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Mangrove Degradation and Management Practices along the Coast of Ghana

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Abstract

Mangroves are increasingly being degraded in West Africa. We explored local utilization, threats and assessed existing conservation practices in Ghana through field visits, mapping, laboratory analyses and interviews. The study reports three species of mangroves along Ghana's coastline; white (*Avicennia germinans*), red (*Rhizophora racemosa*), and black (*Laguncularia racemosa*) mangroves. White mangrove is the most dominant, with black mangroves being the least. The current mangrove cover of Ghana was estimated at 72.4 km^2 with over 18 million trees (average = 2284.21 trees per hectare), both naturally occurring and planted mangroves. The Volta Region had the most abundant mangroves, with the Central region recording the least. Notable flora within the mangrove forests included *Acrostichum aureum*, *Sesuvium portulacastrum*, *Paspalum vaginatum*, *Sporobolus maritima* and *Conocarpus erectus*. Mangrove wetland in Ghana provides suitable nursery habitats for several important fish species, including *Sarotherodon melanotheron*, *Mugil cephalus*, *Callinectes amnicola*, *Cardiosoma armatum*, *Crassostrea* sp, *Periophthalmus papilio*, *Coptodon* spp. Ghana's mangrove forest is declining at a rate of 8.1 km^2 per annum due to over-cutting, land conversion, wildfires, pollution, overgrazing and natural death from disease. Over cutting mangrove for fish smoking and housing construction were significant threats to mangroves nationwide. Continuous education, law enforcement, nature-based methods and local control mechanisms effectively protect mangroves.

Keywords

Mangroves in Ghana, Mangrove Deforestation, Mangrove Management, Traditional Regulations

1. Introduction

Mangroves are one of the most productive ecosystems on the planet [1]. They have the intrinsic ecological function of sustaining the ecosystem, which includes soil stabilization, coastal protection [2] [3] [4] [5], fish habitats and nurseries [6] [7] [8] and vital sources of protein resources for coastal communities. Mangroves can retain, remove and cycle nutrients, pollutants and particulate matter from land-based sources. Most toxins and nutrients are removed during sediment deposition when they bind to sediment particles or within the molecular lattice of clay particles. This makes mangroves invaluable natural filtration systems that help maintain coastal water quality. The filtration function of mangroves also helps protect important but fragile coral reef and seagrass ecosystems [9] [10]. Mangrove stands provide structural support to coastal communities by acting as natural barriers between coastal storms and homes [7].

Globally, mangrove ecosystems are highly threatened and disappearing at an alarming rate [11] [12] [13] due to intense human pressure resulting from population growth, land-use change, and anthropogenic sources of pollution. The annual loss of mangroves around the globe is estimated at 7 million hectares, equivalent to about two years of loss for all types of forest systems [14]. Over the last 50 years, degradation and deforestation have destroyed 20% - 35% of global mangrove cover [15]. In the twentieth century, mangrove losses were mainly a result of clearing, exploitation for timber production and raw materials, rapid coastal population growth and urban expansion [16] [17]. Studies [18] have reported that a third of the world's mangroves have likely been lost over the last 50 years due to anthropogenic activities such as conversion for aquaculture or agriculture, tourism, coastal development, fuel wood, charcoal and lumber production. Between 1980 and 2006, Ghana's mangrove cover was reduced from 181 km^2 [19] to 137 km^2 [20]. This has resulted in the reduction and loss of some associated fauna and flora. Although very few studies have indicated the high demand for mangroves for various purposes as a potential cause of its decline in Ghana, information has been very scanty and fragmentary. In this study, which is the first comprehensive study ever to be conducted along the entire coast of Ghana, we investigated the types of mangroves in Ghana, their distribution, area of coverage, and the dependency of coastal communities on the mangrove resources. The study also sought to identify the threats to mangrove resources and measures that exist to protect the mangroves.

2. Materials and Methods

2.1. Study Area

The study area is located in the Western portion of the Gulf of Guinea and spans the entire 550 km coastline of Ghana, with about 90 lagoons (both open and closed) and associated wetlands [21] [22] [23]. Fieldwork was conducted along the entire coast of Ghana from the eastern to the western coast (**Figure 1**) and covered the four coastal administrative regions of Ghana containing 26 Districts. Although the coastal zone covers only 6.5% of Ghana's land area, it is inhabited by a quarter of the total population of Ghana [24] due to its numerous and diverse

