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University of Palermo
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Full Length Research Paper

Deforestation, biodiversity and biomass losses in Kribi deep sea port area (Cameroon): Some mitigating measures

Ngueguim Jules Romain[1]*, Betti Jean Lagarde[2], Dicka Kwambe Emmanuel[3] Momo Solefack Marie Caroline[4] and Temgoua Lucie Félicité[5]

[1]Institute of Agricultural Research for Development (IRAD), P.o.Box 77 Limbe, Cameroon.
[2]Department of Plant Biology, Faculty of Sciences, University of Douala, BP 24 157 Cameroon.
[3]Institute of Agricultural Research for Development (IRAD). P.o.Box 121 Kribi, Cameroon.
[4]Laboratory of Applied Botany, Department of Plant Biology, Faculty of Science, University of Dschang, P.O. Box: 67 Dschang, Cameroon.
[5]Department of Forestry, FASA, University of Dschang, P.O. Box: 222, Dschang, Cameroon.
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This study is part of the environmental impact assessment realised in the deep sea port area of Kribi. Floristic inventory and diversity assessments were necessary to understand the species composition and diversity status of forests, trees biomass and investigate the potential impact of the project. Floristic analysis shows a high Shannon diversity index (5.3), indicating a rich and diverse flora composed of 83 species, 73 genera and 29 families among which one endanger species (*Diospyros crassiflora*), two lower risk/near threatened species (*Dialium bipendense, Irvingia gabonensis*) and vulnerable species mostly wood with high marketing value (*Afzelia bipindensis, Entandrophragma angolensis, Entandrophragma utile, Khaya ivorensis, Lovoa trichilioïdes, Pterygota macrocarpa*). The mean basal area (28 to 50 m²/ha) reflects the presence of patches of disturbed and non disturbed forest with high frequency of small size trees and few canopy trees with large buttresses. Tree biomass is estimated at 2840 Mg (379 Mg/ha) and carbon stock 189.31 MgC/ha. Ecological impact can be mitigating by a management plan which includes a sustainable choice of urbanization and an emphasis on the protection of biodiversity in the remaining forest especially Campo Ma'an national park known as hot spot of biodiversity and where all the censored species can be found.

Key words: Cameroon-Kribi, deep sea port, deforestation, biomass, mitigating measures.

INTRODUCTION

Biodiversity losses and species extinctions over the next century are expected to be high, driven largely by climate change and land use changes that convert natural vegetation to agricultural and urban uses (Brooks et al., 2002; Dirzo and Raven, 2003). The biodiversity is actually considered as a major driving force behind efforts to reform land management and development practices worldwide and to establish a more harmonious

*Corresponding author. E-mail: njules_romain@hotmail.com. Tel: 00 237 6 77 75 90 62.

relationship between people and nature (Noss and Cooperrider, 1994). The construction of development infrastructures are among human activities that pose the highest threat to the conservation of biodiversity. Such projects represent artificial elements that cut through the landscape and interfere with the natural habitat conditions (Geneletti, 2002). The Kribi deep sea port is the linch pin of vision 2035, the projected year for the socio- economic emergence of Cameroon. The port will be a hub of trade for the entire central African countries and will significantly contribute to the wealth and sustainable development of Cameroon and the sub region. The sea port and the accompanying industrial and urban area will cover 26,000 ha. The residential area is expected to welcome approximately 300,000 inhabitants in 2040. If it is known that the deep sea port will boost the economy of Cameroon, it is also important to note that the project will cause an environmental degradation and the depletion of natural forest. The project needs to be sustainable in economical, social, spatial and environmental sense. Such concerns made evident the necessity for the planning authorities to get information about the possible environmental consequences of development actions. Therefore, Environmental Impact Assessment (EIA) is one of the appropriate tools available to satisfy this need and usually employed during the authorisation process to provide decision-makers with useful information for taking a decision. EIA is now applied worldwide, its potential role in attaining sustainable development objectives was recognised during the Earth Summit held in Rio de Janeiro in 1992 and take into consideration by Cameroonian laws n° 94/01 of 20 January 1994 on forestry, wildlife and fisheries as well as the decree n° 96/12 of August 1996 which recommends for large projects the development of Environmental and Social Impact Assessment (ESIA) to prevent risks and anticipate mitigation solutions. Our interest was to assess floristic diversity and tree biomass and investigate the potential impact of the project on the biodiversity. These informations are usefull to reduce and minimize habitat loss, habitat degradation, and fragmentation and promote landscape linkages which can help to mitigate the effects of the project on species extinctions and biodiversity loss (Von Haaren and Christian, 2011; Roel and Paul, 2013).

MATERIALS AND METHODS

Baseline study

The baseline study consists of the description of the area which will be affected by the project. It requires the collection and the processing of various types of data such as maps, record of floristic and environmental parameters. Some data are obtained from scientific literature and other from field surveys and interpretation of data. These informations serve to set a reference for the subsequent impact analysis. Moreover, it helps decision-makers to become familiar with the environmental features and the needs of the study area (Geneletti, 2002).

Geographic localisation of Kribi deep sea port

The Kribi deep sea port is based in south region of Cameroon, Ocean division and is extend on about 30 km along the coast line from Kribi 1 subdivision to Lolabé 3. The eastern border is the river Lobé which flows in the Ocean close to Kribi. The western border is the coastal line of the Atlantic Ocean. The entire project area is covered with a tropical forest which is part of the biafran rain forest belt (Figure 1).

Aspect of the vegetation in the deep sea port area and nearest forests

The forest consists of evergreen trees forming a fairly continuous canopy with emergent trees. This forest type is characterized by its dominance by Caesalpinioïdeae and Humiriaceae with many species that occur gregariously. Many emergent and canopy trees have large buttress (up to 6 m) and large diameter (greater than 2 to 3 m above buttress). The literature (Gonmadje et al., 2011; Jonkers and Van Leersum, 2000; Ngueguim, 2013; Onana and Cheek, 2011; Tchouto, 2004) indicates that the area has many species of high conservation priorities. The conservation value of the Campo Ma'an national park which is clooser of the site is high at local, national, regional and global levels. The area is recognized to be an important site within the Guineo-Congolian regional centre of endemism. The Campo Ma'an area and nearest forest contain about 2297 species of vascular plants comprise of 114 endemic plant species, 29 species restricted to the area, 29 species occuring just in the south western part of Cameroon such as in the Campo Ma'an national park and Ngovayang's lowland forests. A total of 17 plant species strictly endemic to the area and not found in the park, are threatened since their habitats are fragmented and disturbed as a result of past and present land conversion for people subsistance and industrial plantation (Tchouto, 2004). According to the Red data book of the flowering plants of Cameroon, IUCN global assessments, the south region of Cameroon, among which the Campo Ma'an national park and its surroundings belong to the meso hotspots of 50 to 100 threatened species (IUCN, 2004; Onana and Cheek, 2011). Kribi-Campo is part of the low Guinean forest, and has been recognized as the richness phytochoria endemic and rare plant species in Cameroon (Onana, 2013).

This high endemism and richness may be due to the fact that the site is close (Maley, 1987) or part (Sosef, 1994) of a series of postulated rain forest refuge areas in Central and West Africa. Despite this great biological importance, these forest ecosystems suffered from high human pressure which leads to the degradation of most of the forest along the coast and the lowland forest around settlements. The main conservation effort has been the creation of a technical operational unit (TOU) in August 1999 and one year later, the Campo Ma'an National Park within the TOU.

