



USAID
FROM THE AMERICAN PEOPLE

Rapid assessment of mangrove status to assess potential for payment for ecosystem services in Amanzule in the Western Region of Ghana



Gordon Ajonina, Ph. D., Consultant

November 2011

Hen Mpoano

THE
UNIVERSITY
OF RHODE ISLAND
GRADUATE SCHOOL
OF OCEANOGRAPHY



This publication is available electronically on the Coastal Resources Center's website at <http://www.crc.uri.edu>

For more information on the Integrated Coastal and Fisheries Governance project, contact: Coastal Resources Center, University of Rhode Island, Narragansett Bay Campus, 220 South Ferry Road, Narragansett, Rhode Island 02882, USA. Brian Crawford, Director International Programs at brian@crc.uri.edu; Tel: 401-874-6224; Fax: 401-874-6920.

For additional information on partner activities:

WorldFish: <http://www.worldfishcenter.org>

Friends of the Nation: <http://www.fonghana.org>

Hen Mpoano: <http://www.henmpoano.org>

Sustainamatrix: <http://www.sustainamatrix.com>

Citation: Ajonina, G. (2011) Rapid Assessment of Mangrove Status to Assess Potential for Payment for Ecosystem Services in Amanzule in the Western Region of Ghana. USAID Integrated Coastal and Fisheries Governance Program for the Western Region of Ghana. Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island. 36 pp.

Disclaimer: This publication is made possible by the generous support of the American people through the United States Agency for International Development (USAID)/Ghana. The contents of this report are the responsibility of the Integrated Coastal and Fisheries Governance (ICFG) Program and do not necessarily reflect the views of the United States Government. Associate Cooperative Agreement No. 641-A-00-09-00036-00 for "Integrated Coastal and Fisheries Governance (ICFG) Program for the Western Region of Ghana," under the Leader with Associates Award No. EPP-A-00-04-00014-00.

Cover Photo: *A village in Ghana*

Cover Photo Credit: *Coastal Resources Center – Ghana*

ACKNOWLEDGMENTS

The consultant is gratefully indebted to persons, projects, programmes and institutions contacted during the study. I would like to acknowledge with great thanks the guided assistance of Kofi Agogah of CRC throughout the work. I appreciate greatly the field assistance and contribution of Nicolas Breslyn of NCRC, Balertey Cormey of CRC and Felix Nani of Wildlife Division for their invaluable field assistance without which the work could not have been possible. Great thanks are also due Patrick Sarpong proprietor of Beyin Beach Resort for hospitality and responding to my interview, Tundi Agardi and Winnie Lau of MARES for giving me this opportunity to contribute to mangrove management in Ghana. John Mason of NCRC, Frank Hicks (Forest Trends) and Joerg Seifert-Granzin (Forest Trends) for initial contacts that led to this work. I also thank Esinam Attipoe for sending complementary information about the area.

LIST OF ABBREVIATIONS AND ACRONYMS

BA	Basal Area per hectare
CRC	Coastal Resource Center
GWS	Ghana Wildlife Society
NCRC	Nature Conservation and Research Center
NGO	Non Governmental Organisation
PES	Payment for Ecosystem Services
PSP	Permanent Sample Plot
TSP	Temporal Sample Plot
UNEP	United Nations Environment Programme

Contents

Contents

ACKNOWLEDGMENTS	ii
LIST OF ABBREVIATIONS AND ACRONYMS	ii
List of Figures	iv
List of Tables	iv
EXECUTIVE SUMMARY	1
Introduction	1
Methodological framework	1
Data and information collection.....	1
Survey of mangrove sites.....	1
Findings	1
General status of mangroves.....	1
Carbon storage potentials.....	2
Mangrove wood consumption and impacts on mangrove forests.....	2
Institutional issues, governances of wetlands and potentials for a PES scheme.....	2
Conclusions	3
Recommendations	3
Short-term recommendations.....	3
Medium- and long-term recommendations.....	3
1. INTRODUCTION	4
1.1. Context	4
1.2. Objective of the assessment	4
1.2.1. General objective.....	4
1.2.2. Specific objectives.....	4
1.3. Structure of the report	5
2. METHODOLOGICAL FRAMEWORK	6
2.1. Site description	6
2.1.1. Location of the survey area.....	6
2.1.2. Biophysical environment.....	6
2.1.3. Socio-economic environment and human activities.....	7
2.2. Data and information collection and analysis	7
2.2.1. Survey of mangrove sites.....	8
2.2.2. Assessing mangrove ecosystem services.....	8
3. FINDINGS	11
3.1. Status and threats of mangrove ecosystem services	11

3.1.1. General status of mangroves	11
3.1.2. Carbon storage potentials	13
3.1.3. Mangrove wood consumption and impacts on mangrove forests	14
3.2. Institutional issues, governance of wetlands and potentials for a coastal and marine PES scheme	16
3.2.1. Institutions and stakeholders for mangrove management	16
3.2.2. Importance and potentials of local tourism industry development	18
3.2.3. Prospects of oil and gas industry	21
4. CONCLUSIONS AND RECOMMENDATIONS	23
4.1. Conclusions	23
4.2. Recommendations	23
4.2.1. Short-term recommendations	23
4.2.2. Medium- and long-term recommendations	24
REFERENCES	25
ANNEXES	27

List of Figures

Figure 1 Schematic of mangrove temporal sample plots (a) for measurement of all stems dbh ≥ 1 cm (b) for seedlings & saplings ≤ 1 cm and stiltroots with measurement of middle diameter of stiltroot.	9
Figure 2 Map of Amanzuri wetlands showing distribution of surveyed mangrove sites	11
Figure 3 Stem diameter distribution in mangrove forests of Amanzuri wetlands, Ghana	14
Figure 4 Fish smoke ovens in mangrove communities in (A) West Africa Efasou, Ghana and Central Africa (B) Mouanko , Cameroon (Photos: A: Nicolas Breslyn B: Gordon Ajonina).	16
Figure 5 Monthly and year distribution of tourist visits from sites around Amensuri wetlands, Ghana	19
Figure 6 Monthly and year trends in tourism revenue from sites around Amensuri wetlands, Ghana	20
Figure 7 Interview with the proprietor (in red short) of eco-lodge at Beyin (Photo by Nicolas Breslyn)	21

List of Tables

Table 1 General appraisal of mangrove status and condition in the Amanzuri wetlands (based on 18 mangrove sites), Ghana	12
Table 2 Stand structural characteristics and above ground carbon stocks of intact and degraded Rhizophora dominated mangroves in the Amanzuri wetlands, Ghana	13
Table 3 Characteristics of mangrove wood use and per ha value of mangroves for fuel wood within a typical fishing community (Efasou, Amanzuri wetlands, Ghana)	15
Table 4 Community fuel wood consumption and impacts on surrounding mangrove forests within the Efasou fishing community (Amanzuri wetlands, Ghana)	15
Table 5 First level institutional and stakeholder analysis for mangrove management	17
Table 6 Second level local institutional and stakeholder analysis for mangrove management	18

EXECUTIVE SUMMARY

Introduction

A rapid assessment was carried out within the mangroves of Amanzule Wetlands in Ghana to assess the types and conditions of mangroves and associated ecosystem services (e.g., carbon sequestration, fish nursery, and coastal protection) in the field for use in feasibility assessment of the potential for payment for ecosystem services in the mangroves and wetlands in Amanzuri and surrounding areas.

Specific objectives of the rapid assessment were:

- To provide analysis of the types of mangroves and wetlands and their status and distribution in the Amanzuri region;
- To gather information about the uses and governance of these wetlands
- Provide insights into the use of the information gathered in feasibility assessment of the potential for payment for ecosystem services in the mangroves and wetlands in Amanzuri and surrounding areas.

Methodological framework

Data and information collection

Both primary and secondary data collection approaches were used for the study. A combination of stakeholder's discussions and on-ground surveys during field trips were used to gather the necessary information. A more participatory approach was adopted by interactive discussion of basic issues during various consultative meetings and interviews organized with local institutions: local authorities, private sector operators (especially tourism), public authorities community groups including NGOs: NCRC and CRC to gather information about the governance of these wetlands and to discuss the project status especially preliminary assessment of the potential for developing a blue carbon project in the region, including discussions with NCRC and CRC about their planned larger-scale carbon mapping work.

Survey of mangrove sites

The over 18 mangrove sites visited during the field trip spanning over five days from 11 – 15 September 2011 were guided by information on existence of mangroves from many local informants. Data and information collected from each mangrove site enabled the sites to be mapped, assessed for mangrove ecosystem services especially potentials for carbon storage and sequestration services, mangrove wood use and impacts on the forest.

Findings

General status of mangroves

The survey showed that over 1 000 ha of mangrove forests exist in scattered pockets of less than 10 ha (in 56% of the sites) in Amanzuri area representing about 10% of national mangrove coverage of 14 000 ha. Most of the mangroves do not appear in the current vegetation map of the area are estuarine mangrove type (61%), generally healthy (44%) reaching canopy height of 30m surrounded by coconut plantations (61%) supporting the livelihood and ecological securities of the surrounding fishing or farming population of less than 500 people (56%). There was a general perception by mangrove communities in 50% of the sites surveyed that these mangroves have decreased in area over the last 20 years. Identified threats include wood collection for fuel wood, charcoal, construction, etc, pollution from wastes disposal especially in around urban centers and mining activities) and mouth closure due to sedimentation that impedes tidal flow that maintain mangrove ecological processes. However there have been non or prohibited cutting on mangroves in over 60% of the sites.

Carbon storage potentials

The total above ground carbon stored in intact mangroves in the area ranged from 65 – 422 tC/ha (mean of 185 tC/ha) with mangrove roots holding in some cases 78% in degraded mangrove areas. It should be noted that below ground carbon storage accounts for over 50% and reaching 98% of total whole ecosystem storage in mangrove ecosystems from a recent quantification of whole- ecosystem carbon storage in Indo-Pacific region.