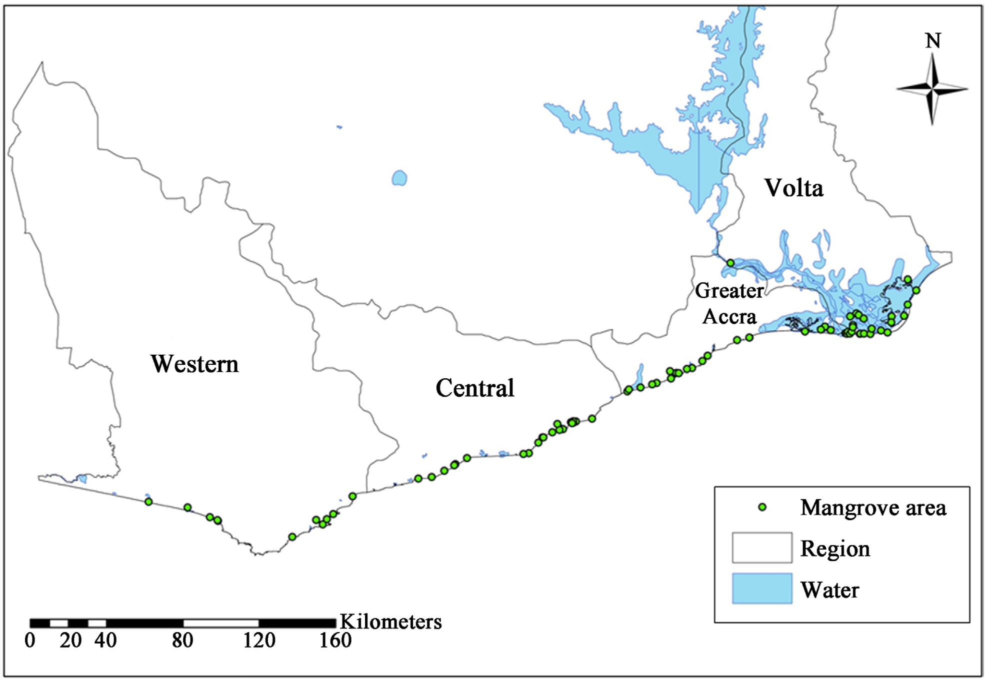

Figure 1. Map of the coastal Regions of Ghana showing the location of mangrove areas.

services. The primary occupation in the study areas is fishing, with a total of 11,583 canoes operated by 107,518 fishermen from 186 fishing villages and 292 landing sites [25]. The area is characterized by low-lying lands not more than 200 m above sea level with a narrow continental shelf extending outwards to between 25 km and 35 km, except off Cape Coast to Saltpond, where it reaches up to 80 km [24].

2.2. Data Collection

The study was conducted over 35 days, from 13th June 2014 to 18th July 2014, in four coastal Regions of Ghana. We used direct field observations, sediment assessment, GIS mapping, and interviews with local communities and stakeholders in the mangrove sector to gather information about the mangrove forests along the coast of Ghana and to determine the utilisations and threats of mangrove resources.

Field visits were made to areas in all four coastal Regions in Ghana where mangroves occur (**Figure 1**, **Table 1**). Overall, 87 mangrove sites were visited; 25 in the Volta Region, 21 in the Greater Accra Region, 23 in the Central Region and 18 in the Western Region. At each visited site, the GPS location was recorded for mapping purposes. Mangrove species/types (identified using leaves, stem, root system and propagules), heights, girth at breast height (for matured stands), and associated flora and fauna were noted. A 10 m × 10 m (100 m^2) plot was marked inside each mangrove site [26], and all mangrove trees and seedlings within the plots were counted and used to estimate tree abundance for the site. Tree height was estimated for the entire stand, while tree girth was recorded for

Table 1. Area distribution of the mangroves forests in the coastal regions of Ghana.

Region	Area of mangrove forest (Ha)	Estimated tree numbers
Volta	4040.97	10,883,763
Great Accra	318.56	660,568
Central	251.93	667,231
Western	2623.89	6,027,218
Total	7235.35	18,238,780

representative samples of the mangrove trees. The 10 m × 10 m sampling plot was chosen because it was the ideal size to be able to estimate tree abundance for mangrove stands with smaller land areas. For more extensive stands, three replicates of 10 m × 10 m sampling plots were conducted per study site, and the average was used to estimate the tree density of the area. Water quality parameter (salinity) was recorded at each mangrove site using a hand-held refractometer.

Soil samples were collected at a depth of between 15 cm to 30 cm on the field within all four regions for analysis in the laboratory using a granulometric method modified from [27]. In the laboratory, the sediment samples were dried overnight in an oven at 60˚C to remove moisture. Silt/Clay fraction was determined by weighing 150 g of dried sediment after attaining a constant dry weight. The 150 g sediment sample was then washed with 1% NaOH using a 63 μm sieve to enable easy dispersal of sand into individual particles. The retained sediment was oven dried to constant weight. The difference in the weight before and after washing was referred to as the silt/clay fraction. 100 g of the dried sediment was weighed and sieved through a stack of sieves using an Octagon Digital Mechanical Shaker for five minutes. The weight of retained sediment on each sieve was determined and reported against the sieve size to determine the composition of the soil.

A digital location map of all the significant mangrove sites in Ghana was also developed using Geographic Positioning System (GPS) coordinates recorded at the various sites visited. Further, Landsat 8 imageries for 2013 covering the entire coast of Ghana were processed using ENVI/ERDAS Imagine/ArcGIS. Subsets of the imageries covering the coastal areas were extracted to map mangrove habitats. A 3-by-3 Sobel filter was applied before implementing classification algorithms to map mangroves at a confidence level of 96%. Datasets developed from field visit of more than 88 mangrove sites along the entire coast of Ghana was fed into the supervised classification module with 20 iterations to produce vegetation classes. Similar vegetation classes were merged to create 4 classes, including mangrove vegetation which was validated using positions of known mangrove sites from the field visit datasets.

Interviews and Focus Group Discussions [FGD] (using a predesigned interview guide) were conducted with all relevant stakeholders, including government officials, residents of local communities, and mangrove users. Each interview session lasted between thirty to forty-five minutes. The interview guide was pretested in some selected communities in the Greater Accra Region to assess respondents' understanding of the questions and the information required with each question. The interview guide was subsequently refined and used in communities in the four regions to gather information about mangroves. A total of forty (40) interviews were conducted; ten (10) in each of the four coastal regions. Key informant discussions were also conducted with some community opinion leaders. Data from interviews and FGD were synthesized to provide information for the analysis of issues at the various study areas.