Tract selection and distribution

Floristic inventory and diversity studies are used to understand the species composition and diversity status of the forests (Phillips et al., 2003). A line transect approach was chosen to sample forest diversity; a total of 19 transects set up over 7.5 ha in the various vegetation types were surveyed. The transect line have 20 m wide and different length (150 to 200 m). All trees with diameter at breast height (dbh) greater than 10 cm were recorded, identified, measured with a diameter tape. Tree species with dbh greater than 10 cm are assumed to reflect the floristic composition and physical structure of the forest. Trees were identified up to species level, and in some cases just up to genus level. For unknown species, voucher specimens were collected for further identifications at the National Herbarium of Cameroon. The measured trees provided

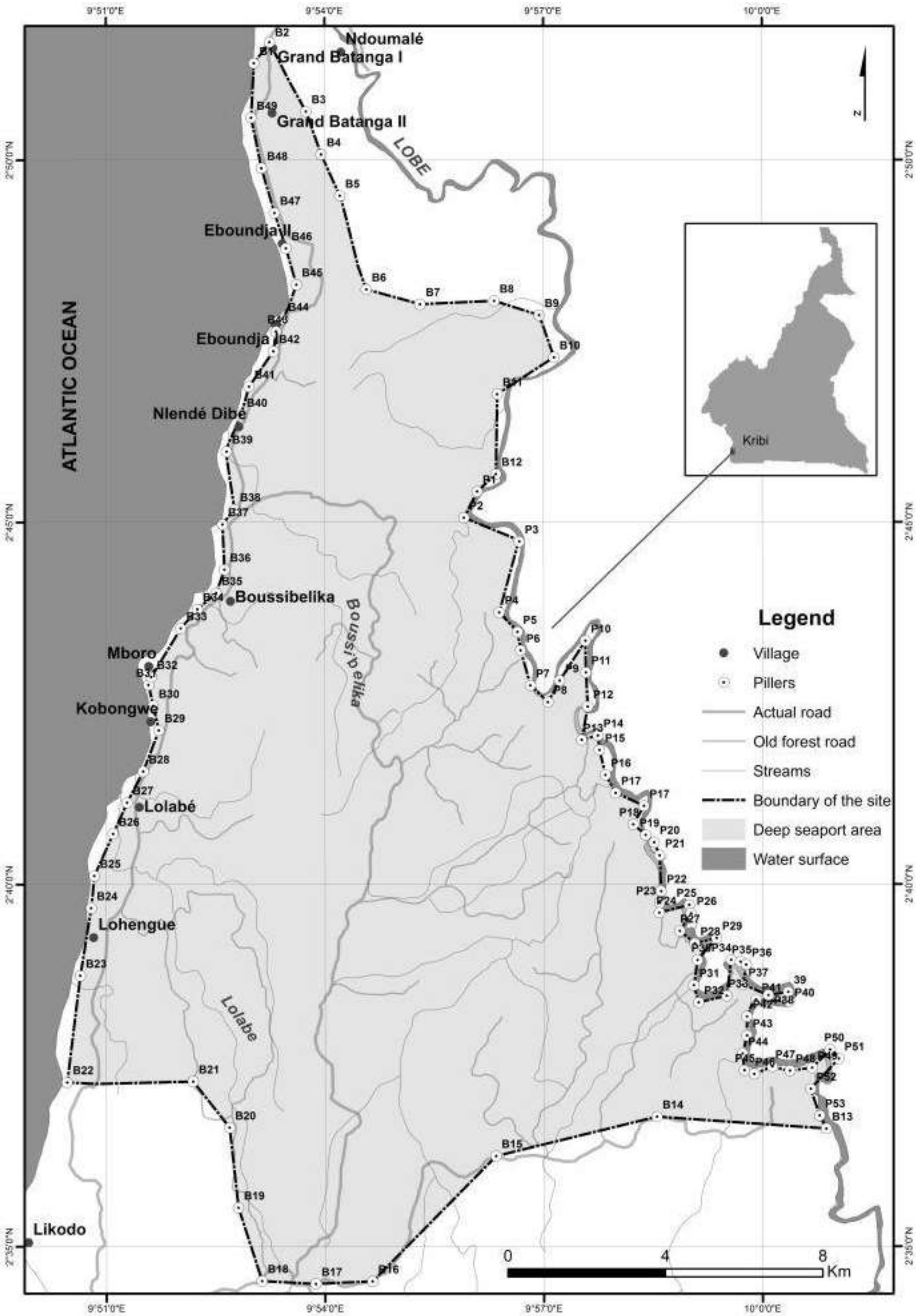

Figure 1. Map of the Kribi deep sea port area.

Table 1. Diversity index of periodically flooded forests (PFF) and terra firm forests (TFF). BA: basal area; N: tree density; RS: species richness; H': Shannon's index.

Types of forests	BA (m²/ha)	N (trees/ha)	RS	H'
Periodically flooded forest (PFF)	8.5	72	43	4.7
Terra firm forest (TFF)	50	453	81	5.3
Total in the KHP forest	28	249	83	5.3

quantitative information on the stand structure and floristic composition of the forest, while qualitative information on species richness was provided by qualitative samples.

Data analysis

Dendrometric parameters

All surveyed data were entered into Excel software. Phytosociological parameters such as basal area, relative density, dominance and frequency, important value index, and Shannon diversity index (H') were used to describe the forest structure and composition, and to measure the species richness and diversity of the various vegetation types.

$$Basal\ area\ = \frac{\sum \P\ \mathrm{D}^2}{4}$$

$$Density\ of\ trees = \frac{\text{Total number of trees}}{\text{area}}$$

$$Relative\ abundance = \frac{\text{Number of individual of the species}}{\text{Total number of individual}}\ \text{x}\ 100$$

$$Relative\ dominance = \frac{\text{Total basal area of species}}{\text{Total basal area of all species}}\ \text{x}\ 100$$

Important value Index (IVI) = Relative abundance + Relative dominance

Shannon diversity index (H') = $\sum p_i \ln p_i$ where $p_i = n_i/N$

where n_i = number of individual of species, N = total number of individuals, and ln = log base$_n$

Biomass estimation

Biomass was estimated using allometric regression models to convert trees diameter measurements from the inventory data to an estimate of Above Ground Biomass (AGB). The moist forest equation delivered by Chave et al. (2005) was used:

$$AGB = \varphi.\ \exp\ [-1.499 + 2.148\ \ln(D) + 0{,}207(\ln(D))^2 - 0{,}0281\ (\ln(D))^3]$$

where D = dbh and φ = wood mass density compiled from the wood density database (http:// worldagroforestry.org/sea /Products/ AFDbases/WD/ Index.htm). In case of the lack of information on the wood density of some species, the average wood mass densitity recorded by Brown (1997) for FAO data concerning tropical Africa species was used (0.58 g/cm^3). The carbon stock was calculated by dividing the AGB values by two.

The species observed from the inventory has been assessed using the IUCN criteria and categories at the global level (IUCN, 2001 ver.3.1). The Hierarchical Ascendant Classification (HAC) will help to constitute floristic groups with different characteristics.

RESULTS

Forest diversity, abundance and guild composition

In total, 1871 trees, shrubs and other vascular plants were recorded, they belonged to 83 species, 73 genus and 29 families. All the records were identified at the species level. Overall, the most diversify and abundant families are Fabaceae (24 species and 23% of the relative abundance, where Caesalpinioïdeae has 17 species (22%)) and Sterculiaceae (6 species, 9%)). The most abundant species are *Uapaca guinensis* Müll.Arg. (10%), *Dialium zenkeri* Harms (7%), *Didelotia africana* Baill., *Diospyros crassiflora* Hiern, *Mammea africana* Sabine, *Coelocaryon preussii* Warb. (5% each), *Gilbertiodendron dewevri* (De Wild.) J. Lénoard., and *Coula edulis* Baill. (4% each).

The mean number of stems/ha for all vascular plants varies from 72 (286 stems) in periodically flooded forest (PFF = 4 ha) to 453 (1585 stems) in terra firms forests (TFF = 3.5 ha). For the entire forest, the tree density is estimated at 1871 trees (249 stems/ha). The mean basal area/ha varies from 8.5 m²/ha in PFF to 50 m²/ha in TFF. In general, the area is characterized by low mean basal area (28 m²/ha) due to the high frequency of small size trees and few canopy trees with large buttresses. The PFF is species poor and less diversify (43 species) than the TFF (81 species). The forest is characterized by a rich and diverse flora as indicated by the value of Shannon diversity index (H') which is relatively high and varied from 4.7 in PFF to 5.3 in the TFF (Table 1).