Mangrove wood consumption and impacts on mangrove forests

The mangroves are currently valued for fuel wood use at 4146 Ghanaian cedis (US\$2765) per ha within the Efasou community. Mangrove wood consumption for cooking and fish smoking from the Efasou community is estimated at 16 and 97m³/household/yr respectively with a respective per capita consumption of 1.8 and 10.8 m³/person/yr. Current deforestation rates for cooking and fish smoking is put at 0.06 and 0.34 ha/household/year respectively with a respective per hectare harvest of 0.006 and 0.038 ha/person/year. Wood consumption for fish smoking were generally lower than for a Cameroonian fishing community owing to the use of more efficient fish smoking ovens

Institutional issues, governances of wetlands and potentials for a PES scheme

The institutions and stakeholders in the management of mangrove forests in the Western Region of Ghana reflect a broad range of interests at national, regional and local community level. The role played by each of these stakeholders has a direct or indirect impact on the resource. At the apex of the stakeholder spectrum is the national government whose policies and programs for management of mangroves and associated wetlands are implemented through the Wildlife Division of the Forestry Commission and other related agencies such as the Lands Commission and the Department of Town and Country Planning. At the regional level we have Regional Coordinating Council. The local level is represented by a number of players or interest groups whose actions and inactions determine the outcome of all mangrove management efforts now and in the foreseeable future. These include among others, the District Assemblies with their substructures, civil society groups, producer groups and trade associations, traditional authorities, commercial organizations and local communities around the mangrove forests.

The following general observations can be made:

First level institutional and stakeholder's analysis (Central government, department agencies, regional administration, academic research institutions, local government and donor agencies).

- Weak enforcement of existing legislation
- Good structures in place but severely limited by logistical capacity of government departments
- Lack of communication and information sharing to intended users
- Poor attitude towards mangrove and wetlands which is not taken in any development planning processes
- Donors funds that address short term solutions to long-term problems with poor level of private sector participation

Second level institutional and stakeholder's analysis (District assemblies, traditional authorities, local communities, NGOs and other civil society groups).

- - Ignorance of roles of wetlands that are taken for granted
- - Land tenure conflicts
- - Long term financing leading to period of neglect in working with communities as less than 40% of the mangrove sites has received any intervention (Table 1 & Annex 1)
- - Lack of adequate knowledge and capacity for wetland management

Conclusions

- *Types, status and distribution of mangroves and associated wetlands in the Amanzuri region.* More than 1 000 ha of mostly estuarine mangrove forests exist in scattered pockets in Amanzuri area representing about 10% of national mangrove coverage with most of the mangroves not captured in the current vegetation map of the area. These mangroves are generally healthy supporting the livelihood and ecological securities of surrounding fishing or farming human population. There was a general perception of mangrove communities that these mangroves have decreased in area over the last 20 years with identified threats that include wood collection for fuel wood, charcoal, construction, etc, pollution from wastes disposal especially in around urban centers and mining activities and mouth closure due to sedimentation that impedes tidal flow that maintain mangrove ecological processes. The total above ground carbon stored in intact mangroves in the area is also important and can be comparable to similar mangrove systems. The mangrove is currently valued for fuel wood use at 4146 Ghanaian cedis (US\$2765) per ha with a significant impact on mangrove forest
- *Institutional issues and governance of wetlands in the area.* The institutions and stakeholders involved in the management of mangrove forests in the Western Region of Ghana reflect a broad range of interests at national, regional and local community level. The role played by each of these stakeholders has a direct or indirect impact on the resource.
- *Feasibility of a PES scheme* can be seen from the view point of the institutional and stakeholders in the region. The challenge is how to get the private sector involved in the deal especially the oil companies. Already private tourisms initiatives hold some promise as some have started some green investments.

Recommendations

Short-term recommendations

- Addressing stakeholders and instructional issues
 - Development of stakeholders contact data base.
 - Organization of an enlarged stakeholder's forum.
 - Cross institutional capacity building.
 - Sharing of research finding
 - Sensitization campaigns.
- Completion of Ghana carbon map and mangrove carbon monitoring

Medium- and long-term recommendations

- Addressing direct on site threats to mangrove ecosystem services
 - *Conservation.* For sites with significant healthy mangroves
 - *Hydrological restoration.* For sites with mouth closure due to sedimentation through channel opening to allow normal tidal exchange with mangroves, areas
 - *Replanting.* For badly degraded sites
 - *Waste removal.* Particularly for urban and peri-urban polluted sites
- Policy review or reforms.
- Sustainable funding through private sector participation

1. INTRODUCTION

1.1. Context

Mangroves cover about 140 km² in Ghana being limited to a very narrow, non-continuous coastal area around lagoons on the west of the country; and to the east, on the fringes of the lower reaches and delta of the Volta River (UNEP, 2007). They are most extensive to the west in the stretch between Cape Three Points and Côte d'Ivoire, especially, areas around Half Assini, Amanzuri lagoon, Axim, Princes Town and Shama, among others including Takoradi area. To the east of the country, they are best developed at Apam, Muni lagoon, Winneba, Sakumo-1 lagoon, Bortiano, Korle lagoon, Teshie, Sakumo-2 lagoon, Ada, Sroegbe and Keta lagoon. Six species of mangroves typical of West-Central African mangroves are found in Ghana: *Acrostichum aureum*, *Avicennia germinans*, *Conocarpus erectus*, *Laguncularia racemosa*, *Rhizophora harrisonii*, and *Rhizophora racemosa*. The open lagoons tend to be dominated by *Rhizophora racemosa*, whilst closed lagoons with an elevated salinity contain *Avicennia germinans*, *Conocarpus erectus*, *Laguncularia racemosa* and *Acrostichum aureum* (UNEP, 2007).

Ghana's mangrove ecosystems are tremendously valuable, providing ecosystem services like carbon sequestration, protection from storms, floods, and erosion, provision of timber and non-timber forest products, processing of waste and nutrient pollution, aquaculture and agriculture support, and habitat for aquatic and terrestrial species. In the lower Volta, the total estimated value for mangrove related harvesting (fish smoking, house roofing) (US \$ 340 per hectare) and contribution to marine fisheries (US \$ 165 per hectare) is over US \$ 500 per hectare with country estimates of well over US\$ 6,000,000 per year but not including all the other mangrove ecosystem services (e.g. erosion control, trapping of pollutants, provision of biomass for the detritivore food chain etc.) (Gordon *et al*, 2009).

Yet, as in many other parts of the world, short-term development needs are undermining long-term mangrove health and survival. Between 1980 and 2006, the mangrove area in Ghana fell from 181 km² to 137 km² representing a loss of 24% (UNEP 2007; Ajonina *et al*, 2008).

Fortunately, economic mechanisms have the potential to tip the balance toward restoration, maintenance, and protection of mangrove forests. The need for proper valuation of mangrove ecosystem services underpins such mechanisms towards the establishment of any realistic payment for ecosystem services scheme in any given mangrove or wetland habitat.

1.2. Objective of the assessment

1.2.1. General objective

To assess the types and condition of mangroves and associated ecosystem services (e.g., carbon sequestration, fish nursery, and coastal protection) in the field for use in feasibility assessment of the potential for payment for ecosystem services in the mangroves and wetlands in Amanzuri and surrounding areas.

1.2.2. Specific objectives

Specific objectives of the rapid assessment were:

- To provide analysis of the types of mangroves and wetlands and their status and distribution in the Amanzuri region; and
- To gather information about the uses and governance of these wetlands
- To provide insights into use of information gathered in feasibility assessment of the potential for payment for ecosystem services in the mangroves and wetlands in Amanzuri and surrounding areas.

1.3. Structure of the report

The report is divided into five chapters:

- chapter one Introduction
- chapter two provides the methodological framework that includes general site description and the methods of data and information collection and analyses.
- chapter three presents and discusses the findings of the assessment
- chapter four then draws general conclusions and recommendations.

2. METHODOLOGICAL FRAMEWORK

2.1. Site description

Ghana

Ghana is located in West Africa on the Guinea Coast. At latitudes of 4-12°N, It shares borders with Togo on the East, Burkina Faso on the North, La Cote d'Ivoire on the West and the Gulf of Guinea to the South. Ghana covers an area of 238,539 square kilometers. Extensive water bodies, including Lake Volta and Bosomtwi, occupy 3,275 square kilometers, while seasonal and perennial rivers occupy another 23,350 square kilometers. Ghana's population is estimated at 23.8 million (2009) and is assumed to be increasing at a rate between 2.8 and 3.0 percent per annum. The birth rate (1999) is estimated at 39 per thousand, death rate 10 per thousand and infant mortality rate is 66 per thousand life births. Ghana is classified as a developing country with a per capita income GDP of US\$ 1098 (2009).

Agriculture and livestock constitute the mainstay of Ghana's economy, accounting for 32% of GDP in 2009 and employs 55% of the economically active population. Agriculture is predominantly rainfed, hence making it a great concern with respect to potential climatic changes. Climate change and variability is already affecting Ghana's water resources, and often attributed to global warming caused by increased greenhouse gas emissions for several decades. Their impacts on the country are evident in climate-induced changes to physical and biological systems which increasingly exert considerable stress on the country's vulnerable sectors: Agriculture, Coastal Zones/Marine Ecosystems and Water Resources.

Whilst there is no concrete evidence of climate change occurring in Ghana, some climate variability through changing regimes of climatic factors are evident. These climatic extremes, has led to periods of severe drought, crop production and livestock herds decline and the severe food shortage experienced in the country in the early 1980's was a clear testimony. The adverse impacts of climate change on the socioeconomic factors driving the sustainable livelihoods of the rural communities coupled with poverty also limit economic development.

2.1.1. Location of the survey area

The survey area lies (see Figure 2) within the Amanzuri Wetlands which is a community protected area in the Western Nzema Traditional Area of the Western Region. The catchment of the wetland lies within the Western Evergreen Forest zone of Ghana. It covers an area of approximately 100 sq. km. Amanzuri wetland (latitudes 4° 53' and 4° 46' North and longitude 2° 00' and 2° 05' west) is 360 km west of Accra. It is bordered to the east by Central Region, to the west by Cote D'Ivoire, to the north by Ashanti and Brong-Ahafo regions and to the south by the Gulf of Guinea. The mangrove areas also lie within six coastal districts of the Western Region: Jomoro District, Nzema East Municipality, Ahanta West District, Sekondi-Takoradi Metropolitan and the newly created Shama District and Ellembele District.

2.1.2. Biophysical environment

Geology and soils

The soil are predominantly Forest Oxysols and Forest Ochrosols-Oxysols intergrades (Brammer, 1962).

Hydrology and wetlands

Amanzuri is approximately 1010 square kilometers in size and its hydrology is driven by six

streams, one lake, and one outlet to the sea. It includes freshwater Amanzuri lagoon, the coastal Amanzuri lagoon and estuary, and the sandy beach between Amanzuri and Ankobra River and the area is subject to seasonal flooding. It is a relatively a pristine complex consisting of a freshwater lagoon, forest, grasslands and rivers. It has the most extensive remaining stand of intact swamp forest in Ghana.

Climate and vegetation

The region lies in the equatorial climate zone characterized by moderate temperatures. About 75 percent of the land area falls within Ghana's high forest zone. It is characterized by high rainfall and relative humidity. It experiences a double-maxima pattern of rainfall and peaks in May-June and October-November each year. The average annual rainfall is 1,600mm with the relative humidity being 87.5%. A mean annual temperature of 26° C has been recorded. However, there is a short dry season (Dec-Mar) during which period a northwesterly directional wind is experienced with slight harmattan conditions.

Biodiversity values

The Amanzuri Wetlands is the only known peat swamp forest in Ghana, and nationally, the best example of swamp forest characterized with black humic water. Some 70% of the site is covered by swamp forest, making accessibility difficult hence contributing its unspoilt nature. Has a rich biodiversity. In terms of flora 33% of the 237 species of plants identified are endemic to the wetland. Notable species include raffia palm and iron wood (*Lophira alata*).

Faunal reports (GWS, 2003) estimate 27 species of mammals, including black and white colobus, Mona, and spot-nosed monkeys; forest squirrels; and red river hog. Some 26 species of reptiles and amphibians, including the slender-snouted crocodile and the dwarf crocodile, green mambas and black forest cobra. There are 26 species of fish.

The wetland is relatively rich in indigenous avifauna and also hosts various migrant species. Over 105 species of bird were recorded in an inventory, 65 of which are of global and national conservation interest. The area is classified as IBA (Birdlife International, 2007) and it meets the criteria for designation as a Wetland of International Importance.

Another important biodiversity characteristic of the site is the coastal areas constituting important turtle nesting sites. Species with possibility of being sighted include (NCRC/Benyin Beach Resort, 2000): the Leatherback, *Dermochelys coreace* (common), Green turtle *Chelonia mydas* (common) Olive Ridley, *Lepidochelys olivacea* (most common) and Hawksbill, *Eretmochelys imbricate* (rare). Species such as Loggerhead *Caretta caretta* and Kemp's Ridley *Lepidochelys kemp* are yet to be sighted in the area

Increasing development trends place them at further risk. A particular concern is that these sensitive lagoons, which are important as nursery grounds for many demersal fish species, as habitat for birds, mammals, reptiles and as turtle nesting beaches, are becoming increasingly vulnerable to degradation from development.

2.1.3. Socio-economic environment and human activities

Activities include fishing, local gin processing, and charcoal production, small scale farming of crops such as coconut, oil palm, cassava, cocoa, plantain and small scale trade.

2.2. Data and information collection and analysis

Both primary and secondary data collection approaches were used for the study. A combination of stakeholder's discussions and on-ground surveys during field trips were used

to gather the necessary information. A more participatory approach was adopted by interactive discussion of basic issues during various consultative meetings and interviews organized with local institutions: local authorities, private sector operators (especially tourism), public authorities community groups including NGOs: NCRC and CRC to gather information about the governance of these wetlands and to discuss the project status especially preliminary assessment of the potential for developing a blue carbon project in the region, including discussions with NCRC and CRC about their planned larger-scale carbon mapping work.

2.2.1. Survey of mangrove sites

The over 18 mangrove sites visited during the field trip spanning over five days from 11 – 15 September 2011 were guided by information on existence of mangroves from many local informants. Data and information collected from each mangrove site visited included:

- GPS fixes and estimation of mangrove area from maximum width and length for mapping purposes using GIS softwares especially ARC Info & ArcView,
- mangrove type (estuarine, lagoonal, etc) ,
- tidal exchange status
- the degraded and health status of the mangrove ,
- Main adjoining vegetation,
- Population, institutional and stakeholders issues around mangroves
- Community perception of trends of mangrove area change during the last 10-20 years
- Main activities within mangroves,
- Current uses and potential threats, and
- future management perspectives

2.2.2. Assessing mangrove ecosystem services

Carbon storage and sequestration services

The carbon storage and sequestration potentials of the mangroves were measured through the establishment of 0.01ha (10m x10m) temporal sample plots (TSPs) systematically laid at 10m interval along a random 30m transect compass direction from a fixed point. This is a simplified modification of 6 (10m x 10m) plots laid along 100m transect used in the Central African coastal region of Cameroon (Ajonina, 2008). A total of four TSPs were assessed in four mangrove sites and one plot in a degraded mangrove site. The diameter at breast height or 30cm above the stiltroot was measured for all trees within the plot with a diameter tape and stand height determined by means of a Suunto Clinometer. Roots and seedlings not measured in the plots were counted in 5(1m²) plots placed systematically at 1m interval along the 10m x 10m plot (Figure 1), middle diameter and height of the roots and seedlings were also measured.



Transect orientation and lay-out (Random compass direction)

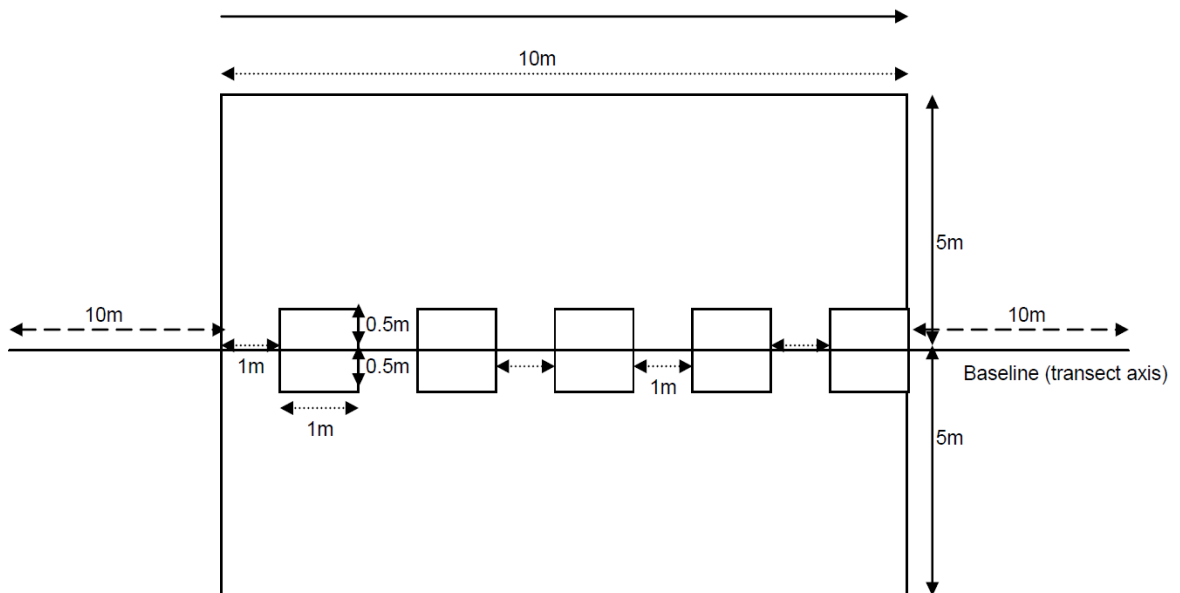


Figure 1 Schematic of mangrove temporal sample plots (a) for measurement of all stems dbh ≥ 1 cm (b) for seedlings & saplings ≤ 1 cm and stilts with measurement of middle diameter of stilts.

The tree and stand data obtained were used to obtain estimates for above ground mangrove forest carbon densities from biomass assessment following various standard volume estimation procedures (Loetsch *et al*, 1973, Cailliez, 1980; Husch *et al*, 2003):

Basal area per hectare

$$BA = \pi/4 \sum (f_i d_i^2) / A \text{----- (1) Volume per hectare}$$

$$V_s = BA.H.F \text{----- (2)}$$

Where BA = basal area per hectare ($m^2 ha^{-1}$)

V_s = standing volume per hectare ($m^3 ha^{-1}$)

d_i = diameter (in metres)

F = tree form factor (0.6) (from Ajonina and Usongo, 2011)

H = canopy height above stilt root (m) or height of roots or seedlings

A = plot area in hectares
 f_i = number of trees in the i^{th} DSR class

Carbon density was estimated as half biomass obtained from product of volume and mangrove mean wood density values obtained from Fearnside (1997) of 0.890 t/m^3

Mangrove wood use and impacts on mangrove forest

A detailed mangrove wood use survey was carried out in the Efasou fishing community area known for intensive use of mangroves for fish smoking. Mangrove wood stocks owned by households¹ in the area were estimated as well as estimates of turnover rates by members of the household for cooking and fish smoking activities. The information and data from mangrove forest stock assessment were then used to assess the rate of mangrove wood utilisation as follows (Ajonina and Usongo, 2001; Ajonina *et al*, 2005):

Estimating the rate of deforestation

Per household

$$D_h = 52V_h/t \text{----- (3)}$$

Total rate of deforestation (volume estimate)

$$D_t = nD_h \text{----- (4)}$$

Total rate of deforestation (per hectare estimate)

$$D_r = D_t / V_s \text{----- (5)}$$

Where D_h = household deforestation rate ($\text{m}^3 \text{ household}^{-1} \text{ yr}^{-1}$)

V_h = mean household wood stock (m^3)

t = turnover rate (in weeks)

n = total number of households

D_t = total rate of deforestation ($\text{m}^3 \text{ yr}^{-1}$) D_r = total rate of deforestation (ha yr^{-1})

V_s = mangrove stocking rate ($\text{m}^3 \text{ ha}^{-1}$)

Mangrove ecosystem services for fisheries and storm protection

Data was very limited to assess mangrove ecosystem services for fisheries and storm/erosion protection within the context and framework of methods provided by (Barbier *et al* 1997).

¹ A household was defined in this case as people irrespective of families, sleeping under one roof or living in same house.

3. FINDINGS

3.1. Status and threats of mangrove ecosystem services

3.1.1. General status of mangroves

The current general status of the mangroves in the Amanzuri wetlands based on the 18 sites surveyed is presented in Table 1 and mangrove distribution map in Figure 2. Details of site specific status are presented at Annex 1.

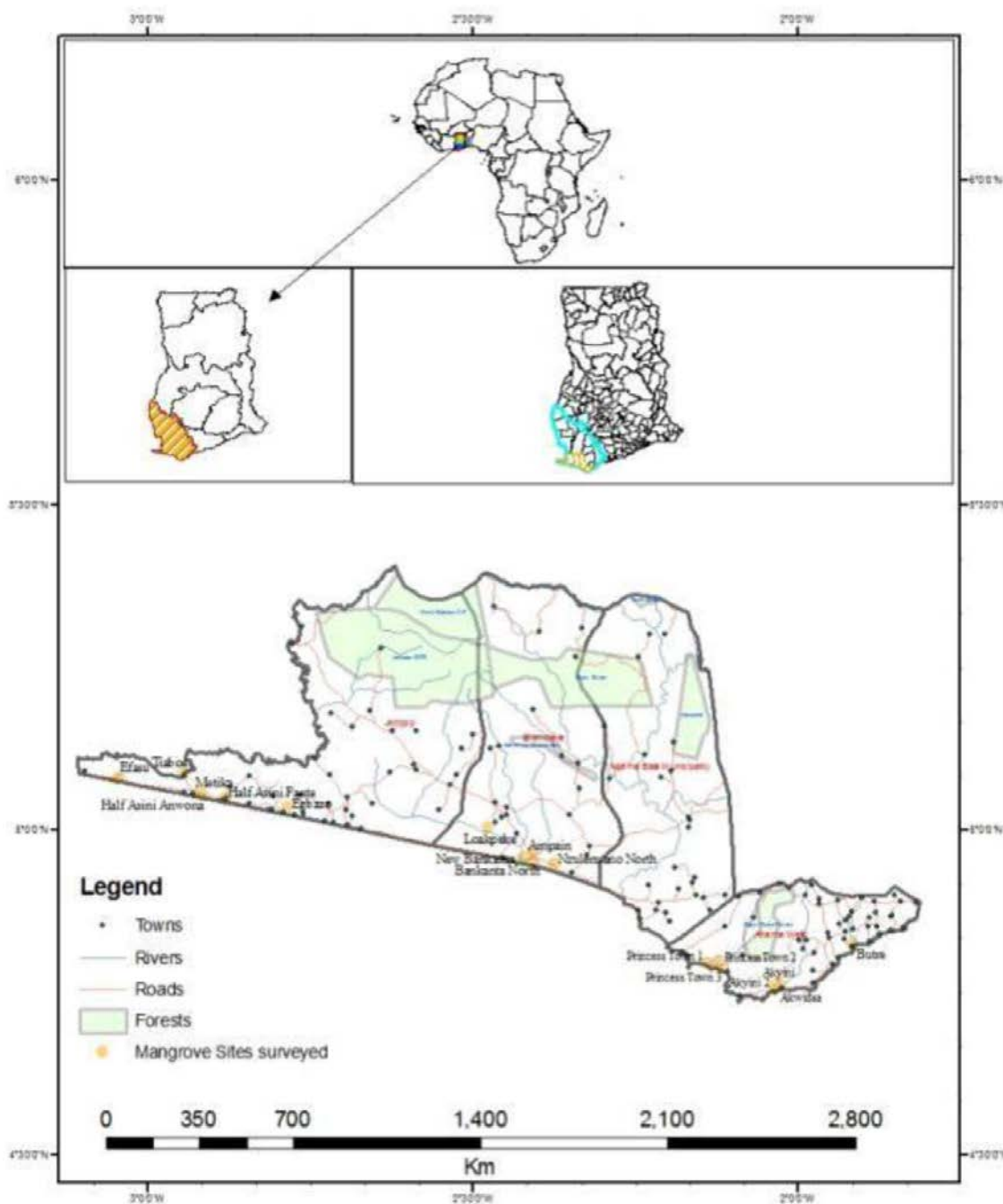


Figure 2 Map of Amanzuri wetlands showing distribution of surveyed mangrove sites

The survey showed that over 1 000 ha of mangrove forests exist in scattered pockets of less than 10 ha (in 56% of the sites) in Amanzuri area representing about 10% of national

mangrove coverage of 14 000 ha following UNEP 2007 sub-regional survey. Most of the mangroves do not appear in the current vegetation map of the area are estuarine mangrove type (61%), generally healthy (44%) reaching canopy height of 30m surrounded by coconut plantations (61%) supporting the livelihood and ecological securities of meeting a surrounding fishing or farming human population of less than 500 people (56%). There was a general perception by mangrove communities in 50% of the sites surveyed that these mangroves have decreased in area over the last 20 years. Identified threats include wood collection for fuel wood, charcoal, construction, etc, pollution from wastes disposal especially in around urban centers and mining activities) and mouth closure due to sedimentation that impedes tidal flow that maintain mangrove ecological processes. However there have been no or prohibited cutting on mangroves in over 60% of the sites.

Table 1 General appraisal of mangrove status and condition in the Amanzuri wetlands (based on 18 mangrove sites), Ghana

Assessment criteria	Ranked category	Number of sites	%
Mangrove type	Estuarine	11	61.1
	Lagunal	7	38.9
Mangrove areal extent (ha)	0-10	9	50.0
	10-50	1	5.6
	50-100	3	16.7
	100ha and above	5	27.8
Mangrove Canopy height (m)	Less than 10	1	5.6
	10 -20	1	5.6
	20-30	11	61.1
	30 and above	5	27.8
Tidal dynamics	Very good	6	33.3
	Good	8	44.4
	Limited	3	16.7
	Very limited	1	5.6
Biodiversity status (presence of large mammals especially monkeys)	Many usually seen	3	16.7
	Few usually or occasionally seen	1	5.6
	Non/rarely seen	14	77.8
Health status	Very healthy	5	27.8
	Healthy	8	44.4
	Partly degraded	3	16.7
	Degraded/polluted from waste disposal/mining	2	11.1
Main adjoining vegetation	Raphia swamps & other marshes	3	16.7
	Cropland	1	5.6
	Coconut plantations	11	61.1
	Others	3	16.7
Population around mangroves (number of people)	Less than 500	10	55.6
	500 – 1000	4	22.2
	1000 – 5000	3	16.7
	5000 and above	1	5.6
Community perception of trends in mangrove area change (over the last 20 years)	Increasing	1	5.6
	Stable	8	44.4
	Decreasing	9	50.0
Main activity within mangrove area	Farming	2	11.1
	Fishing	9	50.0
	Urbanization	7	38.9
Current threats	Non or prohibited cutting	11	61.1
	Wood collection (for fuel wood, charcoal, construction, etc	4	22.2
	Mouth closure due to sedimentation	1	5.6
	Pollution (waste disposal/mining activities)	2	11.1
Past or current conservation or any intervention efforts by NGOs or partners	Present	7	38.9
	Non	11	61.1

3.1.2. Carbon storage potentials

The total above ground carbon stored in intact mangroves in the area (see Table 2 and stem size class distribution in Figure 3) range from 65 – 422 tC/ha per ha with mean of 185 tC/ha with mangrove roots holding in some cases 78% in degraded mangrove areas. It should be noted that below ground carbon storage accounts for over 50% and reaching 98% of total whole ecosystem storage in mangrove ecosystems from a recent quantification of whole-ecosystem carbon storage by Donato *et al* (2011). They measured tree and dead wood biomass, soil carbon content, and soil depth in 25 mangrove forests across a broad area of the Indo-Pacific region where mangrove area and diversity are greatest. These data indicate that mangroves are among the most carbon-rich forests in the tropics, containing on average 1,023Mg carbon per hectare. Organic-rich soils ranged from 0.5m to more than 3m in depth and accounted for 49–98% of carbon storage in these systems. When they further combined their data with other published information, they estimated that mangrove deforestation generates emissions of 0.02–0.12 Pg carbon per year—as much as around 10% of emissions from deforestation globally, despite accounting for just 0.7% of tropical forest area.

Table 2 Stand structural characteristics and above ground carbon stocks of intact and degraded *Rhizophora* dominated mangroves in the Amanzuri wetlands, Ghana

Community	Type	Status	Stand height (m)	Stand Height abv stiltroot (m)	Above ground component	Density (Nr/ha)	Basal area /ha (m ² /ha)	Volume (m ³ /ha)	Carbon content		Shoot/root ratio
									Tonnes/ha	As % of total	
Egbazu	Estuarine	Intact	20	17.82	Shoot/stems	2 500	23.43	250.55	111.49	72.71	0.37
					Roots	82 000	46.50	93.88	41.78	27.24	
					Regeneration	4 000	0.31	0.16	0.07	0.05	
					Total				153.34	100.00	
Metika	Lagoonal	Intact	20	16	Shoot/stems	3 000	15.28	146.70	65.28	66.76	0.50
					Roots	32 000	15.91	72.87	32.43	33.16	
					Regeneration	4 000	0.31	0.16	0.07	0.07	
					Total				97.78	100.00	
Bankanta Nor	Estuarine	Intact	20	16.76	Shoot/stems	2 250	69.13	695.14	309.34	73.39	0.36
					Roots	94 000	71.64	251.86	112.08	26.59	
					Regeneration	4 000	0.31	0.16	0.07	0.02	
					Total				421.48	100.00	
Nzelenoanu	Estuarine	Intact	10	7.74	Shoot/stems	6 000	8.74	40.61	18.07	27.84	2.59
					Roots	64 000	44.42	105.00	46.72	72.00	
					Regeneration	6 000	0.47	0.24	0.10	0.16	
					Total				64.90	100.00	
Mean values for intact mangroves					Shoot/stems	3 438	29.15	283.25	126.05	60.2	0.41
					Roots	68 000	44.62	130.90	58.25	39.7	
					Regeneration	4 500	0.35	0.18	0.08	0.1	
					Total				184.37	100.0	
Bakanta (New)	Estuarine	Degraded	15	11.98	Shoot/stems	3 250	17.51	125.84	56.00	19.71	3.96
					Roots	178 000	179.24	498.02	221.62	78.02	
					Regeneration	368 000	28.91	14.45	6.43	2.26	
					Total				284.05	100.00	

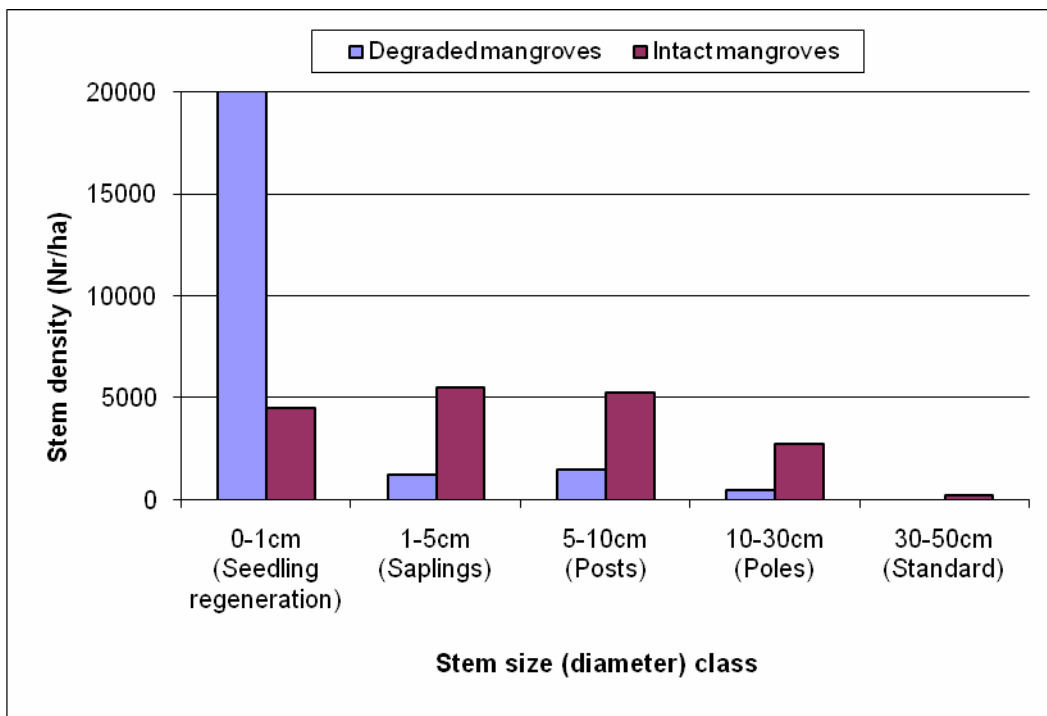


Figure 3 Stem diameter distribution in mangrove forests of Amanzuri wetlands, Ghana

3.1.3. Mangrove wood consumption and impacts on mangrove forests

The mangrove is currently valued for fuel wood use at 4146 Ghanaian cedis (US\$2765) per ha within the Efasou community (Table 3) well above estimates of US \$ 340 per hectare in the lower Volta (Gordon *et al*, 2009). Wood consumption is presented in Table 4 with comparison with estimates from a similar typical Cameroon mangrove fishing community. Mangrove wood consumption for cooking and fish smoking from the Efasou community is estimated at 16 and 97m³/household/yr respectively with a respective per capita consumption of 1.8 and 10.8 m³/person/yr. Current deforestation rate for cooking and fish smoking is put at 0.06 and 0.34 ha/household/year respectively with a respective per hectare harvest of 0.006 and 0.038 ha/person/year.

Table 3 Characteristics of mangrove wood use and per ha value of mangroves for fuel wood within a typical fishing community (Efasou, Amanzuri wetlands, Ghana)

Characteristics	Sub-characteristics	Estimates
Population		260
Number of households		29
Household size		9
Fish species smoked		Tele, <i>Sardenella</i> spp
Provenance of mangrove wood		Bought from wood cutters
Number of wood stacks		23
Wood stack dimensions (maximum)	Length (m)	2.9
	Width (m)	2.0
	Height (m)	1.4
	Volume (m ³)	8.1
Wood cost	Cost /stack	60 Ghanaian cedis (US\$ 40)
	Cost/ stere	7.41 Ghanaian Cedis (US\$ 4.94)
	Cost/m ³	14.64 Ghanaian Cedis (US\$ 9.76)
	Cost/tonne	16.44 Ghanaian Cedis (US\$ 10.96)
	Cost/ha ²	4147 Ghanaian Cedis (US\$2765)

Table 4 Community fuel wood consumption and impacts on surrounding mangrove forests within the Efasou fishing community (Amanzuri wetlands, Ghana)

Region	Activity	Turnover rates (m ³ /yr)		Deforestation rates (ha/yr)		Source
		Per household	Per capita	Per household	Per capita	
West Africa (Efasou mangrove community Ghana)	Cooking	15.83	1.76	0.06	0.006	This survey
	Fish smoking	97.44	10.83	0.34	0.038	
Central Africa (Douala-Edea mangrove villages: Mbiako, Yovo I &)	Cooking	19.74	2.50		0.004	Ajonina and Usongo, 2011
	Fish smoking	105.58	13.39		0.024	

Wood consumption for fish smoking were generally lower than for a Cameroonian fishing community owing to the use of more efficient fish smoking ovens (see Figure 4) whose perspectives can be explored (see Feka *et al*, 2009).

²Based on mangrove wood stocking rate (excluding roots) of 283.25m³/ha (Table 2)



Figure 4 Fish smoke ovens in mangrove communities in (A) West Africa Efasou, Ghana and Central Africa (B) Mouanko , Cameroon (Photos: A: Nicolas Breslyn B: Gordon Ajonina).

3.2. Institutional issues, governance of wetlands and potentials for a coastal and marine PES scheme

3.2.1. Institutions and stakeholders for mangrove management

The institutions and stakeholders in the management of mangrove forests in the Western Region reflect a broad range of interests at national, regional and local community level. The role played by each of these stakeholders has a direct or indirect impact on the resource. At the apex of the stakeholder spectrum is the national government whose policies and programs for management of mangroves and associated wetlands are implemented through the Wildlife Division of the Forestry Commission and other related agencies such as the Lands Commission and the Department of Town and Country Planning. At the regional level we have Regional Coordinating Council. The local level is represented by a number of players or interest groups whose actions and inactions determine the outcome of all mangrove management efforts now and in the foreseeable future. These include the District Assemblies with their substructures, civil society groups, producer groups and trade associations, traditional authorities, commercial organizations and local communities around the mangrove forests. Stakeholder and institutional analysis from the policy to field levels are presented in Tables 5 and 6 while site specific issues are presented at Annex 2. In each tier, the major actors are identified with their roles and responsibilities; an assessment of current level of implementation is made with suggested strategies towards sustainable mangrove management.

The following general observations can be made:

- First level institutional and stakeholder analysis (Central government, department agencies, regional administration, academic institutions, local government and donor agencies).
 - Weak enforcement of existing legislation
 - Good structures in place but severely limited by logistical capacity of government departments
 - Lack of communication and information sharing to intended users
 - Poor attitude towards mangrove and wetlands which is not taken in any development planning processes
 - Donors funds that address short term solutions to long-term problems with poor level of private sector participation

Table 5 First level institutional and stakeholder analysis for mangrove management

Institution/ stakeholder	Roles/ responsibilities	Assessment/remarks	Strategies for improvement towards sustainable mangrove management
Central Government	Policies, treaties, laws (forestry & wildlife policy 1994, Ramsar treaty 1971, wildlife Act.....)	Laws in place, but enforcement is weak	Laws should be revised, more research to enhance policies, more stakeholder participation encouraged
Departments/ agencies	Implementation, regulation, enforcement, compliance, monitoring and evaluation. Wildlife Division is present in the region but is largely focused on game reserves, e.g., Ankasa etc	Structures in place, but are not functioning well due to severe limitations in logistics	More training needed, more resources be provided by central government and donor partners in the near future. Mangrove conservation objectives needs to be emphasized and integrated with game reserve objectives as integral ecological framework
Regional administration	Complementary and supervisory	Does have capacity needed for mangrove management. In recent times efforts are being made by some NGOs to sensitize them.	Its role is important and needs to be involved at the policy and implementation levels.
Academic and research institutions	They are to provide research information on state of wetlands and conditions of mangroves	There have been research efforts by some academic researchers from University of Ghana, some NGOs like Wildlife Society and others. However, the research findings are difficult to come by.	There is the need to coordinate the process of sharing research findings, research efforts in order to avoid duplication of efforts.
Local Government	Regulation, enforcement and implementation	Relative to mangrove and wetland management the six coastal districts have not done much. The laws have not been enforced due to the poor attitude towards wetlands. The weak presence of the Wildlife Division in the region has also contributed to this poor state of affairs.	Local government structures need to be equipped with adequate knowledge on the importance of wetlands in addition to resources to be able to support the Division and other NGOs to protect, conserve the mangroves
Donor/Funding agencies	Provision of funds and technical advice	They have been providing funds for long time now. Eg. WB, EU countries and other bilateral donors. Some of these funds addressed the problems in the short to medium terms. In most instances, the projects stalled as funding dried up and this has created more problems for resource management.	Project planning and funding should be oriented towards long term goals to ensure sustainability. Partners need to work together to achieve this. The Ghanaian government has a role to play by factoring this into annual budgets. It should not be the sole responsibility of outside donors. Commercial bodies whose actions impact the wetlands should also be brought on board, eg. hard and soft mineral producers. Possibilities of a carbon tax/green tax may be explored.

- Second level institutional and stakeholder’s analysis (District assemblies, traditional authorities, local communities, NGOs and other civil society groups).
 - Ignorance of roles of wetlands that are taken for granted
 - Land tenure conflicts
 - Long term financing leading to period of neglect in working with communities as less than 40% of the mangrove sites has received any intervention (Table 1 & Annex 1).
 - Lack of adequate knowledge and capacity for wetland management

Table 6 Second level local institutional and stakeholder analysis for mangrove management

Institution/ stakeholder	Roles/ responsibilities	Assessment/remarks	Strategies for improvement towards sustainable mangrove
District assemblies	Regulation, permitting, enforcement (agencies like town and Country planning is supposed to regulate developments in the districts.)	Laws are not enforced due in part to ignorance about importance of wetlands. They also do not have resources to visit sites for inspection and regulation	They should be involved in the design and implementation of future projects concerning wetlands and also be given some logistics for the task.
Traditional authorities	They the custodians of the land and are supposed to regulate its usage through the granting of tenural rights etc	They have not been playing this role effectively. In most cases they lose control over the management of land in their areas. Most, if not all of them are totally ignorant about the importance of wetlands in their areas.	Their involvement through sensitization is very important in this regard. This will help bring about local ownership of the proposed interventions.
Local communities	They in most cases depend directly on the resource and are to help manage it	Their direct activities in most cases have been impacting negatively on mangrove management in local communities. This has also been aggravated by ignorance, tenure right controversies and concerns of settler fisher folks. There is also the underlining issue of limited livelihood opportunities and severe poverty. The down-turn in fishing and associated activities is forcing most of them to exploit aqua forests on commercial scale. Local perceptions about mangrove forests are not healthy. They see them as ordinary trees which can grow again after harvesting.	Sensitization of local communities, redefining of tenural rights and resolution of concerns of settler fisher folks are very necessary in addressing mangrove management problems. Alternative livelihood schemes needs to be identified and promoted in local communities.
NGOs and other civil society groups	Inform and educate local communities on sustainable management of mangroves	There has been a problem with long term finance. This has led to long periods of neglect in working with communities e.g. RC from Italy did a lot of work in the past but has reduced its presence in local communities due to limited funds. Wildlife Society is present in some local communities but their activities have been limited in their activities. Majority of them are concentrated mainly on the regional capitals. Capacities are also limited in the area scientific and technical appreciation of wetland ecology. Some do the right things wrongly.	All the groups working on mangroves need to be identified through the establishment of a data base initiated by either themselves or a state institution like the Wild Division of the Forestry Commission. This should not be seen as a means to control their activities. Their capacities should also be built and maintained.

3.2.2. Importance and potentials of local tourism industry development

The dominant role of Ghana Wildlife

Society (GWS)

The Ghana Wildlife Society (GWS) has been playing a critical conservation role in the area especially as she has introduced small-scale development projects that protect the biodiversity while enhancing the economy. In addition, they promote activities that have

minimal impacts to the wetlands. To promote tourism, they have built walkways and provided boats to view plant and animal species in the reserve. As a result, the number of tourists has been on the increase since 2006 to more than 10 000 annually (Figure 4). Generating an annual revenue of near 24 000 Ghanaian cedis (US\$ 16000).

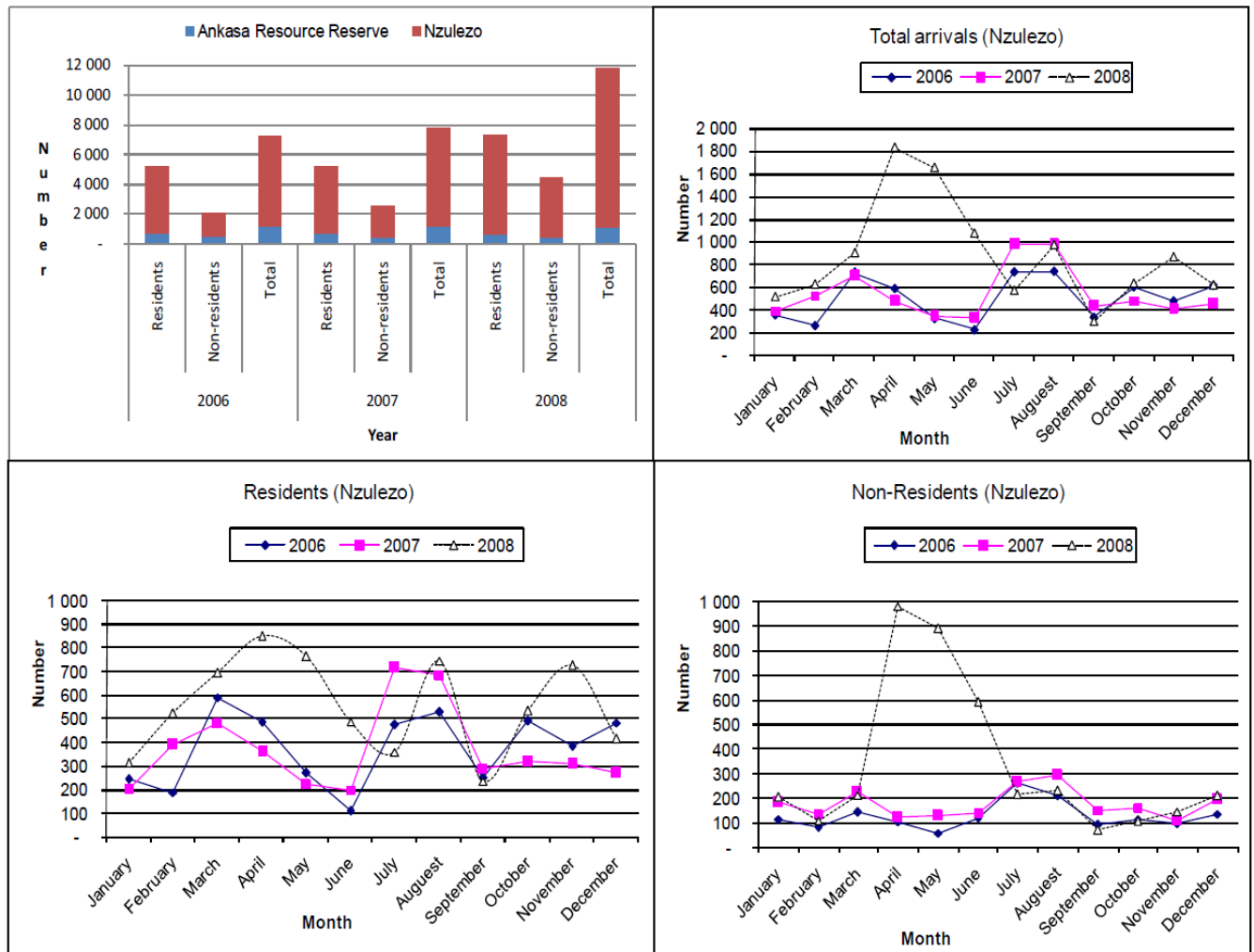


Figure 5 Monthly and year distribution of tourist visits from sites around Amanzule wetlands, Ghana

GWS reaches out to the community and the schools in an effort to educate the population about conservation. In east Nzulezo, they have a taskforce office every five kilometers that provides information on protecting the turtle populations. The task force works with the local law enforcement to discourage people from eating turtles and turtle eggs. They monitor the turtle nesting sites and collect information on the number of different species, the number of eggs and the distance of the nest from the high tide line. To protect the turtle populations, they will sometimes move the eggs to a hatchery until the turtles are ready for release to the sea. In the last two years, they have recorded over 200 turtle nesting sites. And villagers that once hunted the turtles now volunteer on the task force to protect them. Six of the local communities have donated land to the reserve and work with GWS on various projects. In return, the profits are shared among the communities. The people take pride in their communities and the reserve and the success of the project has provided electricity and better roads in the villages. The people now harvest and store fish instead of turtles and profit from tourist activities including home stays. The efforts of GWS have provided a means of sustainable development for the lagoon and reserve that have caught the attention of the government of Ghana. Recently, they recognized the success of the Amanzuri

Conservation and Integrated Development Project during a presentation at a government conference.

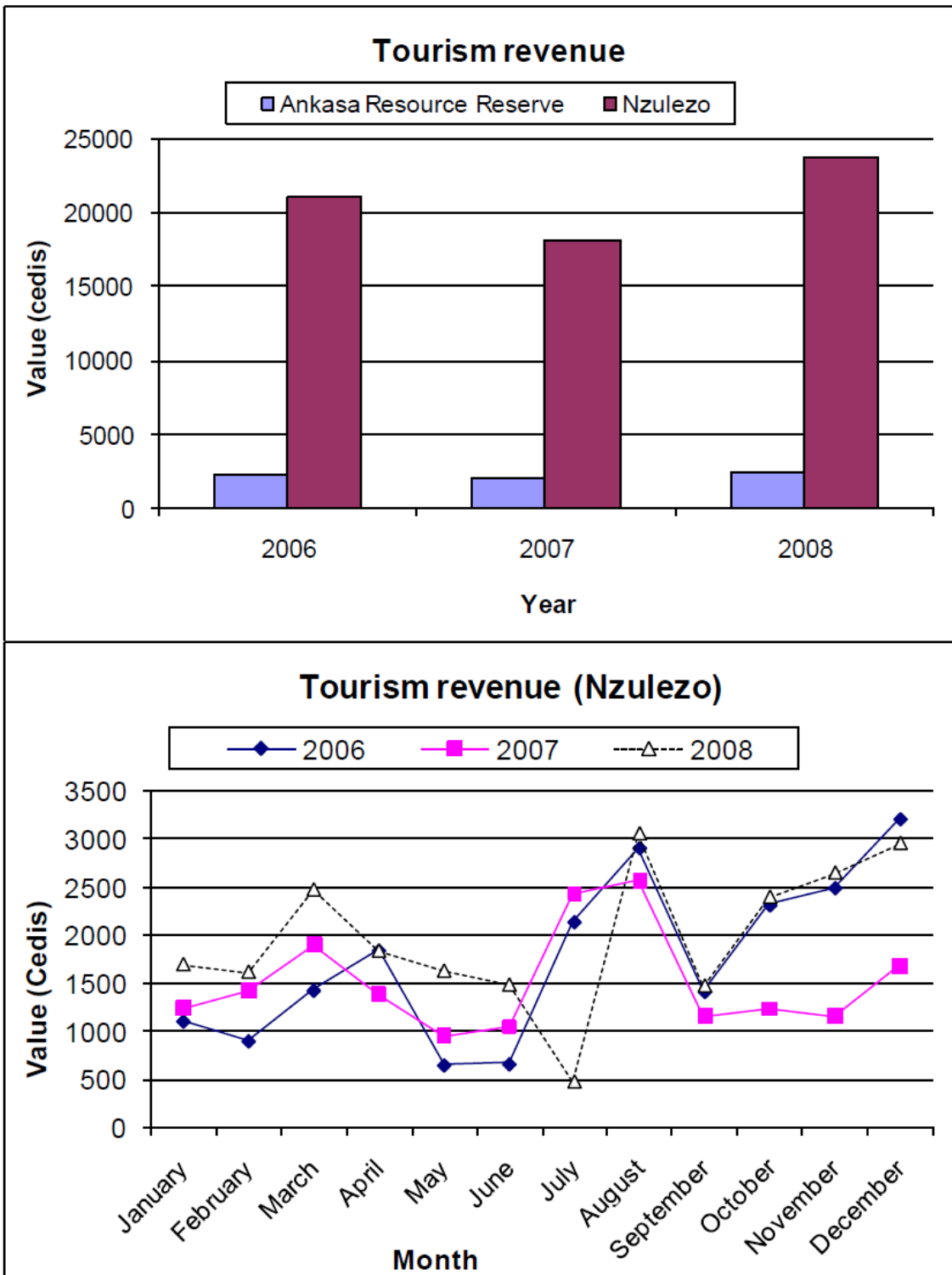


Figure 6 Monthly and year trends in tourism revenue from sites around Amensuri wetlands, Ghana

Private tourism operators case of Eco-Lodge at Beyin



Figure 7 Interview with the proprietor (in red short) of eco-lodge at Beyin (Photo by Nicolas Breslyn)

- Sole proprietorship owned by a Ghanaian
- Effectively started in 2006 from 5 acres (2.03ha) of land leased from the chiefs between the years 2003-2004.
- Infrastructure built from local materials include a restaurant, eight rooms for a maximum of 25 people at a rate including breakfast of 85 Cedis (US\$ 42.5) for two people, 70-135 Cedis (US\$46.7-90.0) for 4 people.
- Nine people are employed (8 ladies & one man) with a senior secondary certificate to meet up the catering, laundry and gardening/landscape tasks
- Most of his visitors (95%) are foreign nationals from Europe, America and Africa while 5% are Ghanaian nationals
- August and December (mostly holidays and Christmas) are peak business periods with over 70% of occupancy corresponding to high profits margins hitting 65% taking into account the replacement (depreciation) rate of local materials of 8 – 15 years. Profit margin has been on the increase being at least 35% per month. Some 10% goes to the Beyin city council
- Environmental support investments include: building of sea turtle conservation trust funds that started in 2007 from which a secondary school library is being built at Beyin that should benefit the more the school Wildlife Group.
- Problem and challenges mostly hinge on finding ways of strengthening weak communication links with the local community, relations with the wildlife division and getting qualified local staff that mostly go into the cities.

3.2.3. Prospects of oil and gas industry

A number of interesting concerns are made and questions asked in a recent coastal publication (Anon. 2010. Hen Mpoano. Our Coast, our future, Western Region of Ghana.

Building capacity for adapting to a rapidly changing coastal zone p. 17) concerning booming prospects of oil and gas and the impacts of offshore and onshore construction and operations on both the marine and terrestrial environments. The publication continues that today in the Western region, the multiple causes and consequences of ecosystem change are overshadowed by the prospect of oil and gas development. How the exploitation of this new source of wealth, employment and development pressures is managed will determine whether the result will be a new and generous source of national income with employment and business opportunities that benefit both the Western Region or yet another example of curse or oil. How will the jobs and the wealth produced be distributed? Will local Ghanaian companies be formed to provide the services required by new industries? Will the local labor force be trained to fill new employment opportunities or will skilled labor be implored and earnings flow overseas? Who will benefit and who will lose? Will new schools, new hospitals and the other entire infrastructure demanded by a bigger population keep pace with a rush of development?

In addition to the above concerns, the mangrove environments will definitely going to be a victim of oil and gas how to get the companies pay for offsets and get involved in mangrove restoration and conservation is yet another uphill task. They need to be guided within a certain platform on mangrove ecosystem valuation information on what the society will lose if ecosystem services provided by the mangroves are lost and get to pay for them.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

The rapid assessment exercise though limited by time and certain information gaps the following conclusions can be drawn:

- *Types, status and distribution of mangroves and associated wetlands in the Amanzuri region*

More than 1 000 ha of mostly estuarine mangrove forests exist in scattered pockets in Amanzuri area representing about 10% of national mangrove coverage with most of the mangroves not captured in the current vegetation map of the area. These mangroves are generally healthy supporting the livelihood and ecological securities of surrounding fishing or farming human population.

There was a general perception of mangrove communities that these mangroves have decreased in area over the last 20 years with identified threats that include wood collection for fuel wood, charcoal, construction, etc, pollution from wastes disposal especially in around urban centers and mining activities and mouth closure due to sedimentation that impedes tidal flow that maintain mangrove ecological processes.

The total above ground carbon stored in intact mangroves in the area is also important and can be comparable to similar mangrove systems.

The mangrove is currently valued for fuel wood use at 4146 Ghanaian cedis (US\$2765) per ha with a significant impact on mangrove forest

- *Institutional issues and governance of wetlands in the area*

The institutions and stakeholders in the management of mangrove forests in the Western Region of Ghana reflect a broad range of interests at national, regional and local community level. The role played by each of these stakeholders has a direct or indirect impact on the resource.

- *Feasibility of a PES scheme*

A PES scheme may be feasible when addressed within the context of the institutional and stakeholders in the region. The challenge is how to get the private sector involved in the deal especially the oil companies. Already private tourisms initiatives hold some promise as some have started some green investments.. Oil and gas companies need to be guided within a certain platform on mangrove ecosystem valuation information on what the society will lose if ecosystem services provided by the mangroves are lost and get to pay for them.

4.2. Recommendations

4.2.1. Short-term recommendations

- **Addressing stakeholders and instructional issues**
 - *Development of stakeholders contact data base.* All the groups working on mangroves need to be identified through the establishment of a data base initiated by either themselves or a state institution like the Wild Division of the Forestry Commission.
 - *Organization of an enlarged stakeholder's forum.* In order to resolve conflict issues on mangrove and coastal resource management issues an enlarged forum of key stakeholders preferably convened by the government with NGOs playing a facilitating role is needed to identify and chart up a common vision and workable strategies for mangrove conservation within the general integrated coastal management issues. The ongoing organization of the proposed coastal forum by NRC could be a window opportunity.- *Cross institutional capacity building.* Need to strengthen the operational

- capacities of governmental organizations by providing them basic logistics.
- *Sharing of research finding.* Mechanisms should be developed to promote communication and sharing of research results either through forums or any communication media.
- *Sensitization campaigns.* Need for adequate sensitization campaigns to strengthen awareness on the importance threat and need to conserve wetlands.

- **Completion of Ghana carbon map and mangrove carbon monitoring**

There is need to complete the current Ghana carbon map with the mangrove component using appropriate methodologies especially those currently implemented within the Central African Mangrove forests with some establishment of long-term mangrove permanent sample plot system for measuring mangrove carbon sequestration and ecosystem dynamics system under various human extraction regimes.

4.2.2. Medium- and long-term recommendations

- **Addressing direct on site threats to mangrove ecosystem services**

There is need to address site specific threats through various actions:

- *Conservation.* For sites with significant healthy mangroves
- *Hydrological restoration.* For sites with mouth closure due to sedimentation through channel opening to allow normal tidal exchange with mangroves, areas
- *Replanting.* For badly degraded sites
- *Waste removal.* Particularly for urban and peri-urban polluted sites
- **Policy review or reforms.** Need to revise existing law with more research to enhance policies with encouragement in stakeholders' communication
- **Sustainable funding through private sector participation.** Donor partners should work with all partners to put in place sustainable funding mechanisms that derive much from existing sources especially stimulating private sector investment.

REFERENCES

- Ajonina, G.N. (2008). Inventory and modelling mangrove forest stand dynamics following different levels of wood exploitation pressures in the Douala-Edea Atlantic coast of Cameroon, Central Africa. *Mitteilungen der Abteilungen für Forstliche Biometrie, Albert-Ludwigs- Universität Freiburg*.2008- 2. 215p.
- Ajonina, G.N. and Usongo, L. (2001). Preliminary quantitative impact assessment of wood extraction on the mangroves of Douala-Edea Forest Reserve, Cameroon. *Tropical Biodiversity* 7 (2-3): 137-149.
- Ajonina, Gordon, Diamé, Abdoulaye and James Kairo (2008). Current status and conservation of mangroves in Africa: An overview. WRM Bulletin 133, August 2008_ <http://wrmbulletin.wordpress.com/2008/08/25/current-status-and-conservation-ofmangroves-in-africa-an-overview/>
- Ajonina, P.U., Ajonina, G.N., Jin, E. Mekongo, F., Ayissi, I. and Usongo, L.(2005).Gender roles and economics of exploitation, processing and marketing of bivalves and impacts on forest resources in the Douala-Edaa Wildlife Reserve, Cameroon. *International Journal of Sustainable Development and World Ecology* 12: 161- 172
- Anon. 2010. Hen Mpoano. Our Coast, our future, Western Region of Ghana. Building capacity for adapting to a rapidly changing coastal zone. 64pp.
- Barbier, E.B., Acreman M.C. and Knowler, D. (1997). *Economic Valuation of Wetlands. A guide for policy makers and planners*. Ramsar Convention Bureau Gland, Switzerland. 143pp.
- Birdlife International (2007). Birdlife’s online World Bird Database: the site for biodiversity conservation. Version 2.1. Cambridge, UK: Birdlife International. Available: <http://www.birdlife.org>
- Cailliez, F. (1980). *Forest Volume Estimation and Yield Prediction*. Vol. 1. Volume estimation. FAO Forestry paper no. 22 FAO Rome.
- Donato, D.C., Kauffman,J.B. , Murdiyarso, D. Sofyan Kurnianto, S. Melanie Stidham, M. and Markku Kanninen, M. (2011). Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience* 4: DOI: 10.1038/NGEO1123.
- Feamside, P.M. (1997). Wood density for estimating forest biomass in Brazilian, Amazonia. *Forest Ecology and Management* 90:59-87
- Feka, N.Z., Chuyong, G.B. and Ajonina, G.N. (2009). Sustainable utilization of mangroves using improved fish smoking systems: A management perspective from the Douala-Edea Wildlife Reserve, Cameroon. *Tropical Conservation Science* 4:450-468
- Gordon, C., Tweneboah, E., Mensah, A.M. and Ayivor, J.S. (2009). The Application of the Ecosystem Approach to Mangrove management: Lessons for Ghana. *Nature & Faune* 24: 30-41

GWS (2003). Amanzuri Wetlands Ecosystem Management Plan 2003: Ghana Wildlife Society

Husch, B., Beers, T.W. and Keuhaw Jr., J.A. (2003). *Forest mensuration*, 4th Edition. John Wiley & Sons. 443 pp

Loetsch, I. Zohier, F. and Haller, K. (1973). *Forest Inventory Vol. 2*. Second Edition BIV, Germany, 469pp

NCRC/Benyin Beach Resort (2000): Sea Turtle Conservation on the west coast of Ghana: A background report.

UNEP (2007) Mangroves of Western and Central Africa. UNEP-Regional Seas Programme/UNEPWCMC. 92pp

ANNEXES

Annex 1. General status and conditions of mangroves in the Amensuri wetlands, Ghana

Site No	Name	Community	Main activity	Mangrove type	Population	Species composition	Extent (ha)	General height (m)	Health status	Tidal dynamics	Biodiversity	Adjoining vegetation	Human use	Community perception of trends	Main threats	Priority actions
1	Alegunsuri	Alegusi	Farming	Estuarine	400	<i>Rhizophora</i> , <i>Avicennia</i>	0.1	25	very healthy	Very good	Used to be crocodiles	Coconut plantation	Non	Decreasing	Non	Conservation
2	Ndabelah	Nzimitianu	Fishing	Estuarine	1000	Large swamp communities with some spotted <i>Rhizophora</i> & <i>Avicennia</i> stands	5.0	25	Partly degraded	Limited		Coconut plantation	Heavy wood collection for fish smoking	Decreasing	Wood collection for firewood and building	Conservation & restoration
3	Efasou	Efasou	Fishing	Estuarine	700	<i>Rhizophora</i>	2.6	25	Partly degraded	Limited		Coconut plantation	Heavy wood collection for fish smoking	Decreasing	Wood collection for firewood, mouth closure	Hydrological restoration, replanting
4	Domuli	Egbazu	Farming/fishing	Estuarine	1200	<i>Rhizophora</i>	75.0	20	Healthy	Good		Coconut plantation	Low wood collection for cooking, construction, fishing	Increasing	Non	Conservation
5	Amaziri	Chiko (Half Assini Anwona)	Urbanisation	Estuarine	700	<i>Rhizophora</i>	0.5	20	Healthy	Limited		Coconut plantation		Decreasing	Mouth closure	hydrological restoration
6	Awine-anloa	Fante (Half Assini Fante)	Urbanisation	Lagoonal	5000	<i>Rhizophora</i>	1.5	30	Polluted	very limited	Few monkeys occasionally seen	Coconut plantation	Waste disposal, livestock rearing, wood collection for fish smoking	Decreasing	Pollution	Waste removal, hydrological restoration, replanting
7	Ekumkpole	Metika (1 & 2)	Fishing	Lagoonal	200	Extensive <i>Rhizophora</i> stands	250.0	25	Healthy	Very good	Monkeys usually seen	Raphia swamps	Low wood collection for cooking, construction	Decreasing	Non	Conservation
8	Amasuri North	Aloakpeke	Fishing/farming	Lagoonal	350	Very few <i>Rhizophora</i> stands (less than 1 per ha). Large swamp mixed of Ironwood (<i>Lophira alata</i> with tree density of 50 per ha with diameter more than 1m)	200.0	25	Healthy	Good	Birds, fishes	Large marshy plain	Wood for charcoal, fishing especially Black Tiliapia	Decreasing	Charcoal production	Conservation
9	Amasuri	Bakanta (New & Old)	Fishing	Estuarine	700	Vast stands of <i>Rhizophora</i>	275.0	40	Patches of partly degraded stands	Good		Coconut plantation	Wood for charcoal, cooking and construction	stable	charcoal production, wood for cooking, wood for construction	Conservation, replanting
10	Amasuri	Bankanta North	Fishing	Estuarine	0	Vast stands of <i>Rhizophora</i>	200.0	30	very healthy	Very good				stable	Non	
11	Ampain	Ampain	Fishing	Estuarine	300	More or less pure stands of <i>Avicennia</i> (900	2.0	10	Healthy	Good				stable	Non	Conservation, education
12	Amunsure	Nzelenoanu	Fishing	Estuarine	0	<i>Rhizophora</i>	180.0	20	Very healthy	very good		Cococunut plantations	Crab collection, fuelwood collection and wood for construction	Stable	Non	Conservation
13	Kikan	Kikan City	Urbanisation	Lagoonal	1000	<i>Rhizophora</i> dominated	12.0	20	Healthy	good		swamps		Decreasing	Non	Conservation
14	Ankoba	Tiaboe	Fishing	Estuarine	500		8.0	20	Healthy	Good		Cococunut plantations		Stable	Non	Conservation
15	Awhuele	Princess town/Anleo village	Urbanisation	Lagoonal	150	Mixed mangrove species	75.0	30	Very healthy	very good	Monkeys present	Grassy hills with mixed tree crop farms & fallows	Wood harvest prohibited by traditional authorities	Stable	Non	Conservation
16	Yan	Princess town/Anleo	Urbanisation	Estuarine	400	Mixed mangrove species	2.0	15	Partly degraded	good		Cococunut plantations	wood harvest prohibited	Decreasing	Mining activities upstream	Sustainable mining
17	Ezele	Akyemin	Urbanisation	Lagoonal	350	Mixed mangrove species	150.0	25	Very healthy	very good		Cococunut plantations	wood harvest prohibited	Stable	Non	Conservation
18	Butare	Butare	Urbanisation	Lagoonal	650	Mixed mangrove species	7.5	30	Very healthy	very good		Settlement	wood harvest prohibited	Stable	Non	Conservation
					13600		1046.2	25.4								

Annex 2. Site specific stakeholders and institutional analysis for mangrove (aqua- forest) management in the western region

No	Site	Current situation	Constraints/ threats	Past and present efforts	Institutions/ stakeholders	Conservation Action	Desired Outcome
1	Effasu	Mangrove area reduced by about half through harvesting for fuel wood, farming.	Limited fuel wood sources, ignorance, presence of energy facility (Osagyefo Barge), unclear land tenure regime and the issue of migrant communities. Sand bar at beach, limited livelihood opportunities	RC of Italy worked there some 6 years ago on turtles but did not focus on mangroves. Nzimitianu Biodiversity Association is currently working with support from CRC-Ghana. Their capacity is very, very weak in all aspects of mangrove conservation.	Traditional authority is willing (Nana Whaji), Nzimitianu Biodiversity Association, Wildlife Division, Office of Assemblyman, Jomoro Assembly	Participatory approach, sensitization, mechanical/ manual clearing of sand at mouth of Effasu river, alternative fuel wood source identification, alternative livelihood scheme.	Mangrove size increased and in healthy condition. Local communities aware of importance of mangroves. Capacity of local actors built.
2	Mitika – Efunkpole lagoon	Potions of lagoon close to town degraded through harvesting and dumping of refuse. However, large tract of mangroves remain intact and healthy. Reported presence of monkeys	Ignorance about mangroves, the downturn in fishing industry, potential use of mangrove for charcoal, construction of tourism facilities.	No known past efforts to protect mangroves.	TA, DA, local community members.	Sensitization, mech/manual sand clearing at the mouth of Efunkpole lagoon	Community member know importance of mangrove to fishing industry, protect it. Mangrove area looks healthy and bigger.
3	Half Assini-Anuawhule lagoon	Severely degraded, lagoon polluted by municipal waste, encroachment from settlement, cattle kraals. Reported presence of monkeys	Human activities, more settlements, more pollution, dumping of waste.	No past attempts at conservation; no present attempt.	TA, DA, Local community members	Clearing of refuse dumps, public education, clearing of sand bar at beach, relocation of dumping sites, enforcement of regulations by DA, presence of Wildlife Division	Lagoon environment restored, pollution reduced or eliminated
4&5	Egbazo and Kablezo	Large tracts of mangrove forest in healthy state	Signs of exploitation at some portions for charcoal production. Proposed gas processing facility along the banks of Domunli river poses a potential threat.	GWS has been working in the two communities since 2010 with support from CRC-Ghana	Government of Ghana, EPA, Wildlife Division, TA, DA, project promoters, local communities, research	Environmental impact Assessment process must be participatory through the involvement of all stakeholders. Public education	Mangrove forest not disturbed by new energy project. EIA becomes a model for other areas.
6	Kengelezo	Small mangrove forest with reported disappearance of crocs	Pollution from domestic waste and harvesting for fuel wood	No past or present intervention	TA, local community	Sensitization, clearing of waste from lagoon.	Mangroves remain intact
7	Akoto	Unique presence of iron wood aqua forest dotted with mangrove	Documented evidence of large commercial harvesting, thereby creating the emergence of	No past intervention. Presently CRC-Ghana is supporting UCSOND a local	TA, Forestry Commission, Lands Commission, DA, Reg. Adm.	Designation of area as forest reserve, sensitization, alternative livelihood program	Destruction halted. Remaining forest left intact, alternative

No	Site	Current situation	Constraints/ threats	Past and present efforts	Institutions/ stakeholders	Conservation Action	Desired Outcome
		within the northern fringes of Amanzure. Very rich in species density	charcoal entrepreneurs. This threat if not checked will completely wipe off the forest within a short period of time. Limited livelihood opportunities, ignorance about the forest, and absence of state forestry officials.	NGO to educate the people under its wetlands conservation program. This is on a limited scale			livelihoods in place
8	Kikam - Asanta	Mangroves are intact	Construction of houses pose a threat.	No past and present intervention	TA, DA, developers and local	Sensitization	Mangroves remain intact
9	Anyan – Princess Town	Lagoon remains largely intact	Settlement expansion, pollution of river upstream by illegal miners (Tomentu)	RC worked on turtles six years ago but not on mangroves. Turtle hunting still goes on according to local people	Local people, TA, DA,	Sensitization, law enforcement,	Mangroves remain intact, pollution controlled
10	Whenle-Princess Town	Very healthy mangrove forest with limited disturbance as result of control by TA	Proposed tourism facility with suspicious EIA,	RC worked there on turtles	Local people, TA, donors	Sensitization and proper EIA of all future development projects.	Mangroves remain intact.
11-12	Akyinin and Akwidane on Nzile river	Very healthy mangrove forest with limited impacts at edge of villages,	Limited livelihood options, potential waste disposal	RC in the past. But CRC is supporting CF to educate local people on mangrove conservation	TA, local people	Sensitization	Mangroves remain intact
13-16	Bankata, Mpain, Nzeleno anu-North and south	Fairly intact with some noticeable disturbances and relatively rich in species diversity	Encroachment from tourism facility owners, fuel wood extraction	RC, GWS,	TA, DA, & NGOs	Sensitization, livelihood enhancement	Mangroves remain intact
17&18	Butre and Busua	Large tracts of mangroves with some disturbance through farming and fuel wood extraction	Limited livelihood options, illegal gold exploitation- reported presence of manganese/bauxite	RC in the past and CF currently working in the area with support from CRC-Ghana	TA, DA, local people etc.	Sensitization, livelihood enhancement, replanting	Mangrove forest size increased and looks healthy

TA= Traditional Authority: DA= District Assembly: WD= Wildlife Division