3. Results

3.1. Mangrove Species Composition, Abundance and Distribution

The current study recorded three mangrove species in the eighty-seven mangroves areas along the coastline of Ghana (**Table 2**), namely white mangrove (*Avicennia germinans*), red mangrove (*Rhizophora racemosa*), and black mangrove (*Laguncularia racemosa*). Of the three species, *Avicennia* was widely distributed along the coast, followed by *Rhizophora* and *Laguncularia*. Though all three species of mangrove occurred in all four Regions, the Greater Accra Region has *Avicennia* predominating. At the same time, *Rhizophora* dominated in the Volta region, with the Central and Western having similar proportions of *Avicennia* and *Rhizophora*. The study estimated the mangrove cover of Ghana to be about 72.4 km^2 with an average tree density of 2284.21 trees per hectare and total tree numbers estimated as 18.2 million, distributed in all four regions along Ghana's coast (**Table 1**). The Volta Region (4040.97 ha) recorded the largest extensive expanse of mangrove forest among the four coastal Regions, followed by the Western (2623.89 ha), Greater Accra (318.56 ha) and Central Regions (251.93 ha). The combined area of mangroves in the three regions have about one-third of the total mangrove area in the Volta Region.

Mangroves in Ghana are generally growing under varied environmental conditions. While sediment grains size ranged from very fine clay to silty-clay, salinity for mangroves ranged between 0‰ and 38‰ (**Table 3**). It was observed in the current study that salinity influenced the distribution of the mangroves in

Table 2. Characteristics of mangrove species present along the coast of Ghana. All parameters were recorded for matured mangrove plants at the sites visited. Newly planted mangroves from restoration sites were not utilized. Short heights recorded were those of mangroves exhibiting stunted growth.

Species	Height (m)		Girth (cm)		Seed length (cm)		Leaf length (cm)
	Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Average*
Avicennia germinans	1	15	2	250	2	3	10
Rhizophora racemosa	1	16	2	80	9	15	12
Laguncularia racemosa	3	10	12	49	1	1.5	7

Table 3. Table showing the location of the different mangrove species, tree and habitat characteristics along the coast of Ghana.

Site	Mangrove Species			Height Range (m)			Girth Range (cm)			Salinity (‰)	Soil Type
	Avicennia germinans	*Rhizophora racemosa*	*Laguncularia racemosa*	*Avicennia germinans*	*Rhizophora racemosa*	*Laguncularia racemosa*	*Avicennia germinans*	*Rhizophora racemosa*	*Laguncularia racemosa*		
Denu Apekotome lagoon	x	-	-	2 - 7	*	*	7 - 17	*	*	*	
Gamenu Torkor	x	x	-	8	5.5	*	22 - 48	21 - 44	*	2	Silty-clay
Agbakpegbor	-	x	-	*	4.5	*	*	5 - 21	*	5	*
Fuveme	x	X	-	19	8	*	55 - 88	18 - 53	*	2	Silty-clay
Havi	x	X	-	4 - 10	*	*	10 - 18	15 - 27	*	2	*
Agokedzi	x	X	-	*	4	*	*	12 - 17	*	0	*
Atitteti	x	X	x	6	5	3	39	13 - 17	23 - 35	0	Clayey
Anyanui	x	X	-	*	3 - 6	*	*	9 - 19	*	0	*
Bomigo	-	x	-	*	4	*	*	13 - 19	*	0	Silty-clay
Tunu	-	x	-	*	*	*	*	10 - 20	*	0	*
Dzita	-	x	-	*	4 - 9	*	*	12 - 26	*	*	Silty
Dzita 2	-	x	-	*	5 - 7	*	*	4 - 22	*	20	Silty
Akplormortokor	x	x	-	1 - 3	8	*	*	*	*	*	*
Galo Sota	x	x	-	2 - 15	*	*	22 - 238	*	*	*	*
Agbatsivi	x	x	-	4 - 6	*	*	16 - 44	*	*	*	Clayey
Agortoe	x	x	-	4	2 - 6	*	8 - 17	9 - 22	*	*	Sandy
Salo	x	X	-	*	2 - 12	*	*	8 - 17	*	*	*
Savietula	-	x	-	*	3 - 8	*	*	9 - 17	*	*	*
Fiahor (salt pans area)	x	-	-	2	*	*	4 - 7	*	*	0	*
Anloga	x	-	-	*	*	*	2 - 4	*	*	*	*
Afiadenyigba	X	x	-	1 - 6	*	*	7 - 28	*	*	*	*
Havedzi	x	X	-	*	1 - 6	*	*	10 - 17	*	35	*
Kedzi korpe	x	-	-	3 - 7	*	*	13 - 58	*	*	*	*
Tegbi	x	X	-	3 - 6	2 - 4	*	3 - 22	12	*	45	*
Whuti	x	X	-	2 - 4	3 - 8	*	*	*	*	15	*
Wasakuse-Ada	x	-	-	4 - 7	*	*	*	*	*	0	*
Obane	x	x	-	1 - 4	3 - 17	*	13 - 41	16 - 56	*	0	Clayey
Kwalakpoyom (near Obane)	x	-	-	<1	*	*	<1	*	*	0	*
Futueya-Ada Foah	x	-	-	2 - 12	*	*	9 - 169	*	*	0	*