Table 2 shows dendrometric parameters of the most important species and families. One can notice that *Sacoglottis gabonensis* is the most important specie; its importance is due to the large size of trees (showing by the high value of basal area), while at the second and third rank *D. zenkeri*, *U. guinensis* have many stems composed by small size trees. The most important families are Fabacea followed by Myristicaceae and Humiriaceae. Fabaceae are the most important families in the various vegetation type, the ranks of the other most important species differed among forest type and with the index used (relative stem density or relative basal area). Based on their IVI, *S. gabonensis, D. zenkeri, U.*

Table 2. Summary of the number of trees (N), basal area (BA) and Important Value Index (IVI) of the various type of vegetation for all plants with Dbh ≥ 10 cm recorded.

Espèces	**N**	**BA**	**IVI**
Sacoglottis gabonensis	52	39	21
Dialium Zenkeri	138	18	16
Uapaca guinensis	183	13	16
Coelocaryon preussii	88	11	10
Didelotia africana	102	9	10
Gilbertiodendron dewevri	77	9	9
Pycnanthus angolensis	26	14	8
Diospyros crassiflora	100	4	7
Mammea africa	98	4	7
Coula edulis	67	4	6
Family	**N**	**G**	**IVI**
Fabaceae	425	59	51
Myristicaceae	172	29	23
Humiriaceae	52	39	21
Euphorbiaceae	214	14	18
Irvingiaceae	148	15	15
Sterculiaceae	160	9	13
Clusiaceae	121	6	9
Olacaceae	94	7	8
Ebenaceae	100	4	7
Burseraceae	63	6	6

guinensis and *D. africana* Baill. had the most important contribution in the PFF, while *S. gabonensis, U. guinensis* and *D. zenkeri* were among the most important species in TFF.

Red data taxa of Kribi – Campo area

The 83 recorded species composed of one endanger (EN) species (*D. crassiflora*) with a relative abundance estimated at 5.34% of the tree population; others are vulnerable (VU) species (2.03%) mostly comprising of wood species with high marketing value (*Afzelia bipindensis, Brachystegia kennedyi, Entandrophragma angolensis, Entandrophragma utile, Guarea cedrata, Khaya ivorensis* A. Chev.*, Lophira alata, Lovoa trichilioïdes, Pterygota macrocarpa* K. Schum.*,* and *Scorodophloeus zenkeri* Harms). About 89.47% of the recorded species do not have a particular status of protection. A survey at large scale (14.7 ha) done by Tchouto (2004) in the area indicate the presence of 11 critically endager (CR) species, 8 EN species and 56 VU species.

Multivariate analyses

The Hierarchical Ascendant Classification (HAC) based on tree biological parameters (Diameter, basal area, IVI, density) shows 3 groups. Inside the groups, one can notice the individualization of some plots (Figure 2). Trees are more or less arranged in three strata. In Group 1, we have large emergent and upper canopy tree species (about 30 to 50 m tall) such as *Piptadeniastrum africanum* (Hook.f.) Brenan*, S. gabonensis, P. angolensis,* and *G. dewevri.* The Group 2 is composed of trees of the intermediate storey with about 20 to 30 m high among which *Desbordesia glaucescens* Engl. Tiegl*, Klainedoxa gabonensis* Pierre*, Ongokea gore* (Hua) Pierre*, D. zenkeri* Harms*,* and *K. ivorensis*; while Group 3 represents the understorey with trees with less than 10 m high, discontinuous and consist of immature trees of upper strata and other small trees and shrubs. This group includes species like: *C. preussii, D. crassiflora, Musanga cecropioïdes* and *D. africana*. In general, the sea port forest is an old secondary forest characterised by a poor density of small trees in the undergrowth, high number of large trees and less pioneer species usually found along roads, logging paths and forest gap.

Forest structure and biomass estimation

The diameter distribution pattern of the stems were almost similar among the various types of vegetation and most of the transects were characterized by a high

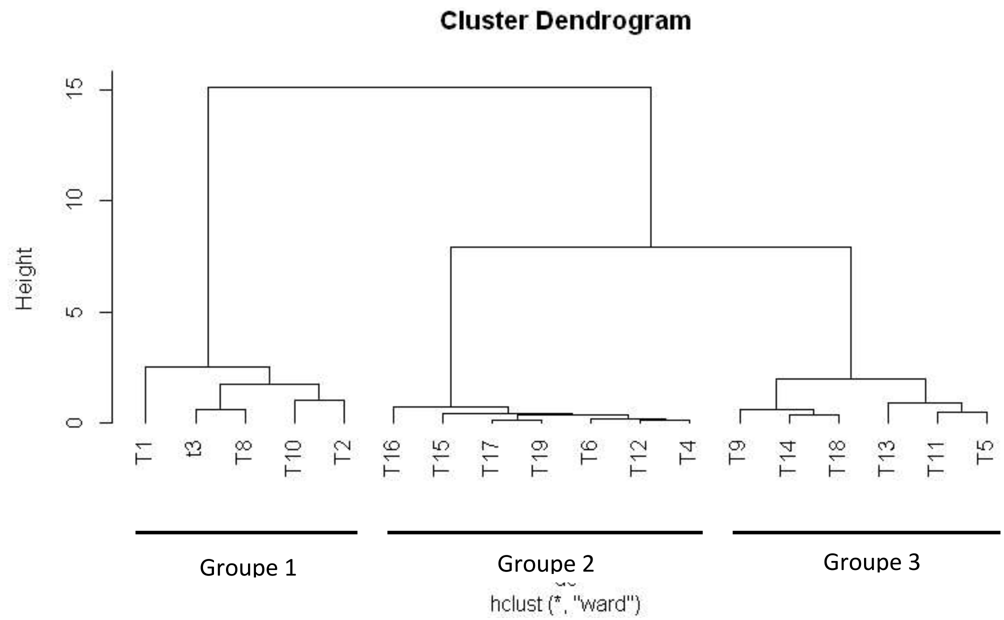

Figure 2. Hierarchical Ascendant Classification (HAC) of 83 species of vascular plants with Dbh greater than 10 cm recorded in 19 transects with different length and 20 cm size, based on tree biological parameters.

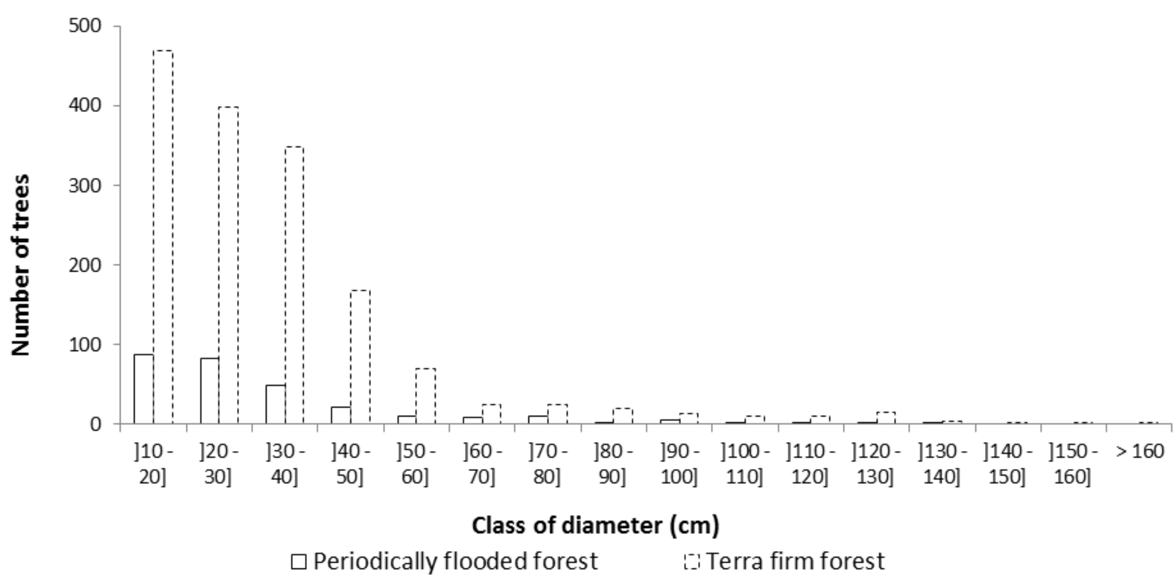

Figure 3. Variation of the density of trees with diameter class (cm) in the different type of forest.

density of stems (10 ≤ Dbh ≤ 30 cm) and a paucity of trees above 50 cm Dbh with a tendancy of large canopy trees in non disturb area especially in the hill and swamps (Figure 3). The stems are more abundant in terra firm forest in all the size class. The high number of trees in the first diameter class indicates a vigorous regeneration, while the presence of large trees with high diameter value shows that we are in an old forest. The sea port forest is constituted by patches of disturbed and non disturbed forest.

