Boubacar Siddighi Balde, Hajime Kobayashi, Makoto Nohmi, Akira Ishida, Mohamed Esham and Emmanuel Tolno: An analysis of technical efficiency of mangrove rice production in the Guinean coastal area. *Journal of Agricultural Science*, Vol.6 (No.8), 179-196, July, 2014.
   Covered in Chapter III and Chapter VII

3. Boubacar Siddighi Balde, Hajime Kobayashi, Akira Ishida, Makoto Nohmi, Mohamed Esham, Ichizen Matsumura and Emmanuel Tolno: Effects of rural livelihood activities on income inequality and poverty reduction in the Guinean coastal area. *Journal of Agricultural Science*, Vol.6 (No.6):113-130, May, 2014.
   Covered in Chapter III and Chapter VIII

4. Boubacar Siddighi Balde, Hajime Kobayashi, Makoto Nohmi, Akira Ishida, Ichizen Matsumura, Mohamed Esham and Emmanuel Tolno: A stochastic frontier approach for measuring technical efficiency of small-scale improved salt production in Guinea. *American Journal of Applied Sciences*, Volume 11(Issue 8):1310-1320, May, 2014.
   Covered in Chapter III and Chapter VII

5. Boubacar Siddighi Balde, Hajime Kobayashi, Ichizen Matsumura, Makoto Nohmi, Mohamed Esham and Emmanuel Tolno: Present status and determinants of mangrove rice production in Dubreka prefecture in Guinea. *Japanese Journal of Farm Management*, Vol.51 (No.3):97-102, December, 2013.
   Covered in Chapter III and Chapter V

6. Boubacar Siddighi Balde, Hajime Kobayashi, Makoto Nohmi, Akira Ishida, Ichizen Matsumura, Mohamed Esham and Emmanuel Tolno: Socio-economic analysis of small-scale salt production techniques in the coastal area of Guinea: As an alternative for improving livelihood status and sustainable mangrove forest management. *International Journal of Research in Engineering, IT and Social Sciences*, Volume 3 (Issue 9):1-23, September, 2013.
   Covered in Chapter III and Chapter VI