Continued

Pute	x	-	-	3	*	*	11	*	*	0	*
Ahwiam beach	x	-	-	4.7	*	*	30 - 118	*	*	*	Sandy
Pacho lagoon, Ahwiam	x	-	-	1 - 2	*	*	10 - 15	*	*	15	*
Old - New Ningo Bridge	x	-	-	1 - 5	*	*	7 - 74	*	*	35	*
Djange lagoon (Tema New Town)	x	-	-	2 - 6	*	*	20 - 81	*	*	28	Silty
Chemu I lagoon	x	-	-	6	*	*	*	*	*	*	*
Sakumo II Ramsar Site	x	-	-	3	*	*	*	*	*	0	*
Mukwe Lagoon	x	-	-	2 - 8	*	*	17 - 78	*	*	10	Clayey
Teshie Sangonaa beach	x	-	-	*	*	*	*	*	*	*	*
Teshie (off main road opp Dandi Plaza)	x	-	-	5 - 11	*	*	*	*	*	*	*
Kpeshie (before bridge LHS)	x	-	-	2 - 15	*	*	34 - 69	*	*	*	*
Kpeshie (after bridge RHS)	x	-	-	2 - 15	*	*	34 - 69	*	*	*	*
Mensah Guinea Beach	x	-	-	*	*	*	*	*	*	*	*
Korle Lagoon	x	-	-	4 - 6	*	*	*	*	*	*	*
Glefe (near Agege)	x	-	-	3 - 4	*	*	40 - 50	*	*	*	*
Bortianor	X	-	x	3 - 6	*	*	40 - 182	*	*	0	*
Tsokomey (Near Bojo Beach)	X	-	x	1 - 4	*	*	6 - 9	*	*	*	Clayey
Kokule Lagoon (Senya Beraku)	X	x	-	*	*	*	*	*	*	*	*
Warabeba 1 (bridge before community)	x	-	-	6	*	*	23 - 41	*	*	5	*
Warabeba 2 (bridge before community)	-	x	-	*	12	*	*	15 - 27	*	5	*
Warabeba 3-Ayensu estuary	x	X	-	4 - 6	8	*	83 - 167	19 - 27	*	*	*
Nsuekyir 1 (before bridge)	x	X	-	5	7	*	21 - 54	*	*	*	*
Nsuekyir 2 (after bridge)	-	x	-	*	8	*	*	*	*	5	*
Sankor	X	x	-	6	*	*	45 - 53	*	*	*	*
Sankor-Royal Beach (estuary)	-	x	-	*	7 - 10	*	*	*	*	*	*
Muni lagoon	x	x	-	2 - 8	3	*	6 - 13	3	*	38	*
Muni estuary	x	-	-	4	*	*	11 - 19	*	*	*	*
Pratu river	x	-	-	2 - 8	*	*	63 - 100	*	*	15	*
Mankoadze	x	-	-	4 - 7	*	*	26 - 42	*	*	*	*
Apam Wetlands (Apaa Baka 1)	x	-	-	1 - 4	*	*	5 - 15	*	*	*	Fine clay
Apam wetland (Apaa Baka 2-At Beach)	x	-	-	1 - 5	*	*	47 - 53	*	*	*	Sandy
Mumford	x	-	-	2 - 4	*	*	12 - 23	*	*	10	*

Continued

Dago-Otuam	x	-	-	2 - 3	*	*	*	*	*	10	*
Otuam (Awonakrom)	x	-	-	12	*	*	44 - 250	*	*	0	*
Abandze	x	-	-	8 - 15	*	*	17 - 77	*	*	0	*
Biriwa 1	x	-	-	4 - 7	*	*	17 - 23	*	*	20	*
Biriwa 2	x	-	-	5 - 12	*	*	*	*	*	*	*
Moree	x	-	-	5 - 8	*	*	40 - 105	*	*	2	*
Fosu Lagoon-Cape Coast	-	-	-	*	*	*	*	*	*	*	*
Iture Wetlands	X	x	x	2 - 12	*	*	26 - 37	*	*	0	*
Shama	x	-	-	1 - 10	*	*	10 - 90	*	*	*	*
Aboadze-Anankware estuary	x	x	-	2 - 10	2 - 10	*	*	*	*	*	*
Essei lagoon	x	-	-	2 - 6	*	*	5 - 12	*	*	0	*
Butua lagoon	x	-	-	1 - 10	*	*	12 - 41	*	*	0	*
Whin (Adakope, Takoradi)	x	x	x	1 - 12	*	*	5 - 70	*	*	*	*
Whin Bridge, Apowa	-	x	-	*	15	*	*	*	*	0	Clayey
Butre	x	x	x	*	5 - 12	*	*	*	*	*	*
Ehunli lagoon (Near Princess Town)	-	x	-	*	*	*	*	*	*	*	*
Kpani-Nyila estuary	x	x	-	2 - 10	4 - 12	*	10 - 105	10 - 60	*	28	*
Ankobra I (before bridge, RHS)	-	x	-	*	7 - 9	*	*	34 - 80	*	0	*
Ankobra II (after bridge)	x	x	x	*	*	4 - 5	*	*	12-49	*	Very fine clay
Ambedu (before first bridge)	-	x	-	*	7 - 15	*	*	20 - 36	*	*	*
Amansule (bridge, off main road)	-	x	-	*	*	*	*	*	*	*	Fine clay
Ambedu (Before second bridge)	-	x	-	*	5 - 15	*	*	27 - 36	*	*	*
Amansule lagoon, Benyin	-	x	-	*	*	*	*	*	*	*	*
Amansule River at Asemdasuazo	x	x	-	2 - 12	2 - 15	*	10 - 250	10 - 45	*	5	*
Amansule outlet at Azulenoanu	x	x	x	4 - 8	2 - 15	2 - 10	*	2 - 34	*	38	*
Domunli Lagoon (near Old Kabensuazo)	-	x	-	*	2 - 16	*	*	4 - 45	*	33	*

Key: X = species present and dominant; x = species present; - = species absent;* = no measurement take.

terms of the species; white mangroves dominated areas with high salinity with the red mangrove located mainly in areas with relatively lower salinities.

3.2. Ecological Functions of Mangrove

Mangrove forests are highly productive ecosystems and provide valuable resources around the globe. They provide numerous goods and services to the aquatic and terrestrial environment and coastal communities. In Ghana, fisheries form an essential source of food and employment for thousands of coastal communities [25] [28]. **Table 4** presents the species of flora and fauna recorded among mangroves in the study area. Most fish species in this study were observed utilising the mangrove forest as nursery grounds for shelter and spawning. Several fin and shellfish were recorded over the study period to feed, spawn, or avoid predators within the mangroves. In communities within the study area, such as Anyanui in the Volta Region and Whin estuary in the Western region, the roots of mangroves were found to provide attachment areas for shellfish like

Table 4. Fish and Flora associated with mangroves vegetation along the coast of Ghana.

Associated Flora	Associated Fauna
Acrostichum aureum	*Callinectes amnicola*
Albizia adianthifolia	*Caranx hippos*
Cactus sp	*Cardiosoma armatum*
Carnegiea gigantea	*Ceryle rudis*
Chromolaena odorata	*Crassostrea* sp
Cocos nucifera	*Egretta garzetta*
Conocarpus erectus	*Egretta gularis*
Crotalaria retusa	*Himantopus himantopus*
Pteridophytes	*Liza* sp.
Imperata cylindrica	*Macrobrachium rosenbergii*
Lonchocarpus sericeus,	*Microcarbo pygmeus*
Opuntia ficus-indica	*Mugil cephalus*
Elaeis guineensis	*Periophthalmus papilio*
Panicun maxima	*Periopthalmus rouxi*
Paspalum vaginatum	*Ploceus* sp.
Pennisetum purpureum	*Porogobius schlegelii*
Sesuvium portulacastrum	*Sardinella* sp.
Ericameria nauseo)	*Sarotherodon melanotheron*
Sporobolus pyramidalis	*Sesarma huzardi*
Sporobolus maritima	*Shrimp*
Tetracera alnifolia	*Captodon* sp.
Thespesia populnea	*Tympanotonus* sp
Thespesia populnea;	*Uca tangerii*
Typha sp	*Sarotherodon melanotheron*
Waltheria indica	*Mugil cephalus*

Crassostrea tulipa and other sessile invertebrates requiring a hard surface. Mangroves help maintain water quality and clarity by filtering and trapping pollutants and sediments from land. The roots of *Rhizophora* were observed to have trapped plastics being carried by River Ayensu, in the Central Region, from land to sea, thereby clearing the ocean ecosystem of these plastic materials and their associated negative impacts. On the contrary, lagoons (e.g. Gao, Korle, and Apam lagoon) with little or no mangrove stands were highly polluted with plastics and silted. Fisheries in these water bodies were assessed to be very low to almost non-existing.

3.3. Mangrove Utilisation in Coastal Communities

The study found that the livelihoods of coastal communities in Ghana depend on mangrove resources in diverse ways. Mangroves are utilized in many ways by coastal dwellers close to the mangrove and its associated resources. Mangroves are considered durable, water-resistant wood, making it the most preferred wood in most coastal communities. In all the study sites, local communities use mangrove trees to build houses and furniture. The wood from mangroves is also utilized in the production of charcoal in some of the study areas. Data from this study suggest that mangroves are preferred fuelwood for smoking fish because of the belief that it gives the fish a unique taste and nice colour while preserving the fish. Fish smoked with mangroves attract higher prices on the market than fish smoked with other wood types. Also, the hardy nature of mangrove trees makes it burn longer than ordinary firewood making them the most preferred heating materials for domestic use. Mangrove leaves have previously been used as tea, leprosy medicine, livestock feed, and a substitute for tobacco for smoking. These practices are, however limited in recent times.

3.4. Threats to Mangroves

From the field observations and interviews, population expansion and its associated demand for land for diverse use have resulted in the degradation of most wetlands and their resources, including mangrove forests. Mangroves in the study area have been overexploited for various economic reasons, including fuel (firewood, charcoal, wood for fish smoking), construction materials (timber and poles), fishing (brush park), industry (salt production) and agriculture farmlands. Mangrove trees are highly exploited, resulting in the degradation of the mangrove forest, leaving most stands in a deplorable state. There has been a reduction in the mangrove cover of Ghana from 137 km^2 in 2006 [20] to its current area of 72.4 km^2, estimated in the present study.

Conversion of mangrove land into other land uses such as agriculture, human settlement and salt production was also a major cause of mangrove degradation identified in the current study. Mangrove habitats in the study area are cleared to obtain land for farming. Wetlands in mangrove areas are filled with sand and in some cases refuse, to create solid grounds for putting up housing facilities.

Mangrove forests are also cleared to make way for salt pans for salt production. What are usually left of the once bio-diverse ecosystems are a few small stunted growing mangroves or the remnants. Using mangroves for construction materials also contributes to the widespread degradation of the resource along the coast. Other minor causes of mangrove degradation included their use for "acadja" fishing and wildfire, which accidentally moved into mangrove forests from nearby farmlands during the traditional slash and burn methods used for clearing farmlands.

The lack of freshwater and tidal flow affects the growth and survival of mangroves. Proper growth and development of mangrove were observed to occur along areas with freshwater run-off and tidal water flushing. The lack of tidal flushing resulted in stagnant water around some mangrove sites, which resulted in the mangrove areas experiencing high pollution. Pollution from anthropogenic sources contributes to the depletion of mangroves, which affects the associated biodiversity. Mangrove habitats in most of the coastal communities visited in this study were used as dumping sites for solid waste and for discharging the effluents from various sources. Most of the lagoons harbouring mangroves were also highly polluted due to open defecation in and around the lagoons. Pollution from illegal mining (locally called "galamsey") also threatens the growth of mangrove stands, particularly in the Western Region of Ghana. Mangroves in such areas experienced stunted growth with small girth size and heights and decreased biodiversity of associated flora and fauna. Grazing by livestock such as goats and sheep was identified as a threat to planted mangrove seedlings in a few communities within the study area. While goats and sheep fed on the leaves, the pigs uprooted the planted seedlings. Crabs (*Uca tangerii* and *Cardiosoma armatum*) also destroy the young seedlings of mangroves by "cutting" them with their claws.

Sediment analysis from the mangrove sites indicated that most mangroves were growing under different sediment types. The sediment characteristics recorded for the various sites ranged from very fine sand (clayey) to coarse sand (sandy). However, the sediment from majority of the sites sampled were clayey (**Table 3**).

4. Discussion

4.1. Mangrove Species and Abundance

Among the eighty-seven mangrove sites visited in the four coastal regions of Ghana, three species of mangrove were recorded, namely white mangrove (*Avicennia germinans*), red mangrove (*Rhizophora racemosa*), and black mangrove (*Laguncularia racemosa*). Contrary to this current study, other research [24] reported that five species of mangroves are found in Ghana- the red mangroves, *Rhizophora racemosa*, *Rhizophora mangel* and *Rhizophora harrisonii*, the white mangroves *Avicennia germinans* and *Laguncularia racemosa.* It is, however possible that the *Rhizophora racemosa*, *Rhizophora mangel* and *Rhizophora harri-*

sonii are the same species with likely variation at the sub-species level. This study, however established that three genera of mangrove are found in Ghana-*Rhiziphora*, *Avincennia*, and *Laguncularia*, *are* similar to what has been reported in previous studies [24]. Other studies [23] also reported six species of mangroves in Ghana, namely *Rhizophora harrisoni*, *Rhizophora racemosa*, *Avicennia germinans*, *Laguncularia racemosa*, *Acrostichum aureum*, and *Conocarpus erectus*. Other studies on mangroves [29] also report *Rhizophora racemosa*, *Rhizophora harrisonii*, *Rhizophora mangle*, *Avicennia germinans*, *Lagunculacia racemosa*, *Conocarpus erectus* and *Acrostichum aureum* as the pure mangrove species in West and Central Africa. While the current study as well as [24] reported *Acrostichum aureum* and *Conocarpus erectus* as mangrove-associated flora (**Table 4**), other authors [23] [29] [30] classified the *Acrostichum aureum* as true mangrove. Further studies on DNA analysis of species will elucidate the "true" mangrove species in Ghana. The presence of higher numbers of *Rhizophora* in the Volta region could be due to the commercial planting of mangroves as a major livelihood for economic benefits and the presence of the Volta River, which presented relatively lower salinities preferred by *Rhizophora* for survival [24].

The area of mangroves recorded in this current study is lower than the 137 km^2 and 100 km^2 respectively reported by [20] and [31] for Ghana, indicating a massive decline in the country's mangrove cover over the years. The current study reports a 47.2% reduction between 2006 and 2014, which translates into 8.1 km^2 reduction in mangrove cover per annum. This observed reduction in mangrove cover of Ghana is because of the high rate of degradation due to overcutting, habitat destruction and habitat conversion, as has also been reported by other authors [29] [32] [33] [34].

The large expanse of mangroves observed in the Volta and Western Regions is due to the presence of relatively healthier lagoons and rivers that provide suitable conditions for the growth of mangroves. Mangroves in Ghana are reported to be concentrated in areas around lagoons on the west coast of the country and bordering the lower reaches and delta of the Volta River [19] [23] [35] [36]. Similarly, [24] reported that the good stands of mangroves in Ghana are located in the Amansuri wetlands (Western Region), the Kakum River (Central Region) and the Volta Delta (Volta Region). The Volta Region having the most extensive area coverage of mangroves is also attributed to the fact that most communities in the Volta region engage in mangrove planting for sale as an income-generating livelihood. For instance, in the Anyanui community of the Volta region, mangroves are cultivated as cash crops and cut after 12 to 15 years for sale. The least area of mangrove coverage recorded in the Central region was a result of overcutting of the resource (for sale, firewood and fish smoking). Although the Western region was also impacted by overcutting, it had the second largest mangrove coverage along the coast due to several non-governmental organisations in the area that had embarked on mangrove restoration in the past several years. Restoration of water bodies, abandoned rice farmlands and degraded mangrove areas by government and non-governmental organisations can potentially increase mangrove forests [37].

The wide range of salinity presented in this study was because of mangroves located along both fresh and brackish water systems, which presented different salinities. Both the varied sediment characteristics and wide range of salinity recorded in this study suggest that the mangroves in Ghana survive under various environmental conditions that could have influenced the trees' sizes and health (growth rate) recorded. Similar studies [38] reported that different mangrove forests thrive under different environmental conditions that influence the productivity and area coverage of the mangrove forest. Physicochemical parameters play critical functions in developing mangrove ecosystems [39]. Salinity has been reported to influence water quality parameters that promote the growth of aquatic flora and fauna in an ecosystem [40]. The variation in salinity could have influenced the distribution of the various species encountered. *Avicennia* predominates in lagoons where salinities can be very high, while *Rhizophora* is usually absent [24].

4.2. Ecological Functions of Mangroves

Mangroves are home to a large variety of animals, including fish, crab, shrimp, and mollusc species [6] [7] [8] [29]. Most fish species encountered in this study were observed to utilise the mangrove forest as nursery grounds for spawning because the mangrove habitats provide a rich source of food and refuge from predation [7] [8] [40] [41]. Mangrove plants provide a significant source of food by producing an average of 3,035 g/m^2 of litter (in the form of bark, leaves, twigs, fruit, flowers, etc.) per year [41]. Some of this litter is directly consumed by small animals like crabs and fishes, while most of it is broken down further before the nutrients are available to other animals or plants. This makes the mangrove a critical food and nutrient source for animals and plants that inhabits the mangrove areas [40] [41]. As important nursery areas for fish species, mangroves are critical for sustaining production in coastal fisheries [2].

Mangroves help maintain water quality and clarity by filtering and trapping pollutants and sediments originating from land, as was observed in this study and also by other authors [10] [42] [43]. Lagoons in the study area, which had little mangrove stands, were highly polluted with plastics and silted. Fisheries in these water bodies were assessed to be very low to almost non-existing. Lagoons contribute significantly to the diversity and status of fish stocks in coastal waters as many marine species spend part of their life cycle in these lagoons [2] [28]. Most lagoons in Ghana that suffer from pollution and environmental degradation have their fishery resources destroyed [28]. The ability of mangroves to filter pollutants from water, therefore, suggests mangroves could help promote fish stocks by improving the habitat quality of the lagoons around which they occur. From a fishery management perspective, this observation is vital and underscores the need for conservation and rehabilitation of mangrove forests to help address the declining fish stocks in the coastal waters of Ghana. The utilization of mangroves areas as nursery habitats by fish species [29] [44] [45] and promoting of the growth and survival of juveniles of some species [46] have been influential in essential management decisions on habitat conservation and restoration of mangroves and other coastal wetlands [47].

4.3. Mangroves Utilisation in Coastal Communities

Mangroves are utilized in many ways by coastal dwellers close to the mangrove and its associated resources. Mangroves are considered durable, water-resistant wood, making them the most preferred wood in most coastal communities. Local communities use mangrove trees in building houses and furniture. The use of mangrove wood for construction has been reported in parts of Africa [29], while the use of mangrove wood as timber is reported in Malaysia [48]. The wood from mangroves has also been utilized in the production of charcoal in some of the study areas. According to research [49], coastal communities highly utilise mangrove trees as the main source of firewood for cooking and smoking fish. Several authors [50] [51], also report on the increased demand for mangroves for charcoal production (fuel) in coastal communities. The mangrove wood is also the most preferred choice for smoking due to its high calorific value, good burning characteristics under wet conditions, which help reduce unnecessary wood processing costs, and time for drying before use [29].

4.4. Threats to Mangroves

Around the globe, several large areas of mangroves have come under severe threat due to diverse human impacts, which have resulted in severe degradation of mangrove ecosystems and their resources [29] [30] [37] [42]. The leading cause of mangrove deforestation in the study areas is over-harvesting for fish smoking and construction, as has also been reported by [37] and [49]. Mangroves have been overexploited for diverse economic reasons including fuel (firewood, charcoal, wood for fish smoking), construction materials (timber and poles), fishing (brush park), industry (salt production) and agriculture farmlands, resulting in their degradation [37] [49]. Similar to the finding of this study, significant amounts of the mangrove cover in west and central Africa is reported to have been lost over the years due to cutting for fish smoking [29]. In Cameroon, the exploitation of mangroves for fish smoking has been identified as a major threat to the mangrove ecosystem [52]. Deforestation is the main cause of mangrove declines in Ghana and accounts for about 70% of the country's mangrove forest loss [33]. This has left most stands in a deplorable state.

There has been a reduction in Ghana's mangrove cover from 137 km^2 reported in 2006 [20] to its current area of 72.4 km^2, estimated in the present study. The loss of 64.6 km^2 over 8 years represents a 47.2% degradation which translates into 8.1 km^2 mangrove area loss per annum. Ghana lost 5.7% of its mangrove vegetation yearly between 2006 and 2014.

Around the globe, mangroves are highly threatened and are being lost at an alarming rate [29] [30] [37] [53], as data from this study also suggests. Cutting mangroves for fuel wood and clearing mangrove forests for other land use have been a source of threats to mangrove habitats [37] [38] [49], as was also observed in this study along the coast of Ghana. Most communities harvest natural stands of mangroves for use as fuelwood or charcoal production, and this has led to the depletion of mangroves in most locations of the study area [49] [54] [55] [56]. In Indonesia, several thousand hectares of mangroves were cleared for timber, fuelwood, tambak, and brackish water ponds [57]. In Madagascar, mangroves' severe destruction is due to cutting for lime production [58].

Conversion of wetlands and mangrove lands was one of the significant causes of mangrove degradation identified in the current study. The mangrove resources have been declining over the years due to anthropogenic pressure resulting in the conversion of mangrove lands [59]. Large mangrove areas in eastern Africa were cleared for urban, agriculture, tourism and freshwater [53]. The conversion of mangrove areas into agricultural lands, salt ponds, and the expansion of towns and villages are major threats to mangroves in Ghana [60]. In Southeast Asia, mangroves are cleared for aquaculture establishments, oil palm plantations and settlements [37]. Conversion of mangrove forests into agricultural land use, shrimp ponds and urban development is reported also to pose a major threat to the resource in Malaysia [48] [60]. Mangrove habitats are cleared to obtain land for farming. Wetlands in mangrove areas are filled with sand and sometimes refuse to create solid grounds for housing facilities. Mangrove forests are also cleared to make way for salt pans for salt production [61]. What are usually left of the once bio-diverse ecosystems are a few small stunted growing mangroves or the remnants.

Population expansion has increased pressure on wetlands resulting in the degradation of wetlands and their associated mangrove resources in the study areas. Ramsar [62] reported that most wetlands are degraded because of increased human pressures resulting in over-exploitation, drainage, conversion, pollution and other conflicting land-use practices. The coastal area of Ghana makes up less than 7% of the national land area, but it is currently occupied by 25% of the approximately 32 million population of Ghana [63] because of migration from inland regions. With this high population occupying the 550 km long coastline, there is increased demand and competition on the area's few resources, resulting in overfishing, poor sanitation, wetland degradation and coastal erosion [32]. In Singapore, the increasing population is an underlying factor for mangrove destruction [16].

Extracting mangroves for construction materials contributes to the widespread degradation of the resource along coastal areas [52]. Lack of freshwater and tidal flow affects the growth and survival of mangroves [64] by reducing the rate at which pollutants are removed from mangrove areas. Proper growth and development of mangrove were observed to occur along areas with freshwater run-off and tidal water flushing probably because these exchange processes also supply nutrients to the mangrove areas through sediment deposition and regulate the area's salinity [45] [65]. The poor flow of tidal and freshwater results in mangrove swamps' high salinity, killing mangroves.

Pollution from anthropogenic sources contributes to the depletion of mangrove forests and affects the overall biodiversity [66] [67] [68]. Pollution from industrial and domestic waste has been reported to be responsible for the mangroves' poor state in Ghana [34], similar to other parts of the world [64]. Mangrove habitats in most coastal communities are used as dumping sites for solid wastes and for discharging the effluents from various sources. Most of the lagoons harbouring mangroves were also highly polluted due to open defecation in and around the lagoons. Pollution from illegal mining in Ghana (locally called "galamsey") threatens the growth of mangrove stands in the Western Region of Ghana, as observed in this study and also by other authors [64] [67]. Mangroves in such areas usually experience stunted growth with small girth size and heights and decreased biodiversity of associated flora and fauna [66] [67].

4.5. Mangrove Conservation

In Ghana, there is also no centralized body or single legislation that addresses issues on the sustainable utilisation of mangroves. This is typical of natural resource conservation around the globe [1]. Though there is the reconstituted Forestry Commission to regulate the utilization of forest resources in Ghana, it appears mangroves were not considered forests in the past and hence received little protection. There is shared responsibility between several government divisions and organizations with local community members who cultivate mangroves for sale and ensure the protection of the resources. Ghana's ratification of the Ramsar Convention led to the designation of five coastal wetlands as Ramsar sites; the Keta lagoon complex, Songor, Sakumo, Densu, and Muni-Pomadze. Most of these wetlands contain mangrove habitats protected by the Ramsar designation. Ghana's National Wetland Strategy ("*Managing Ghana's Wetlands: A National Wetlands Conservation Strategy*") recognizes mangroves as playing a significantly important role in the socio-economic development of coastal communities in which they occur, protecting them as an integral part of the wetland resources.

National laws alone have not been ineffective in protecting mangroves due to the absence of government institutions in most areas to enforce federal laws. Traditional (indigenous) management systems exist in such areas to protect wetlands and mangroves. Most wetlands and their resources (including mangroves) have been protected in the past through varied traditional practices that depend on the belief of the traditional community that claims ownership. These beliefs lead to myths, taboos, folklore, and other practices that protect the species of interest [69]. In Madagascar, taboos against the degradation of sacred forests in the Androy region helped maintain the ecological integrity of the forest [70].

Local communities around the Muni lagoon in Effutu Municipality believed that mangroves could "heal" the lagoon water around which they grow, thereby allowing fish to increase. For this reason, traditional practices, including taboos and customary laws that determine the right to land and resource use, should be set up to protect the mangroves.

Some lagoons in the study area are "worshipped" as deities, and the mangrove stand around the lagoon are not harvested because they are believed to be the property of the water deity. These traditional beliefs have successfully protected mangroves and must be promoted to ensure their continuous existence. In areas where national and traditional regulations exist, the latter has offered a high level of protection for natural resources compared to the former [71]. In recent times, however, this traditional protection has lost its effectiveness. Traditional protection is fading and may disappear over time [72]. The influx of foreign religions like Christianity and the migration of foreigners into areas where these traditional beliefs exist has been a main contributor to the dilution of the traditional beliefs rendering them less effective in ultimately protecting the mangrove resources [71]. There should be active measures to promote these traditional belief systems through oral and written history for posterity to inherit these beliefs and sustain them.

5. Conclusion

Mangroves play diverse ecological and socio-cultural roles. Our study reports three genera of mangrove along the coast of Ghana. Human activities highly impact mangroves due to their multiple uses in coastal communities. The mangrove cover of Ghana experienced a 47.2% reduction between 2006 and 2014, declining at a rate of 8.1 km^2 per annum. Over-cutting is the primary cause of mangrove degradation but habitat destruction, conversion, and pollution also are responsible for the destruction of appreciable mangrove forests. The current conservation laws in Ghana offer inadequate protection due to inflexibility in the face of ever-changing challenges to mangrove forests. The existing laws are not comprehensive and are also not enforced in all coastal communities. Traditional laws protect mangroves in some coastal communities but are fading over time due to the influx of foreign religions and foreigners into coastal areas.

6. Recommendations

We suggest continuous education, law enforcement and active community involvement in protecting mangroves. Developing mangrove areas into tourism and recreational facilities has the potential to protect them from destruction. Using mangroves as nature-based solutions for erosion and climate change adaptation is the way to improve mangrove utilisation.

Authors' Contributions

Francis Kofi Ewusie Nunoo: Funding acquisition, Project conceptualization, Methodology, Field data collection/investigation, Data curation, Formal analysis, Writing (Review and editing)

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Project conceptualization, Methodology, Field data collection/investigation, Data curation, Data analysis, Writing (Original draft, review and editing)

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Ethics Approval

The project did not involve human or animal subjects.

Consent to Participant

Consent of all respondents was sought before undertaking interviews. All interview participants willingly gave their consent to participate in the discussions about the mangroves in their communities.

Consent for Publication

Both authors have read the manuscript and given their consent for the publication of this research material.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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