The total biomass estimate for the forest is 2840 Mg equivalent to 379 Mg/ha. These values varied significantly between the types of forest, respectively estimated at 117 Mg/ha for PFF and 677 Mg/ha in TFF. Most Above Ground Biomass (AGB) was found in trees with large diameters in the two types of forest. Individuals

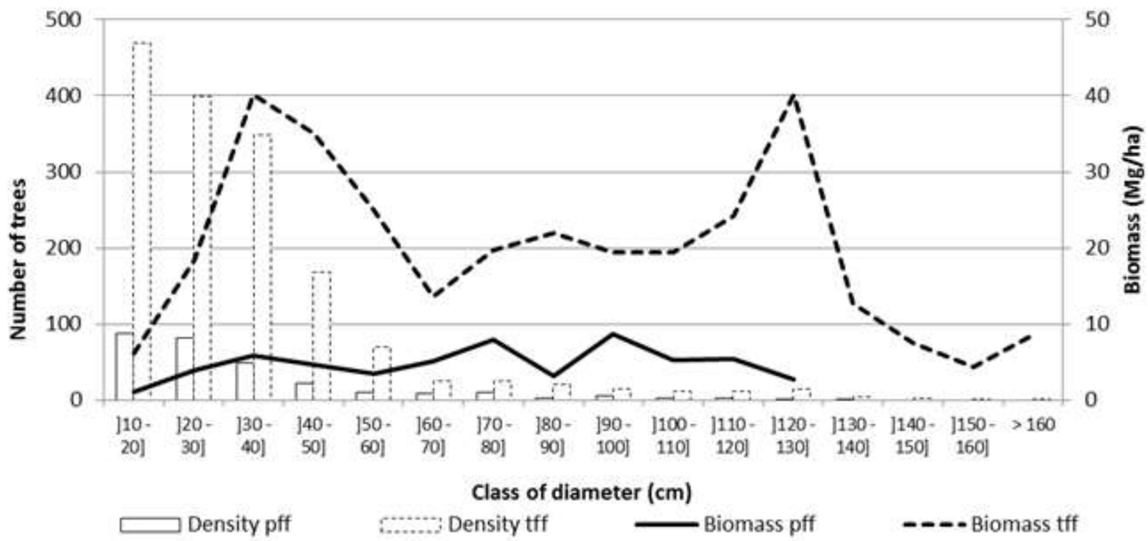

Figure 4. Variation of density and biomass depending on diameter classes in the different types of forests.

Table 3. Ten top species with the highest value of Above Ground Biomass in the deep sea port forest.

Species	N	Mean diameter (cm)	Standard deviation (cm)	AGB (Mg/ha)	AGB (%)
Sacoglottis gabonensis	52	91.92	32	87.86	23.20
Pycnanthus angolensis	26	76.35	36	32.14	8.49
Dialium Zenkeri	138	35.17	20	31.10	8.22
Coelocaryon preussii	88	36.36	18	19.27	5.09
Uapaca guinensis	183	26.91	12	18.35	4.85
Gilbertiodendron dewevri	77	33.44	21	16.68	4.40
Didelotia africana	102	28.57	17	14.64	3.87
Piptadeniastrum africanum	4	90.75	97	11.70	3.09
Klainedoxa gabonensis	21	52.64	26	11.24	2.97
Pachyelasma tessmanii	9	59.44	41	7.76	2.05
Total	700	53.16	32	250.73	66.22

with diameter greater than 50 cm accounted for 76% of the biomass in PFF and 68% in TFF. Variation in the abundance of trees with large diameter was the main reason for these differences (Figure 4).

Tree biomass allocation by different families and species

Few dominant species made the greatest contribution to the AGB. The top five species with the most important AGB contributed, in the entire site for 53.85% of the total biomass, with mean diameter of the stems of the group estimated at 53.34 ± 23.60 cm and a total stems 487 individuals which represent 26% of the trees population (Table 3).

The top five families contributed to 78.25% of the total biomass, with mean diameter of the stems of the group estimated at 46.24 ± 26 cm and a total stems 1011 individuals which represent respectively 54% of the trees population. The most important family according to their AGB are Fabaceae (28.42% where Caesalpiniaceae represent 24%) and Humiriaceae (23.18%) (Table 4).

DISCUSSION

Comparison of the floristic richness of Kribi deep sea port forest with other tropical forest

This study shows that the deep sea port area has a rich and diverse forest, rich in Caesalpinioïdeae, mixed

Table 4. Ten top families with the highest value of Above Ground Biomass in the deep sea port forest.

Species	N	Mean diameter (cm)	Standard deviation (cm)	AGB (Mg/ha)	AGB (%)
Fabaceae	425	44.93	40.43	107.72	28.42
Humiriaceae	52	91.92	32.24	87.86	23.18
Myristicaceae	172	37.68	26.62	55.59	14.67
Irvingiaceae	148	30.34	18.33	24.76	6.53
Euphorbiaceae	214	26.35	12.19	20.64	5.45
Sterculiaceae	160	24.91	10.36	12.59	3.32
Rubiaceae	56	30.93	19.53	10.15	2.68
Olacaceae	94	27.87	11.37	9.66	2.55
Clusiaceae	121	21.32	13.22	8.86	2.34
Burseraceae	63	32.55	11.04	8.83	2.33
Total	1505	36.88	19.53	346.66	91.47

evergreen and semi deciduous forest, periodically flooded, swamp forest, riparian vegetation, and secondary forest. Considering the Important Value Index (IVI), Caesalpinioïdeae was the dominant subfamily while *S. gabonensis* was the dominant species. The species of Caesalpinioïdeae subfamily were codominant and their abundance varied with the type of vegetation. Some of them were gregarious with a high regeneration capacity and many juvenile trees.

The specific richness of the forest is also important like those observed in other tropical forest as indicated by the low value of the report number of species over number of genus (E/G) and the high value of Shannon diversity index (H'). The high value of H' corresponds to the good condition of the environment which favours regeneration of many species which composed of few numbers of individuals. This tendances of high diversity associated to low density of each species is always observed in tropical forest (Swaine et al., 1988; Peters, 1997). The site has a low basal area (28 to 50 m²/ha) like that of some disturbed forest of southern Cameroon (Ngovayang's lowland forest: 29 to 42 m²/ha) compared to that of less disturbed forest such as Campo Ma'an national park (87 m²/ha) and Bawangling a Chinese natural reserve (54 m²/ha) (Table 5).

Impact assessment: Forest clearing and their influences on rural community survival, biodiversity conservation and environment

Habitat lossess

The clear cutting of the forest in the project area has many impacts such as the direct loss of ecosystems and the fragmentation of ecosystems. The project affected the floristic composition notably species density, abundance, distribution and their ecological importance. Disturbance of wet habitats like swamps can also contribute to loss of wetland biodiversity. In the context of disturbance and deforestation, species with low dispersal capability will be the first one affected. In case low dispersal, capability is combined with low possibility to survive during critical periods, the extinction risk increases. Various researches indicated that the probability of extinction increases dramatically when less than 10 to 30% of the original habitat area remains (Andrén, 1994). This is not the case for the censured species which can be found in the Campo Ma'an national park and in various other area of cameroonian dense humi forest where the beneficiate for a suitable and protected habitats (Raulund et al., 2011).

Long term disturbance

The kribi deep sea port area is mostly composed of people that rely on the sea and forest for their livelihood and have fishing and forest product gatherers as their main occupation. The clearing of the forest will seriously affect their life. The project will quickly contribute to increase the density of the population. Some people will be employed in the port and accompanying industries, others will be obliged to develop private activities to meet up with their basic needs. This can have some ecological impacts on the environment.

Deforestation due to agriculture practices/agro industries

Clearing of the natural vegetation to provide land for industries and agroindustries, subsistance agriculture and the port infrastructures are the biggest threats to the forest. Few years ago, large scale agro-industrial plantations destroyed about 7.5% of the forest covered in this area, this rate will significantly increase in the future. An analysis of Onana and Cheek (2011) in anonymous (2014:5) indicates that one of the main causes of the impoverishment of biological diversity for the threatened species is due to the degradation of the habitat which

Table 5. Comparison of tree density, specific richness, generic richness, specific quotient (E/G), Shannon diversity index and basal area of deep sea port forest to that of some tropical forests [1. Ngueguim (2013); 2. Sonké (2004); 3. Djuikouo et al. (2010); 4. Tchouto (2004); 5. Gonmadje et al. (2011); 6. Nshimba (2008); 7. Ukizintambara et al. (2007); 8. Scotto Di Vettimo (2010); 9. Naing et al. (2011)].

Sites	Code	Stations forestières	Density	Species	Genera	Species/Genus	H'	Basal area
Cameroun		Deep sea port forest	249	83	73	1.14	4.7 - 5.3	28
	1	Mangombé	708	91	78	1.16	5.52	49
	1	Bidou	538	88	80	1.10	5.41	54
	1	Campo	569	75	68	1.10	5.40	87
	2	Reserve de biosphère du Dja	352 - 460.4	281 - 372	215	1.44	5.62	29 - 37.5
	3	Parc National de Campo *		1116	421	2.65	/	58 - 89
	4	Ngovayang's lowland forests (South Cameroon)	532 ± 75	293	170	1.72	4.12	29 - 42
	5	Ile Mbiye, RDC*	-	470	297	1.58	/	
	6	Gabon - Lopé	742 - 932	251	/	/	/	19.5 - 58
Asie	7	Chine, natural reserve of Bawangling	755 ± 170	305	134	2.3	4.75	54
	8	Parc de Popa, Myanmar (Asie du sud Est)	604 ± 39	38 - 68	32 - 54	0.84 - 0.79	/	17 - 38

contributes for 76.6% of the decline of population according to the generations. When a species has a very low number of known individuals and is confined in a small number of localities, the rate of losses is estimate at 8.8% of the population through a generation (Anonymous, 2014). Slash and burn agriculture mostly practices in the area represents one of the major causes of degradation and deforestation around settlements since it involves land conversion from forest to permanent agricultural land, reducing the soil fertility and the natural vegetation covered. These practices can potentially eliminate or severely deplete the population of any localized endemic or threatened species of herb, shrups, liana or small tree. The presence of such important species might be unknown by the farmers (Onana and Cheek, 2011).

Legal and illegal logging

Timber exploitation is one of the main economic activities in the area. Logging concession represents about 31.4% of the area. The main wood species with high marketing value observed during the survey is estimated at 19 species, equivalent to 16.30% of the tree population. Tchouto (2004) estimated about 112 wood species in the Campo-Kribi area among which only 60 are exploited. According to the literature, the coastal zone has been selectively logged at least twice during the past 50 years. Less than one tree/ha is felled and logging is limited to about 60 trees species (Jonkers and Van Leersum, 2000). Any degree of damage represents a capital loss in terms of trees and deterioration of the biotic and physical environment. Logging creates skid trails that allow easy access for poachers and encourage settlers to establish forest camps, villages and farms. Furthermore, logging damage includes breakage of samplings and residual sterms and hinders the growth of seedlings by discarded crowns of felled trees (Parren, 2003).

The specific composition of the forest shows that the vegetation is actually strongly influenced by human activities. The presence of secondary species like *L. alata* and *Pycnanthus angolensis* characterize mature secondary forest. It is also important to notice that the replacement of forest in the coastal area of Cameroon into land use types began centuries ago, and results in the degradation of vegetation (Maley, 2002; Oslisly, 2001). Archeological exploration shows the presence of village along the coast in Lolabé (village in the port area) dated 3000 to 2500 BP (Ossa Mvondo, 1998) indicating that coastal forest may have undergone some changes in the past.

Non timber forest product (NTFP)

Southern forest offers about 250 Non Timber Forests Products (NTFPs), these forest products form an integral part of the rural economy and contributes to all aspects of rural life, providing food, fuel, employment, building materials,

Table 6. Comparison of the biomass and carbon uptake of the Kribi deep sea port with those of some tropical forests. [1. Kira (1971); 2. Chave et al. (2001); 3. Djuikouo et al. (2010); 4. Mugnier et al. (2009); 5. Zapfack et al. (2013); 6. Ngueguim (2013)].

No.	Sites	Biomass (Mg/ha)	Carbon (MgC/ha)
	Deep sea port forest	378.62	189.31
1	Tropical forests	148 - 669	74 - 334.5
2	French Guiana (Nouragues)	309	154.5
	French Guiana (Piste de Saint-Elie)	260	130
3	Dja Biosphere Reserve (Cameroon)	383.14 - 596.1	191.57 - 298
4	Congo Basin	324 - 300	162 - 150
5	Primary forest Lobeké national park Cameroon	247.52 ± 68.64	123.76 ± 34.32
	Secondary forest Lobeké national park Cameroon	237.20 ± 73.24	118.60 ± 36.62
	Bidou (10 km from port, south Cameroon)	738	369
6	Campo Ma’an national park (south Cameroon)	1277	638.5
	Mangombe (littoral region of Cameroon)	611	305.5

medecine, craft material, household items, ornamental and horticultural plants. The harvesting of NTFP is mostly done in the area for local consumption, but very few of the local people rely on it as source of income. So far, the gathering of NTFPs has little effect on the forest ecosystems and the biodiversity.

A total of 19 species known as NTFPs were recorded, they are estimated at 22.66% of the total number of stems. The most abundant are *Mammea africana, Irvingia gabonensis, C. edulis* and *Cola acuminata*. In the Kribi - Campo area, Tchouto (2004) indicate the presence of 249 species of NTFPs. The clear cutting of the forest can reduce the stock of some species like *Enantia chloranta*, the bark is harvested and used to cure malaria and fever. *C. edulis*, the fruits are consumed or sold in the local market. *Pausinystalia johimbe* the bark is used to perform genital organs while the fruit of *I. gabonensis* are eaten as spices, the marketing chain of this species extend to Gabon, Nigeria and some Europeans country (France, Italia, Germany).

Losses of forest biomass and carbon uptake

A precise knowledge of the biomass is crucial for harvesting assessments (Vanclay, 1995) and, at a much larger scale, for the study of greenhouse warming scenarios (Houghton et al., 2000). Atmospheric carbon uptake by the vegetation is believed to play a major role in the global climate changes of the century to come. An estimated 37% of the world’s living terrestrial carbon pool is stored in tropical forests. Table 6 indicates that the value of biomass (378.62 Mg/ha) and carbon stock (189.31 MgC/ha) in the deep sea port forest is higher than that obtained in some tropical forests such as French Guiana where the trees biomass is estimated at 260 to 309 Mg/ha and the carbon uptake (130 to 154.5 MgC/ha) and lower than the value observed in Bidou (site distance from 10 km of the port) (738 Mg/ha biomass and 369 MgC/ha).

How to attenuate and mitigate some potential impacts of the deep sea port project?

The proposed solutions to attenuate and mitigate impacts of the project follow some of the five approaches recommended by George (2000). They will come together to reduce, restore and compensate impacts of the project such as to the following.

Improve ecological sustainable agriculture

Shifting cultivation is among the most destructive uses of the forest since it involves large amount of land conversion from natural forest to farms and fallow. In order to prevent further encroachment into the remaining lowland and coastal forests, farmers need to intensify their agriculture production systems. Crop production need to be increased in the existing agricultural land to feed the growing population. This need the professionalization of agriculture for food supply, to modernize agriculture practices through an adequate training of farmers on nursing, planting, maintenance, harvesting, storage, and marketing techniques in order to stabilized farms, stopped shifting cultivation and improve food production.

Implication for biodiversity conservation

The survey indicates that all the recorded species are present in the Campo Ma’an National Park (not far from the project area), where they benefit from an integral protection. In a short term, the population density in the area will considerably increase, and this will represent a serious threat for the ressource in the park. In such a situation the measures taken to protect the park, needs to be reinforce.

The rate of forest degradation is likely to accelerate in the near future, as the present trends in the land use patterns of exploitation will persist. Conservation needs are exceptionally urgent in Kribi, Campo area since plant species of great scientific interest are under severe threat. There is an urgent need for the developement of a separate management plan strategy in order to ensure the protection of the biodiversity hotspot and their endemic species. For example we can encourage other forms of land use such as community and communal forest recognized by Cameroonian forest law and compatible with the conservation of biodiversity, since their management is not only focused on nature conservation but also takes into consideration community interests. In each of these forms of forest, the beneficiary most identify biodiversity hotspot as the core conservation area surrounded by a buffer zone in which the sustainable management of non timber forest products and hunting are developed. Nowadays, as the forest loss increase, a careful sustainable land use strategy in the buffer zone surrounding the national park of Campo Ma'an and other identified core biodiversity hotspots is neccesary for their long term survival and the protection of the species of high conservation priority.

Conservation and environmental education

The biodiversity conservation is a new concept that needs to be mastered and understood by the local communities. This mis-understanding usually results to permanent conflict between conservation initiatives and the needs of the stakeholders (communities, logging industries, agro-industries). This necessites the reinforcement of environmental education progams in the area at all levels within different target groups such as traditional leaders, elite, farmers, timber exploiters, agroindustrials, and local administive authorities.

Afforestation and recreational value

The project will need a best and sustainable choice of urbanization of the Kribi-Campo area and implementation of urban forestry which will consist of plant trees and install garden and green space in some appropriate points of the town. The uses of teledetection and high-resolution satellite image can help to survey along the years evolution of landscape and vegetation around the project area.

Conclusion

The sea port forest is constituted by patches of disturbed and non disturbed forest. The disturbed area is reduce and generally covered with pioneer vegetation and has a low conservation value while the patches of natural forest have been weakly disturbed. However, the disturbed forest still has some ecological value. There are several habitat types, the most common are: riverine forest, swamp forest, few Raphia forest, old and mature forest. The evaluation of conservation potential of the 83 recorded species shows one endemic species (*Dialium bipendense* Harms), one endanger species (*D. crassiflora*) and 10 vulnerable species (2.03%) most composed of wood species (*A. bipindensis, B. kennedyi, E. angolensis, E. utile, G. cedrata, K. ivorensis, L. alata, Lovoa trichilioides, P. macrocarpa,* and *S. zenkeri*). A large majority of plant species identified within the project are used as food, medicine and construction materials. All the recorded plant species can be found in the Campo Ma'an National Park where they benefit from protection according to Cameroonian forest law. Few dominant species made the greatest contribution to the AGB in the studied forest.

Installation of the port and the accompanying industries will lead to the clearing of many hectares of forest and losses of biodiversity and their socioeconomic and ecologic services. Associated to this, the increasing number of inhabitants within a short term in this area will also contribute to disturb the remaining forest for subsistence and economic activities such as illegal logging, shifting agriculture, and urbanization. To mitigate the environmental impacts it would be better to: (i) create a sustainable choice of urbanization of the Kribi Campo area; (ii) manage the entire coastal zone; (iii) improve ecological sustainable agriculture; (iv) reinforce the protection and management of the Campo Ma'an national park and the buffer zone, (v) promote the conservation and environmental education and (vi) develop urban forestry.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Managing mangroves for coastal ecosystems change: A decade and beyond of conservation experiences and lessons for and from west-central Africa

Zebedee N. Feka[1]* and Isaac Morrison[2]

[1]Coastal Resilience and Adaptation Specialist, West Africa Biodiversity and Climate Change Project. Freetown, Sierra Leone.
[2]Evaluation Specialist Management System International, 200 12th Street South, Suite 1200 Arlington, VA 22202 USA.

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Unsustainable human activities and climate change are threatening the sustainability of coastal ecosystems in countries of West-Central Africa. This paper advocates that focusing on mangrove ecosystem management can potentially mitigate these threats by pointing out clues on management orientations and opportunities for other coastal systems. This article elucidates this point by using evidence from informal interviews with stakeholders and expert-led literature reviews to assess mangrove conservation interventions implemented between 2000 and 2014 across countries of West Africa and Cameroon. Results show that many institutions are taking actions in countries of West Africa and Cameroon to conserve and restore mangroves. These interventions may be slowing down the rate of mangrove forest loss across West-Central Africa. However, this recovery does not appear to be benefiting other coastal ecosystems. This unequal distribution may be linked to the increasing challenges plaguing coastal ecosystems management, and hence the effectiveness of mangrove conservation efforts in this region. These problems are both internal and external to institutions, undertaking targeted interventions. External challenges are beyond the control of implementing organizations and synergize with internal institutional deficiencies to impede overall coastal ecosystem sustainability. Improving overall coastal ecosystems sustainability in this region will, therefore, require a coordinated approach between all stakeholders that are directly or indirectly influencing coastal ecosystems. In this regard, practitioners need to improve the effectiveness of traditional conservation practices, expand conservation efforts and funding mechanisms as well as develop integrated strategies that encompass all activities that affect coastal ecosystems, in a vertical and horizontal manner.

Key words: Mangroves, coastal ecosystems, conservation effort, conservation challenges, ecosystem services.

INTRODUCTION

A coastal ecosystem is a collection of habitats often located along the continental margins of the world. They include; coastal forests, coral reefs, estuaries, lagoons, marine-water, salt marshes, sandy beaches, rocky shores, and mangrove forests amongst others. Environmental variables and geographic location determine the global distribution of coastal ecosystems habitat types. For instance, mangroves are limited to the tropical and sub-tropical regions of the world (Spalding et al., 2010). Coastal ecosystems are among the most productive globally, and their values have been extensively studied (Spalding et al., 2010; Baba et al., 2013; UNEP, 2014). Across some coastal countries of West Africa (Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Benin, Nigeria) and Central Africa (Cameroon), coastal ecosystems have been assessed to provide a broad range of socio-economic and ecological services to various stakeholders (UNEP, 2007; Nwilo and Badejo, 2005; UEMOA and IUCN, 2010; Diop et al., 2014). However, poor policies and open management practices by stakeholders within these coastal ecosystems are promoting their degradation and depletion (Diop et al., 2006; FAO, 2007; Feka et al., 2009; Feka and Ajonina, 2011).

These transformations threaten and risk the very existence of these ecosystems and the livelihood strategies of millions of vulnerable coastal communities; who depend on them for subsistence and posterity (UNEP, 2007; Nwilo and Badejo, 2005; IUCN and UEMOA, 2010; Diop et al., 2014). Moreover, the effects of these ecosystem transformations are compounded by climate change, suggesting far-reaching socio-economic and ecological consequences in countries of West Africa and Cameroon (Abe et al., 2002; de Lacerda, 2002; Ellison and Jouah, 2012; Munji et al., 2013). Against these threats and risks to both the environment and the proximate human communities, it is imperative to identify and promote conservation solutions that can adequately address these issues, without compromising a sustainable supply of ecosystem services to humankind.

Various biodiversity conservation strategies have been developed to support the sustainability of coastal ecosystems with mixed results (FAO, 1994; McClanahan et al., 2005; Diop et al., 2006; McClennen and Marshall, 2009). Amongst these is the use of the ecosystems-based conservation approach, which is gaining wide acceptance in global political agendas as a sustainable option with various co-benefits and which can be used to reduce pressures resulting from both anthropogenic activities and climate change (CBD, 2009; Munang et al., 2013). This strategy is particularly relevant to most developing countries because they lack the capacities and technologies for more intensive approaches to climate change mitigation (IPCC, 2007). Land Use and Land Use Change and Forests (LULUCF), [of which mangrove forests are a subset] is one of the cheapest climate change adaptation and mitigation options (Stern, 2006). The conservation of mangroves and their constituent habitats is already being employed to address climate change and anthropogenic pressures across East Africa, Madagascar and South-East Asia (Fischborn and Herr, 2015; Wylie et al., 2016). Although this research is still in the preliminary stages, focusing on mangrove management to guide the overall sustainability of coastal ecosystems would be widely beneficial, because of the connecting, provisioning, supporting and regulatory services mangrove ecosystems provide to other coastal habitats, their biodiversity, and vulnerable human communities.

Therefore, careful management of mangrove forests may be beneficial by to the broader coastal ecosystem landscape by providing clues on management orientations and opportunities for intervention (Blasco et al., 1996; UNEP, 2014; Alongi, 2014; Ellison, 2015). Evidence of this guiding role is shown by the increasing number of studies that correlate the state of mangrove health to the well-being of other coastal habitats and biodiversity. This role is further seen, for instance, in the link between mangrove forest degradation and drop-offs in fish and crustacean productivity. The dieback of mangrove trees is tied to changing water nutrient and temperature levels, while the alteration of mangrove zonation patterns influences species composition. In addition, mangrove forest depletion exposes the coastline and hence exposure to erosion (Blasco et al., 1996; McClennen and Marshall, 2009; Brenon et al., 2004; Adite et al., 2013; Das and Crépin, 2013; Hutchison et al., 2014; Worm et al., 2006; Hutchison et al., 2014; Ellison, 2015). These linkages imply that any significant changes in the state, health, population structure, species composition, location and chemistry of the mangrove ecosystems could serve as important bio-indicators of changes to other coastal habitat variables.

The management of mangrove ecosystems has been marginalised in political agendas across Africa and many other developing regions of the world for a very long time (CEC, 1992; Van Lavieren, 2012; Feka, 2015). However, the last two decades have seen a worldwide proliferation of mangrove conservation initiatives in coastal West Africa and Cameroon (USAID, 2014). Increasing interest in mangrove conservation is fuelled by improved scientific understanding of the ecological and climatic services, coupled with the socio-economic values of the goods and services derived from this ecosystem (Macintosh and Ashton, 2002; Adekanmbi and Ogundipe, 2009; Ajonina, 2010; Diop et al., 2014; Osemwegie et al., 2016). Despite these values, mangroves remain the most vulnerable tropical ecosystem globally (Spalding et al., 2010). These recognized values and threats are prompting growing international commitments to manage and sustain mangrove forests (Alongi, 2008; Van Lavieren et al.,

*Corresponding author. E-mail: feka_nz@mespom.eu.

2012; UNEP, 2014; IUCN-MSG, 2014).

As is the case with most tropical ecosystems, the sustainable management of mangroves in countries of West-Central Africa is constrained by the lack of funding, scarcity of adequate data to facilitate informed decision-making, and restrictively short project financing time-frames in which to design and implement feasible solutions (BSP, 1993; FAO, 2007). These factors are at the center of failures in conservation initiatives in most developing countries, particularly because they undermine stakeholder expectations and promote poor conceptualisation of issues. Lack of funding and data may lead to inadequate or wrong mangroves and coastal ecosystem management strategies (FAO, 1994; Feka, 2015). Therefore, it is imperative that governments, national institutions, and international aid agencies with interest in the development of coastal ecosystems across West Africa and Cameroon learn from previous mangrove conservation initiatives experience which will support the scaling-up or implementation of new coastal ecosystem conservation interventions (USAID, 2014). Region-specific data is scarce for this region (Armah et al., 1997; Kjerfve et al., 1997; Diop et al., 2006). Additionally, when available, this knowledge will help guide funding and aid agencies to the most productive and sustainable investment options and will inform and improve prospective implementation strategies by orienting efficient use of resources for effective results. Extensive research and knowledge sharing on coastal and mangrove ecosystem in East Africa and South East Asia has led to the development of strategic management plans for mangroves and other coastal systems (FAO, 1985; Chan and Baba, 2009; Spalding et al., 2010; Van Lavieren et al., 2012; Fischborn and Herr, 2015; Wylie et al., 2016). This research concentration and the knowledge-sharing environment has also produced some of the most highly regarded experts in mangrove and coastal ecosystem management. The availability of extensive information/data and knowledgeable specialists is attractive to long-term investors supporting conservation of coastal ecosystems across South-East Asia and East Africa. Consequently, these regions have already seen a reversal in mangrove forest loss (Aung et al., 2013; Giri et al., 2014).

Unfortunately, current regional information/data from previous mangrove conservation initiatives in countries of West Africa and Cameroon is dispersed, scarce or not readily available to support planning for mangrove and coastal ecosystem management. Even when available, such information is incomplete, fragmented or exists just as an account of independent research initiatives rather than a strategic regional perspective (Kjerfve et al., 1997; Diop et al., 2014). This study thus aims to promote the sustainable management of coastal ecosystems, by presenting the experiences and challenges of implementing mangrove conservation interventions in some of the coastal countries of West Africa and Cameroon between 2000 and 2014. Specifically, to (i) assess mangrove related research and progress towards the development of a legal framework for mangrove ecosystems management, (ii) determine intervention(s) implemented between 2000 and 2014 to highlight lessons, and (iii) examine how externalities are collectively challenging coastal ecosystem conservation efforts across countries of West Africa and Cameroon. The results of this study will radically re-shape the way coastal ecosystem interventions should be designed in the future. It will be a valuable resource to international development agencies, government and national organisations seeking to invest in the management of coastal ecosystems of West Africa and Cameroon. Project managers and researchers will benefit from the lessons learned, and the extensive bibliography on mangroves and coastal ecosystems of the region as documented in this study.

METHODS

Study areas

The study was carried out from February 2014 to February 2016. It focused on coastal ecosystems, with an emphasis on mangrove forests. Study sites were selected using the following criteria: (1) Biological significance, such as harbouring regionally or nationally important biodiversity or essential nesting or spawning grounds; (ii) Potential to sequester significant amounts of carbon with improved management, and (iii) Inclusion in national or regional adaptation plans as an area where human populations will feel great stress from climate change. Shortlisted countries included; Senegal, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Benin Nigeria and Cameroon (Figure 1). Cameroon was included because of the region's extensive experience in mangrove ecosystem research and management.

The morphology of the coastline of the selected countries, and the different ocean currents, which influence continental fisheries, are widely reported (Kelleher et al., 1995; UNEP, 1999; Feka, 2007). Along with this coastal margin, several rivers drain from the hinterland into the Atlantic Ocean along this West African and Cameroon coastline, creating suitable conditions for the development of about 19,581.0 km^2 of mangrove vegetation dispersed over 4710.0 km across these countries (FAO, 2007). The mangroves establish along creeks, bays, estuaries, and major rivers towards the hinterland. The established mangrove vegetation is complex in structure, with trees generally decreasing in size as the salinity increases from Cameroon (low mean salinity of [16%] and high main rainfall [4000 mm $year^{-1}$] levels), towards Senegal's high mean salinity of 26% and low mean annual rainfall of 1800 mm (Godstime et al., 2013; Tening et al., 2014; Sakho et al., 2015). Established mangroves are cumulatively made up of nine re[1] Mangrove tree species across countries of the region, with no significant variation in species numbers between countries (UNEP, 2007; FAO, 2007; Essomè-Koum et al., 2012). These mangroves establish on sheltered sedimentary coastlines, with soft muddy substrates, under anaerobic conditions. These muddy soils are formed from continuous interaction between the processes of sedimentation and erosion along this coast (UNEP, 1999; Diop et al., 2014). The growth and development of mangrove plants is influenced by large masses of warm water (above 24°C) and a

[1] Tomlinson (1986) categorises mangroves into three groups, namely; true, minor, and mangrove associates.

Figure 1. Map of countries of study showing mangrove distribution.

generally low average salinity (less than 35‰) because of high levels of precipitation and freshwater from numerous rivers that discharge into the Atlantic Coast also contribute to the flourishing of mangroves in this region (Tening et al., 2014).

Ecological characteristics at this environmental edge of West Africa and Cameroon, create favourable environmental conditions for various resident, migratory and endemic species. For instance, the West African manatee (*Trichechus senegalensis*), the globally endangered pygmy hippopotamus (*Choeropsis liberiensis*) found in the coastal forests of Liberia and the Niger Delta, and numerous cetaceans including; the humpbacked whale (*Megaptera novaeangliae*), sperm whale (*Physeter microcephalus)*, bottlenose dolphin (*Tursiops*) and humpback dolphin (*Sousa*) who use the warm coastal waters of the region for reproduction and migration. Also, the threatened Pennant's red colobus monkey is found in the isolated forests of the Niger Delta and Bioko, while the Dwarf crocodile and slender-snouted crocodile thrive in the coastal forests of Liberia, Niger Delta, and Cameroon. This unique fauna competes for food, reproductive space and migratory routes with other generalists such as the Loggerhead, green, and leatherback sea turtles). From an ecological perspective, some of these species such as the *Trichechus senegalensis,* are recognised by Convention on International Trade in Endangered Species (CITES) as being of outstanding conservation value (IUCN, 2008).

Most coastal lagoons of the region are also of international importance for a significant number of water birds (Kelleher et al., 1995; Diop et al., 2014). The *Anambra waxbill*, *Loango weaver* species, and many other waterbirds are restricted to the estuarine and mangrove forests of some countries of this region. The mangroves of the Sierra Leone River Estuary, for instance, are major hosting site for Palaearctic migrant waders, supporting at least eight wintering waterbird species (IUCN, 2007; FAO, 2007; UNEP.,2007; Ngo-Massou et al., 2014). The biological diversity of this entire coastline is complemented by some coastal invertebrate species associated with the mangroves and benthic habitats adjacent to mangroves. This combination of, invertebrates, and fruiting mangrove vegetation attracts larger predators and grazers such as vervet monkeys, marsh mongooses, royal antelopes, and the western Sitatungas, (*Tragelaphus spekii*), and others. It is estimated that these coastal waters harbour about 239 species of fish, of which over 70% are endemic to the Gulf of Guinea and the Niger Delta (Kelleher et al., 1995; Sankaré, 1999)

Current data indicates an increasing human population, with, 43.8% of the population across these countries living in or near to coastal ecosystems (Table 1). This coastal growth is heavily driven by socio-economic opportunities in the urban centres of these areas, particularly assets linked to coastal ecosystems. The mean per-capita income across these countries is

Table 1. Demographic, economic and some characteristics of mangroves and forests ecosystems of target countries.

Countries	Land area (million km^2)	Population 2015 (million)	Coastal Population (% of total population)	Annual population (growth rate %)	Per-capita income $USA (2016 estimates)	Mangrove area (2015 km^2)	Mangrove tree species	Change in mangrove forest area (2000-2015 Km^2)	Total terrestrial forest in protected areas Km^2, 2005
Senegal	192.5	15.12	66.6	2.45	2500	1,222.0	7	48.0	15680
Gambia	10.0	2.02	10.00	2.16	1600	596.0	7	-15.0	418
Guinea Bissau	28.1	1.84	60.00	1.91	1500	1,880.0	6	330.0	125.4
Guinea	245.7	12.60	50.00	2.63	1300	2,310.0	7	452.0	2420
Sierra Leone	71.6	6.45	35.00	2.35	2100	830.0	6	223.0	1120
Liberia	96.3	4.50	58.00	2.47	900	109.0	6	-16.5	1980
Côte d'Ivoire	318.0	22.70	60.00	1.91	3090	100.0	5	-0.6	8080
Ghana	227.5	27.40	40.00	2.18	4300	96.0	6	42.0	1300
Benin	110.6	11.02	50.00	2.78	2100	8.5	6	5.0	25220
Nigeria	910.8	182.20	22.60	2.45	6100	9,970.0	8	70.0	25090
Cameroon	465.4	23.34	30.00	2.59	3100	2,460.0	8	55.0	63730

Source: Compiled from FAO, 2007; UNEP, 2007; Feka and Ajonina, 2011; USAID, 2014; CIA, 2016; https://knoema.com/ Accessed February 2016).

small (USA$2500±1514.26), compounded by unequal distribution of wealth in countries of the region, which is forcing vulnerable coastal communities to be highly dependent on natural resources for survival and posterity (Feka and Ajonina, 2011). For instance, mangrove forests are a major source of food, timber, fuel-wood and numerous other materials (Kjerfve et al., 1997; Din et al., 2008; Feka and Manzano, 2008; Adite et al., 2013a; Baba et al., 2013). In Benin and Guinea-Bissau, mangroves are a source of medicine to the local people (Da Silva et al., 2005; Teka et al., 2012; Vasconcelos et al., 2015). And although a consistent economic value of mangroves is not yet established for the region, 1 m^3 of mangrove fuel-wood costs about $US18/m^3 (Feka and Manzano, 2008). These mangrove forests could potentially yield even better economic returns on the carbon markets because of their high carbon stocking densities, estimated at 1048.91 Mg/ha (Tang et al., 2015).

Across countries of West Africa and Cameroon, the scenery of mangroves and beaches adds aesthetic value for tourism and ecotourism to the coastal ecosystems, which is a growing industry across all the countries of study (Feka, 2007; UNEP, 2007; Leijzer et al., 2013). Also, indigenous traditions such as restriction of access to areas reserved for worshiping ancestral spirits and adoration of gods, adds sociocultural and aesthetic value to these coastal habitats (FAO, 2007). Adjacent coastal forests are extensively cleared and used for the cultivation of food crops and cash crops by local people and industries. Cashew nuts, rice, palm, coconut and salt are just some products (Agyen-Sampong, 1999; Daan et al., 2006; Feka and Ajonina, 2011; Green Scenery, 2011; USAID, 2014). Coastal and marine fisheries are vital to the economy of this region, contributing significantly to the social and economic well-being (Table 2). Offshore and coastal extractive industries are rapidly expanding into these countries, and contributing to the national Gross Domestic Product (GDP) of some of these countries (CIA, 2016)

Study methods

The methodology for this study was designed to be iterative and adaptive, to capture inputs from desk review of published articles and progress reports, interviews with field-based project managers and decision-makers, and consultation with coastal ecosystem specialists in countries of West Africa and Cameroon. This study was carried out in two stages, a literature review (stage i) and a field and status project assessment (stage ii),

Stage (i)

The literature review was limited to peer-reviewed articles and technical reports from (1999-2015), but old key foundation documents on mangroves/coastal ecosystem management were included. Published articles were searched online in English in publicly accessible databases. Groups of keywords linked with the and operator were used for the searches. The groups referred to mangrove ecosystem management in the country [e.g. