
Mangrove Conditions as Indicator for Potential Payment for Ecosystem Services in Some Estuaries of Western Region of Ghana, West Africa

Gordon N. Ajonina, Tundi Agardy, Winnie Lau, Kofi Agbogah, and Balertey Gormey

Abstract

A rapid assessment was carried out on the Greater Amanzule wetlands in Ghana to assess the types and conditions of mangroves and associated ecosystem services (e.g. carbon sequestration, wood collection and tourism) for determining the potential for payment for ecosystem services (PES). A combination of stakeholder discussions and on-the-ground surveys was used to gather information on 18 mangrove sites. The survey showed that over 1,000 ha of mangrove forests exists in scattered pockets of less than 10 ha (in 50 % of the sites), representing nearly 10 % of the known national mangrove coverage of 14,000 ha. The mangroves are estuarine type, generally healthy, and reach canopy height of 30 m. They support livelihoods and ecological securities of the surrounding fishing or farming communities. There was a general community perception that mangrove forests have decreased in area over the last 20 years. Identified threats include harvesting for fuelwood and construction, pollution from domestic and mining waste disruption in the tidal regime at some estuaries. Carbon sequestration remains a valuable service: total aboveground carbon stored in intact mangrove areas ranged from 65 to 422 tC/ha (mean of 185 tC/ha) with estimated aboveground roots (aerial roots) making up 78 % of the carbon stock in some degraded areas. The economic value of mangroves as a source of fuelwood was approximated at US\$2,765/ha. A number of factors were identified as contributing to suboptimal governance of mangroves and wetlands. Appropriate PES schemes with improved legal and institutional arrangements are expected to help surmount management challenges.

Keywords

Rapid assessment • Payment for ecosystem services • Mangroves • Ghana

G. N. Ajonina (✉)

CWCS Coastal Forests and Mangrove Programme, BP 54,
Mouanko, Littoral Region, Cameroon
e-mail: gnajonina@hotmail.com

T. Agardy · W. Lau

The Marine Ecosystem Service (MARES) Programme, Forest
Trends, 1050 Potomac Street N.W, Washington, DC 20007, USA

K. Agbogah · B. Gormey

Coastal Resources Center, P.O. Box MC 11, Takoradi, Ghana

G. N. Ajonina

Institute of Fisheries and Aquatic Sciences, University of Douala
(Yabassi), Douala, Cameroon

Introduction

Mangroves cover about 140 km² in Ghana. They are limited to very narrow, noncontinuous coastal areas around lagoons in the west of the country; to the east, they are found on the fringes of the lower reaches of the Volta River delta (UNEP 2007). In western Ghana, the most extensive stretches are between Cape Three Points and the border with La Côte d'Ivoire. Six genera 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 *R. racemosa*, while closed lagoons with an elevated salinity harbour *A. germinans*, *C. erectus*, *L. racemosa* and *A. aureum* (UNEP 2007).

Ghana's mangrove ecosystems are tremendously valuable, providing ecosystem services such as carbon sequestration, protection from storms, floods, erosion, provision of timber and nontimber forest products, processing of waste and nutrient pollution, aquaculture and agriculture support and habitat for aquatic and terrestrial species. In the lower Volta area, the total estimated value, including mangrove-related harvesting for fish smoking or house roofing (US\$340/ha) and contribution to marine fisheries (US\$165/ha), is over US\$500/ha, with total country estimates of well over US\$6,000,000/year. These values do not include all the other mangrove ecosystem services (e.g. erosion control, trapping of pollutants and provision of biomass for the detritivore food chain) (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 to 137 km² representing a loss of 24 % (UNEP 2007; Ajonina et al. 2008).

Economic mechanisms have the potential to tip the balance towards restoration, maintenance and protection of mangrove forests. The need for proper valuation of mangrove ecosystem services underpins such mechanisms, including the establishment of any realistic payment for ecosystem services (PES) schemes in any given mangrove or wetland habitat. The objective of this study was to assess the types and conditions of mangroves and associated ecosystem services (e.g. carbon sequestration, wood collection and tourism) in the field for use in feasibility assessment for PES schemes in the mangroves and wetlands in Greater Amanzule and surrounding areas in coastal Western Region of Ghana. This study provides an analysis of the types of mangroves and wetlands, their status and distribution in the coastal Western Region; gathers information about the uses and governance of these wetlands; and provides insights into the use of information gathered in feasibility assessments of the potential for PES in the mangroves and wetlands in the region.

Methods

Site Description

Location of the Survey Area

The survey area lies within the Amanzule wetlands, which is a community-owned wetland with no official conservation status in the eastern and western Nzema traditional

areas of the Western Region (Fig. 1). The catchment of the wetland lies within the Western Evergreen Forest zone of Ghana. It covers an area of approximately 100 square km and lies within latitudes 4°53' and 4°46' north and longitude 2°00' and 2°05' west, 360 km west of Accra. The mangrove areas lie within the Greater Amanzule region in the Jomoro district, Ellembelle, Nzema east and Ahanta west districts of the Western Region.

Biophysical Environment

The region lies in the equatorial climate zone characterized by moderate temperatures. About 75 % of the land area falls within Ghana's high forest zone. The area is characterized by high rainfall with a double maximum and peaks in May–June and October–November each year. The average annual rainfall is 1,600 mm with the relative humidity being 87.5 %, at a mean annual temperature of 26 °C. There is a short dry season (December–March) during which a south-westerly directional wind is experienced with slight Harmattan conditions.

The soil is predominantly Forest Oxisols and Forest Ochrosols–Oxisols intergrades. Its hydrology is driven by six streams, one lake, the Amanzule freshwater lake and one outlet to the sea. The area is subject to seasonal flooding. The Amanzule wetlands is a relatively pristine complex consisting of a freshwater lake, forest, grasslands and rivers. It has the most extensive remaining stand of intact swamp forest in Ghana. These extensive swamps are outside the mangrove areas. Swamps cover about 70 % of the area and associated with a dense hydrological network. Within the area, there is still some logging of an important swamp forest species—*Lophira alata* (ironwood)—for charcoal. The Amanzule wetlands is the only known swamp forest in Ghana and 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 to its unspoiled nature. The area has a rich biodiversity and in terms of flora: 33 % of the 237 species of plants identified are endemic to the wetland. Notable species include raffia palm and ironwood (*L. 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. Twenty-six species of reptiles and amphibians, including the slender-snouted crocodile and the dwarf crocodile, green mambas and black forest cobra, and 26 species of fish have been recorded. The wetland is relatively rich in indigenous avifauna and also hosts various migrant species. Over 105 species of birds were recorded in an inventory, 65 of which are of global and national conservation interest. The area is classified as an Important Bird Area (IBA) (Birdlife International 2007), and it meets the criteria for designation as a wetland of international importance under the Ramsar



Fig. 1 Map of wetlands distribution in Western Region (Greater Amanzule covers wetlands from Ivory Coast border to Ankobra River)

Convention. Another important biodiversity characteristic of the site is that the coastal sandy beaches are important turtle nesting sites. Species recorded include the leatherback turtle, *Dermochelys coreacea* (common); green turtle, *Cheloniemydas* (common); olive ridley turtle, *Lepidochelys olivacea* (most common); and hawksbill, *Eretmochelys imbricate* (rare) (NCRC/Beyin Beach Resort 2000). Increasing development trends place these wetlands and its biodiversity at further risk. A particular concern is that the wetlands, which are important nursery grounds for many demersal fish species and habitat for birds, mammals and reptiles, are becoming increasingly vulnerable to degradation from development.

Socio-Economic Environment and Human Activities

Generally, the foundation of the economy in Western Region of Ghana and particularly the goods and services traded can be summarized as fish, port services, cocoa, gold, bauxite, manganese, tourism, timber and oil and gas (a new development trend). There is a strong agricultural base, with the agricultural sector employing nearly 60 % of the economically active population in the region. The main crops harvested are rubber, coconut and cocoa, accounting for the largest share of national production. Recently, coconut

production has suffered due to Cape Saint Paul wilt disease, which is destroying coconut plantations. Food crop production, on the other hand, is quite low, contributing less than 8 % to national production—which may be due to the lower revenues when compared to other crops (cocoa, coconut, etc.). The six major food crops cultivated in the area are maize, rice, cassava, yam, cocoyam and plantain. Activities within the mangrove areas include fishing, local gin processing, charcoal production, small-scale farming of crops such as coconut, oil palm, cassava, cocoa and plantain, and small-scale trading.

Data and Information Collection and Analysis

Both primary and secondary data collection approaches were used for the study. A combination of stakeholder discussions and on-the-ground surveys was used. A participatory approach was adopted by interactive discussion of basic issues during various consultative meetings and interviews organized with local institutions to gather information about the governance of these wetlands and to discuss the potential for developing a blue carbon project in the region. The institutions included local authorities

(district assemblies), private sector operators (especially tourism), community groups, and NGOs, especially Nature Conservation and Research Center (NCRC) and Coastal Resources Center (CRC). Discussions with NCRC and CRC focused on their planned larger-scale carbon mapping work.

Survey of Mangrove Sites

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

- GPS fixes and estimation of mangrove area from maximum width and length for mapping purposes using GIS software (ARC/Info and ArcView),
- mangrove type (estuarine, lagoonal, etc.),
- tidal exchange status,
- health status of the mangrove, based on foliage conditions and live–crown ratios,
- 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,
- options for future management practices and policies.

Assessing Mangrove Ecosystem Services

Carbon storage and sequestration services

The carbon storage and sequestration potential of the mangroves were measured through the establishment of 0.01 ha (10 m × 10 m) temporal sample plots (TSPs) systematically laid at 10-m intervals along a random 30-m transect and compass direction from a fixed point. This is a simplified modification of 6 (10 m × 10 m) plots laid along a 100-m transect used in the central African coastal region of Cameroon (Ajonina 2008). A total of four TSPs were assessed in four mangrove sites (1 TSP per site) and one plot in a degraded mangrove site. The diameter at breast height (at 1.3 m) (dbh) or at 30 cm above the stilt root 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 five 1-m² plots placed systematically at 1-m intervals along the 10 m × 10 m plot (Fig. 2). Middle diameter and height of the roots and seedlings were also measured.

The tree and stand data obtained were used to obtain estimates for aboveground 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

$$BA = \pi/4 \sum (f_i d_i^2) / A \quad (1)$$

Volume per hectare

$$V_s = BA \cdot H \cdot F \quad (2)$$

where

- BA basal area per hectare (m² ha⁻¹)
 V_s standing volume per hectare (m³ ha⁻¹)
 d_i diameter (in metres)
 F tree form factor (0.6) (from Ajonina and Usongo 2001)
 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 the biomass obtained from product of volume and mangrove's mean wood density value of 0.890 t/m³ (Feamside 1997) and biomass expansion factor of 1.18 (Ajonina 2008).

Mangrove Wood Use and Impacts on Mangrove Forest

A detailed mangrove wood-use survey was carried out in the Effasu 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 estimate the rate of deforestation (Ajonina and Usongo 2001; Ajonina et al. 2005):

Per household

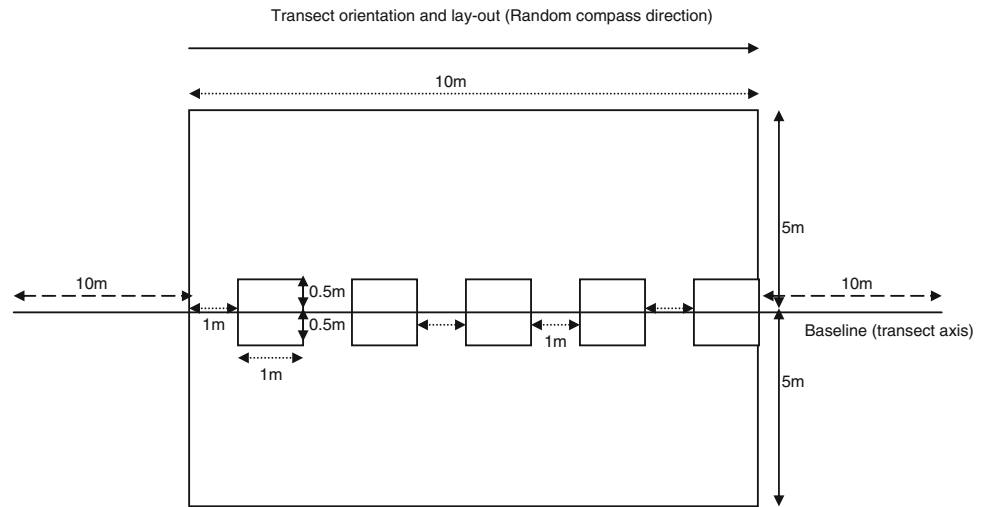
$$D_h = 52V_h/t \quad (3)$$

Total rate of deforestation (volume estimate)

$$D_t = nD_h \quad (4)$$

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

Fig. 2 Schematic layout of mangrove stands temporal sample plots (a) for measurement of all trees and stems diameter at breast height (1.3 cm) dbh ≥ 1 cm and (b) for counting seedlings and samplings ≤ 1 cm and stilt roots, with measurement of middle diameter and height of stilt root in 1 m² quadrats systematically laid along transect axis



Total rate of deforestation (per hectare estimate)

$$D_r = D_t/V_s \tag{5}$$

where

- D_h household deforestation rate (m³ household⁻¹ year⁻¹)
- V_h mean household wood stock (m³)
- t turnover rate (in weeks)
- n total number of households
- D_t total rate of deforestation (m³ year⁻¹)
- D_r total rate of deforestation (ha year⁻¹)
- V_s mangrove stocking rate (m³ ha⁻¹).

The survey showed that over 1,000 ha of mangrove forests exists in scattered pockets of less than 10 ha (in 50 % of the sites) in the Amanzule area, representing about 10 % of national mangrove coverage of 14,000 ha following UNEP (2007) subregional survey (Table 1). Most of the mangroves that do not appear in the current vegetation map of the area are of the estuarine mangrove type (61 %) (the area is known to cover about 70 % of swamp forests, including mangroves, but it has been difficult to measure how much has been lost); generally healthy (44 %); reaching a canopy height of 30 m in areas surrounded by coconut plantations (61 %); supporting the livelihoods (from wood demands and use as estimated from this survey); and securities of a surrounding fishing or farming human population, generally 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 fuelwood, charcoal, construction, etc.; pollution from waste disposal from urban centres and mining activities; and river mouth closure due to sedimentation that impedes tidal flows that maintain mangrove ecological processes. However, there has been no cutting of mangroves in over 60 % of the

Results and Discussions

Status and Threats of Mangrove Ecosystem Services

General Status of Mangroves

The current general status of the mangroves in the Greater Amanzule wetlands based on the 18 sites surveyed is presented in Table 1 and the mangrove distribution map in Fig. 3.

Table 1 Appraisal of mangrove status and condition in the Greater Amanzule wetlands (based on 18 mangrove sites), Ghana

Assessment criteria	Ranked category	Number of sites	Percentage
Mangrove type	Estuarine	11	61.1
	Lagoonal	7	38.9
Mangrove areal extent (ha)	0–10	9	50.0
	10–50	1	5.6
	50–100	3	16.7
	100 ha 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 (very free tidal flow throughout the year)	6	33.3
	Good (partially blocked in some periods of the year)	8	44.4
	Limited (blocked in some periods of the year)	3	16.7
	Very limited (blocked throughout the year)	1	5.6
Biodiversity status (presence of large mammals especially monkeys within the day)	Many usually seen (more than 10 animals)	3	16.7
	Few usually or occasionally seen (less than 10 animals)	1	5.6
	Not/rarely seen	14	77.8
Health status (visual average proportion of yellow foliage or dead leaves, roots and stems in a given mangrove site)	Very healthy(less than 10 %)	5	27.8
	Healthy (10–30 %)	8	44.4
	Partly degraded (30–50 %)	3	16.7
	Degraded/polluted from waste disposal/mining (more than 50 %)	2	11.1
Main adjoining vegetation	Raphia swamps and 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
	500–1,000	4	22.2
	1000–5,000	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	Noncutting (deliberate decision not to cut) or prohibited cutting(by customary laws with fines to defaulters or by conservation organizations)	11	61.1
	Wood collection (for fuelwood, charcoal, construction, etc.)	4	22.2
	Mouth closure due to sedimentation	1	5.6
	Pollution (in situ pollution, waste disposal/mining activities)	2	11.1
Past or current conservation or any intervention efforts by NGOs or partners	Present	7	38.9
	Not present	11	61.1

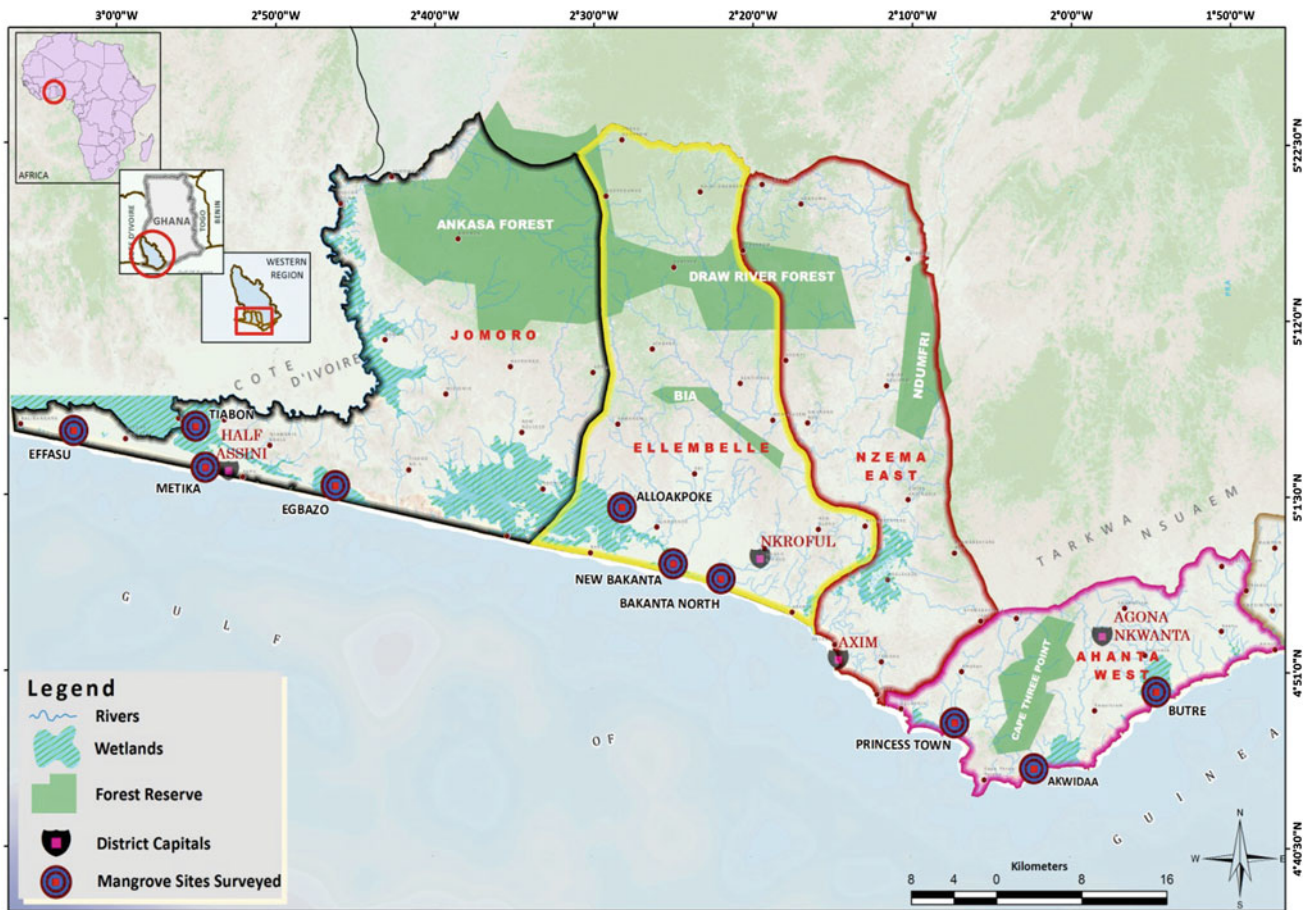


Fig. 3 Map of Greater Amanzule wetlands showing distribution of surveyed mangrove sites

sites due to effective prohibitions. These include community-based by-laws as a result of public education campaigns by NGOs which have been operating in the areas concerned and also the enforcement of traditional norms in some limited cases.

Carbon Storage Potential

The total aboveground carbon stored in intact mangroves in the area (see Table 2 and stem-size class distribution in Fig. 4) ranges from 65 to 422 tC/ha per ha with mean of 185 tC/ha with mangrove aboveground roots (aerial roots), holding in some cases 78 % of the aboveground biomass in degraded mangrove areas. It should be noted that belowground carbon storage accounts for up to 98 % of total whole-ecosystem storage in mangrove ecosystems, based on a recent quantification of whole-ecosystem carbon storage by Donato et al. (2011), so in actual fact, carbon sequestration by mangroves is much larger than measured in this study.

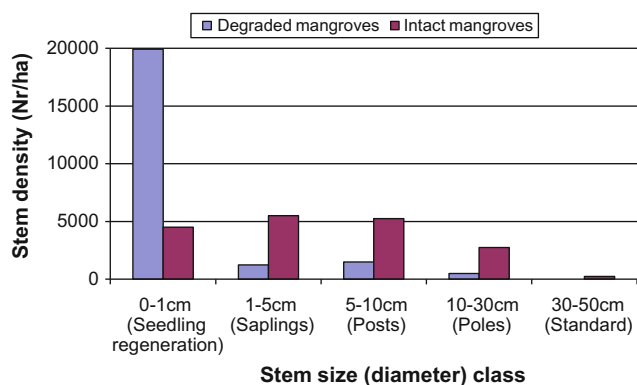
Mangrove Wood Consumption and Impacts on Mangrove Forests

The mangrove is currently valued for fuelwood use at 4,146 Ghanaian cedis (US\$2,765) per ha within the Effasu community (Table 3)—well above estimates of US\$340/ha in the lower Volta (Gordon et al. 2009). Wood consumption is lower than estimates from a similar typical Cameroon mangrove fishing community (Table 4). Mangrove wood consumption for cooking and fish smoking from the Effasu community is estimated at 16 and 97 m³/household/year, respectively, and per capita consumption is 1.8 and 10.8 m³/person/year, respectively. Current deforestation rate for cooking and fish smoking is estimated at 0.06 and 0.34 ha/household/year, respectively, with a per-hectare harvest rate of 0.006 and 0.038 ha/person/year, respectively.

Wood consumption for fish smoking was generally 1.1–1.3 times lower than that for a Cameroonian fishing community owing to the use of more efficient fish smoking ovens.

Table 2 Stand structural characteristics and aboveground carbon stocks of intact and degraded *Rhizophora*-dominated mangroves in the Greater Amanzule wetlands, Ghana

Community	Type	Status	Stand height (m)	Stand Height above stilt root (m)	Above ground component	Density (Nr/ha)	Basal area /ha (m ² /ha)	Volume (m ³ /ha)	Carbon content		Aboveground root/shoot ratio
									Tonnes/ha	As percentage 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 and Old)	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	

**Fig. 4** Stem diameter distribution in mangrove forests of Greater Amanzule wetlands, Ghana

Importance and Opportunities for Local Tourism Industry Development

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

promote activities that have minimal impacts on 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 (Fig. 5), generating annual revenues of nearly 24,000 Ghanaian cedis (US\$16,000).

GWS reaches out to the community and the schools in an effort to educate the population about conservation. In east Nzulezo, they have a task force office that distributes information on protecting the turtle populations in 5 km stretches along the length of the major nesting beaches. 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 tideline. 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 who 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

Table 3 Characteristics of mangrove wood use and per ha value of mangroves for fuelwood within a typical fishing community (Effasu, Greater Amanzule 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 Ghana cedis (US\$40)
	Cost/stere	7.41 Ghana cedis (US\$4.94)
	Cost/m ³	14.64 Ghana cedis (US\$9.76)
	Cost/tonne	16.44 Ghana cedis (US\$10.96)
	Cost/ha ^a	4,147 Ghana cedis (US\$2,765)

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

Table 4 Community fuelwood consumption and impacts on surrounding mangrove forests within the Effasu fishing community (Greater Amanzule wetlands, Ghana)

Region	Activity	Turnover rates (m ³ /year)		Deforestation rates (ha/year)		Source
		Per household	Per capita	Per household	Per capita	
West Africa (Effasu 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, Yoyo I & II)	Cooking	19.74	2.50		0.004	Ajonina and Usongo (2001)
	Fish smoking	105.58	13.39		0.024	

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 homestays. 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 and private tourism operators, especially the Eco-Lodge at Beyin (Fig. 7). Recently, they recognized the success of the Amanzule Conservation and Integrated Development Project during a presentation at a government conference (Fig. 6).

Prospects of Oil and Gas Industry

A number of interesting concerns are posed and questions asked in a recent coastal publication Hen Mpoano—Our Coast, Our Future, Western Region of Ghana (Anon. 2010) concerning booming prospects of oil and gas and the impacts

of offshore and onshore construction and operations on both the marine and the terrestrial environments. The publication contends 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 is said to 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 and the country as a whole, or yet another example of the curse of oil. Questions posed include the following: 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 labour force be trained to fill new employment opportunities or will skilled labour be imported and earnings flow overseas? Who will benefit and who will lose? The discovery of oil and gas and associated onshore infrastructure development will undoubtedly impact heavily on natural resources and especially local livelihoods. In addition to the above concerns, the mangrove environments and the delivery

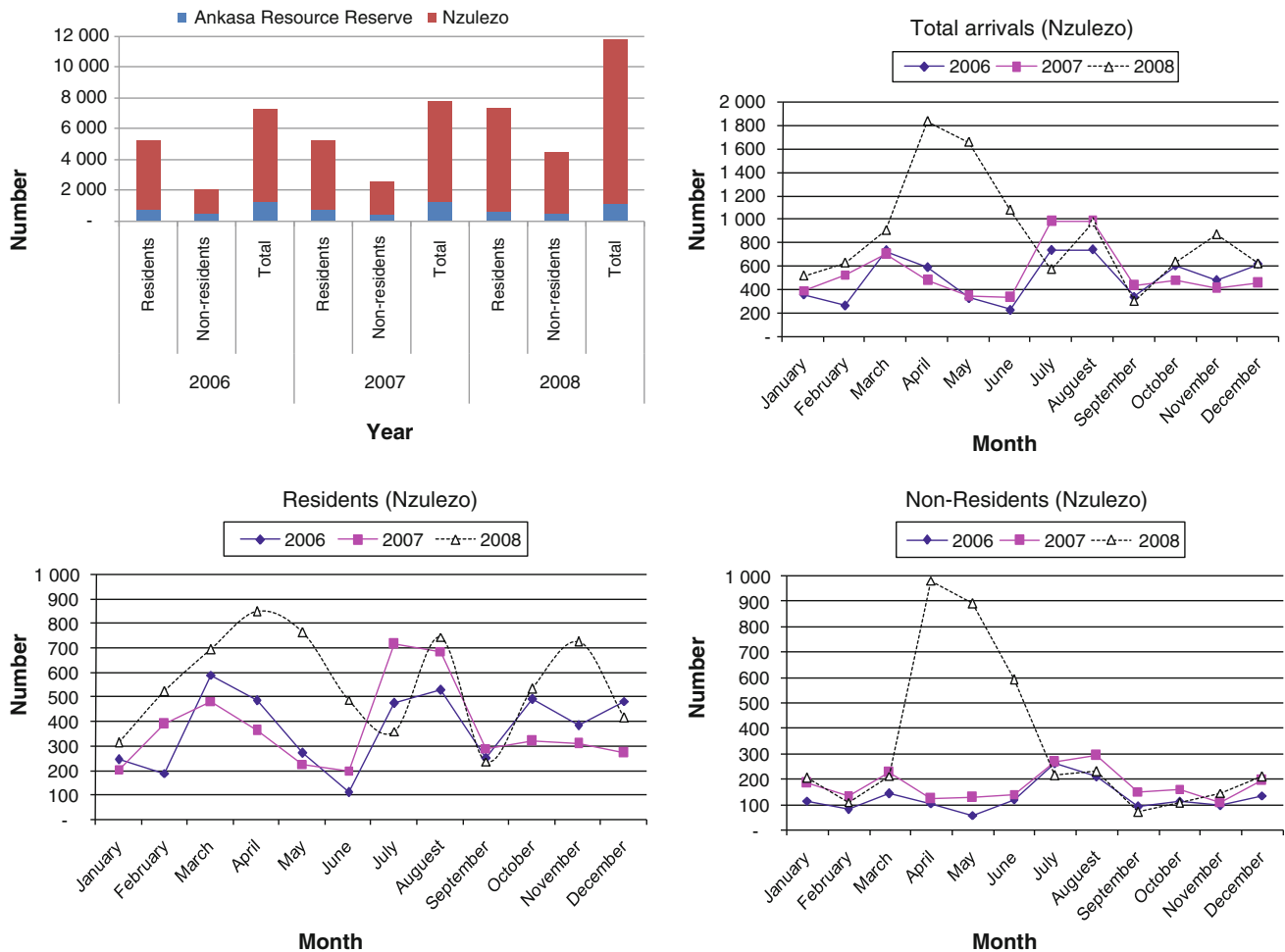


Fig. 5 Monthly and yearly distribution of tourist visits from two touristic sites located around Amanzule wetlands, Ghana (Source Data from Ghanaian tourism review)

of services from them will be affected. How to get oil companies to pay for offsets and get involved in mangrove restoration and conservation remains a challenge. They need to be guided within a certain platform on mangrove ecosystem valuation information on what society will lose if the ecosystem services provided by the mangroves are lost, and they must pay costs for their replacement/restoration of these degraded ecosystems.

Institutional Issues and Governances of Wetlands and Potentials for a Coastal and Marine PES Scheme

Institutions and Stakeholders for Mangrove Management

The institutions and stakeholders in the management of mangrove forests in the Western Region of Ghana reflect a broad range of interests at the 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 programmes 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, there is the Regional Coordinating Council. The local level is represented by a number of players or interest groups whose actions or 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. Stakeholders and institutional analysis from the policy to field levels are presented in Tables 5 and 6. In each tier, the major actors are identified, together with their roles and responsibilities, and

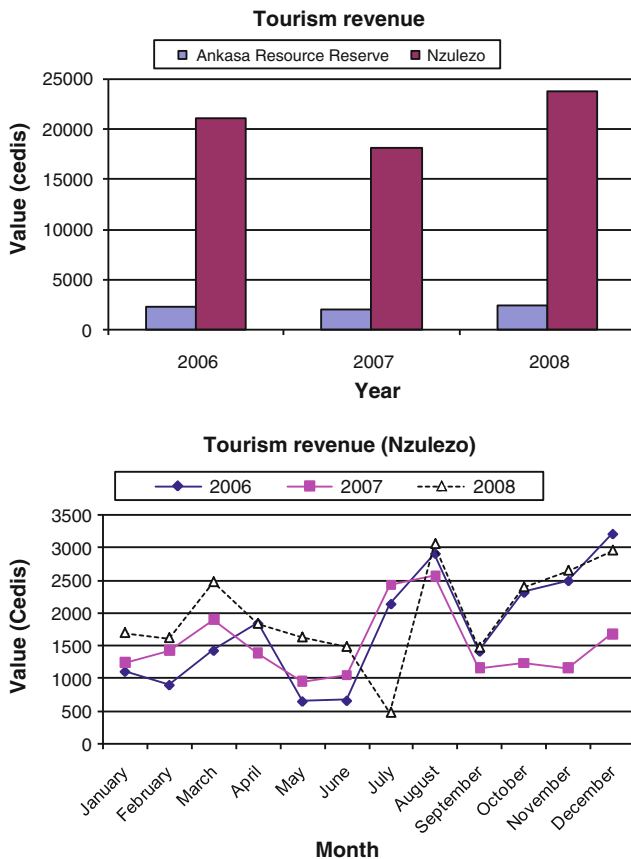


Fig. 6 Monthly and yearly trends in tourism revenue from two touristic sites located around Amanzule wetlands, Ghana (Source Data from Ghanaian tourism review, Ghana Tourist Board, Ministry of Tourism, Ghana)

an assessment of the current level of implementation is made with suggested strategies for implementation towards sustainable mangrove management.

The following general observations can be made:

- First-level institutional and stakeholder 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 into account in any development planning processes.
 - Donor funds that address short-term solutions to long-term problems with poor level of private sector participation.
- Second-level institutional and stakeholder 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.
- Lack of long-term financing leading to periods of neglect in working with communities as less than 40 % of the mangrove sites have received any intervention (Table 1).
- Lack of adequate knowledge and capacity for wetland management.

Conclusions and Recommendations

Conclusions

From this rapid assessment exercise, limited in time and by certain information gaps, the following conclusions can be drawn:

- *Types, distribution, values and status of mangroves and associated wetlands in the Amanzule region.*

More than 1,000 ha of mostly estuarine mangrove forests exists in scattered pockets in the Amanzule area, representing about 10 % of national mangrove coverage with most of the mangroves not captured in the current vegetation maps 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 by mangrove communities that these mangroves have decreased in area over the last 20 years with identified threats that include wood collection for fuelwood, charcoal and construction; pollution from wastes disposal, especially in around urban centres and mining activities; and mouth closure due to sedimentation that impedes the tidal flows that maintain mangrove ecological processes.

The total aboveground 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 fuelwood use at 4,146 Ghana cedis (US\$2,765) per ha with a significant impact on mangrove forest.

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

The various institutions and stakeholders at the national, regional and local community levels have varying interests which should be considered in any effort aimed at managing the wetlands in the area *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, especially the oil companies, interested in investing in ecosystem services protection. Already, private tourism initiatives hold promise as some have started green investments. Oil and gas companies need to be guided within a certain platform on mangrove ecosystem valuation information on what society



Fig. 7 Private tourism operators' case of Eco-Lodge at Beyin (the proprietor in red shorts) (Photograph by Nicolas Jengere)

will lose if the ecosystem services provided by the mangroves are lost, and they must pay for their replacement/restoration.

Recommendations

Short-Term Recommendations

- Addressing Stakeholders and Instructional Issues
 - *Development of stakeholders contact database.* All the groups working on mangroves need to be identified through the establishment of a database initiated by either themselves or a state institution like the Wildlife Division of the Forestry Commission.
 - *Organization of an expanded stakeholder forum.* In order to resolve conflict issues on mangrove and coastal resource management issues, an expanded forum of key stakeholders, preferably convened by the government with NGOs playing a facilitating role, is needed to identify and chart out a common vision and workable strategies for mangrove conservation within the general integrated coastal management discussion. The ongoing organization of the proposed coastal forum by Coastal Resources Center (CRC) could be a window opportunity.
 - *Cross-institutional capacity building.* Need to strengthen the operational capacities of governmental organizations by providing them basic logistics, especially transport, etc.

- *Sharing of research finding.* Mechanisms should be developed to promote communication and sharing of research results either through forums or through any communication media.
- *Sensitization campaigns.* Need for adequate sensitization campaigns to strengthen the awareness on the importance of mangroves, the threats affecting them and the 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 permanent sample plot system for measuring mangrove carbon sequestration and ecosystem dynamics under various human extraction regimes.

Medium- and Long-Term Recommendations

- Addressing the direct on-site threats to mangrove ecosystem services is critically important in order to develop effective management/conservation policies and to lay the groundwork for innovative financing, including PES schemes.
- A focus on areas for potential wet carbon benefits via avoided deforestation or the peat/swamp forests and restoration of mangroves (Table 7) could provide the necessary foundation for PES.

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 and laws (forestry and wildlife policy 1994, Ramsar treaty 1971, etc.)	Laws in place, but enforcement is weak	There is need for legal reforms that harmonize existing laws/acts to reduce overlap and promote their enforcement
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	Structures in place, but are not functioning well due to severe limitations in logistics (vehicles, communication for field monitoring operations)	More training needed (on efficient use and maintenance of logistic equipment) and more resources to be provided by central government. Mangrove conservation objectives need to be emphasized and integrated with wildlife reserve objectives as an integrated ecological framework. This means that protected areas containing mangroves should specifically state in one of their objectives that it will ensure protection and sustainable use of mangrove forests as fisheries nurseries grounds and protection against storms
Regional administration	Complementary and supervisory	Does have capacity needed for mangrove management. Recently 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 and some NGOs such as Wildlife Society and others. However, the research findings are difficult to come by except on the Internet sometimes and some foreign journals	There is the need to coordinate the process of sharing research findings for wider dissemination of information and in order to avoid duplication of efforts
Local government	Regulation, enforcement and implementation	With respect to mangrove and wetland management, the six coastal districts have not done much. The laws have not been enforced due to the general 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 and conserve the mangroves
Donor/funding agencies	Provision of funds and technical advice	They have been providing funds for long time now, e.g. 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. All partners need to work together to achieve this. The Ghanaian government has a role to play by factoring this into annual national budgets. It should not be the sole responsibility of outside donors. Commercial bodies whose actions impact on the wetlands should also be brought on board, e.g. hard and soft mineral producing companies. Possibilities of a carbon tax/green tax may be explored

- Conservation should be the focus in sites with significant peat/swamp forests, especially Ekumkpole and Amanzule, and significant healthy mangroves, especially Alengezule, Domunli, Kikam, Ankobra, Awhuele, Ez-ele, Butre, Ndabelah and Ampain.
- Potential areas for restoration include the following:
 - *Hydrological restoration with replanting.* For sites with mouth closure due to sedimentation through channel opening to allow normal tidal exchange with mangrove areas or badly degraded sites especially Amanzule and Effasu.
 - *Waste removal.* Particularly for urban and peri-urban polluted sites that include Yan and Awine-anloa areas.

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

Institution/ stakeholder	Roles/responsibilities	Assessment/remarks	Strategies for improvement towards sustainable mangrove management
District assemblies	Regulation, permitting enforcement	Laws are not enforced due in part to ignorance about importance of wetlands. Limited resources to visit sites for inspection and enforcement	Workshops should be conducted to educate assemblies. They should be involved in the design and implementation of future projects concerning wetlands backed by some logistics (basic field operation equipment and transport vehicles, fuelling, etc.) for the task
Traditional authorities	Are custodians of the land and are supposed to regulate its usage through the granting of tenure 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 education and sensitization is very important in this regard that can help bring about local ownership of the proposed interventions
Local communities	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 aggravated by ignorance, tenure right controversies and concerns of settler fisher folks. Limited livelihood opportunities and severe poverty associated with downturn in fishing and associated activities are forcing most of them to exploit aqua forests at a commercial scale. Local perceptions about mangrove forests are not healthy who see them as ordinary trees which can grow again after harvesting	Sensitization of local communities, redefining of tenure rights and resolution of concerns of settler fisher folks are very necessary in addressing mangrove management problems in their areas of jurisdiction. Alternative livelihood schemes need to be identified and promoted in local communities
NGOs and other civil society groups	Inform and educate local communities on sustainable management of mangroves	Problem with securing long-term finance has led to long periods of neglect (in activity with the local communities) in working with communities, e.g. CRC 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. The majority of them are concentrated in the regional capitals. Capacities are also limited in the area of scientific and technical appreciation of wetland ecology	All the groups working on mangroves need to be identified through the establishment of a database initiated by either themselves or a state institution like the Wildlife Division of the Forestry Commission. This should not be seen as a means to control their activities. Their capacities should also be built, and long- term financing mechanisms secured

To capture the full range for such wet carbon initiatives, a specific targeted research agenda may be needed including getting reliable estimates of belowground carbon stocks, growth rates and carbon sequestration potentials of mangroves through laying out and periodically measuring permanent sample mangrove plots as ongoing in central African mangroves.

- Policy review leading to reforms may be needed to revise existing laws with more research to enhance policies to encourage stakeholder communication, actual management and enforcement.
- Sustainable funding through private sector participation should be encouraged and should constitute a main focus of mangrove conservation efforts. Donor partners should

Table 7 Site-targeted specific actions for wet carbon initiatives

Site name	Community	Species composition	Extent (ha)	Other characteristics
<i>(a) For conservation</i>				
Allengenzule	Allengenzule	<i>Rhizophora, Avicennia</i>	0.1	Used to be crocodiles, little threats, nonhuman use, etc.
Domunli	Egbazo	<i>Rhizophora</i>	75.0	Low wood collection for cooking, construction and minimal threats
Ekumkpole	Metika (1 & 2)	Extensive <i>Rhizophora</i> stands with adjoining <i>Raphia</i> swamps	250.0	Monkeys usually seen, low wood collection for cooking, construction
Amanzule North	Aloekpoke	Very few <i>Rhizophora</i> stands (less than 1/ha), large swamp mixed of ironwood (<i>L. alata</i> with tree density of 50/ha with diameter more than 1 m)	200.0	Birds, fishes, wood for charcoal, fishing especially black tilapia with charcoal production
Amanzule	Nzelenoanu	<i>Rhizophora</i>	180.0	Abundance of crabs which are collected by the population including fuelwood collection
Amanzule	Kikam City	<i>Rhizophora</i> dominated with adjoining	12.0	Nonidentified threats
Ankobra	Tiaboe	<i>Rhizophora</i> dominated with adjoining coconut plantations	8.0	Nonidentified threats
Awhuele	Princess town/Anleo village	Mixed mangrove species with adjoining grassy hills with mixed tree crop farms and fallows	75.0	Monkeys present with nonidentifiable threat especially wood harvest prohibited by traditional authorities
Ezele	Akyenum	Mixed mangrove species	150.0	Nonidentified threats
Butre	Butre	Mixed mangrove species	7.5	Nonidentified threats
Ndabelah	Nzimitianu	Large swamp communities with some spotted <i>Rhizophora</i> and <i>Avicennia</i> stands	5.0	Nonidentified threats
Ampain	Ampain	More or less pure stands of <i>Avicennia</i> (900 trees/ha), <i>Conocarpus</i> , <i>Rhizophora</i>	2.0	Nonidentified threats
<i>(b) For restoration through replanting and/or hydrological restoration</i>				
Amanzule	Bakanta (New and Old) and north	Vast stands of <i>Rhizophora</i> with adjoining coconut plantation	475.0	Charcoal production, wood for cooking, wood for construction
Amanzule	Chiko (Half Assini Anowa)	<i>Rhizophora</i>	0.5	Threats of mouth closure
Effasu	Effasu	<i>Rhizophora</i>	2.6	Heavy wood collection for fish smoking with threats of mouth closure
<i>(c) For waste removal with hydrological restoration</i>				
Yan	Princess town/Anleo	Mixed mangrove species	2.0	Area with dumped wastes
Awine-anloa	Fante (Half Assini Fante)	<i>Rhizophora</i>	1.5	Though few monkeys occasionally visit the area, there is heavy dumping of wastes in the area

work with all partners to put in place sustainable funding mechanisms based on existing funding sources, especially to stimulate private sector investment.

Acknowledgments The assessment was supported by USAID through the Coastal Resources Center, Ghana, and Forest Trends, USA. The authors are gratefully indebted to persons, projects, programmes and institutions contacted during the study. We appreciate greatly the field assistance and contribution of Nicolas Jengere of Nature Conservation and Research Center (NCRC) 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 the interview. John Mason of NCRC, Frank Hicks (Forest Trends) and Joerg Seifert-Granzin (Forest Trends) provided initial contacts that led to this work. We also thank Esinam Attipoe (Hanns Seidel Foundation, Ghana) for sending complementary information about the area.

References

- Ajonina GN (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 Fortschrittliche Biometrie, Albert-Ludwigs-Universität Freiburg*. 2. 215 p
- Ajonina GN, Usongo L (2001) Preliminary quantitative impact assessment of wood extraction on the mangroves of Douala-Edea Forest Reserve. *Cameroon Trop Biodivers* 7(2–3):137–149
- Ajonina G, Abdoulaye D, Kairo J (2008) Current status and conservation of mangroves in Africa: An overview. *WRM Bull* 133, August 2008. <http://wrmbulletin.wordpress.com/2008/08/25/current-status-and-conservation-of-mangroves-in-africa-an-overview/>
- Ajonina PU, Ajonina GN, Jin E, Mekongo F, Ayissi I, Usongo L (2005) Gender roles and economics of exploitation, processing and marketing of bivalves and impacts on forest resources in the Douala-Edea Wildlife Reserve, Cameroon. *Int J Sustain Dev World Ecol* 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, p 64
- Barbier EB, Acreman MC, Knowler D (1997) Economic valuation of wetlands. A guide for policy makers and planners. Ramsar convention bureau gland, Switzerland, p 143
- 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 DC, Kauffman JB, Murdiyarsa D, Sofyan Kurnianto S, Melanie Stidham M, Markku Kanninen M (2011) Mangroves among the most carbon-rich forests in the tropics. *Nat Geosci* 4, doi: [10.1038/NNGEO1123](https://doi.org/10.1038/NNGEO1123)
- Feamside PM (1997) Wood density for estimating forest biomass in Brazilian, Amazonia. *For Ecol Manage* 90:59–87
- Feka NZ, Chuyong GB, Ajonina GN (2009) Sustainable utilization of mangroves using improved fish smoking systems: a management perspective from the Douala-Edea Wildlife Reserve, Cameroon. *Trop Conserv Sci* 4:450–468
- Gordon C, Tweneboah E, Mensah AM, Ayivor JS (2009) The application of the ecosystem approach to mangrove management: lessons for Ghana. *Nat Fauna* 24:30–41
- GWS (2003) Amanzule wetlands ecosystem management plan 2003. Ghana Wildlife Society
- Husch B, Beers TW, Keuhaw JA (2003). *Forest mensuration*, 4th edn. Wiley, 443 p
- Loetsch I, Zohier F, Haller K (1973) *Forest inventory*, vol 2. Second Edition BIV, Germany, 469 p
- NCRC/Beyin 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. 92 p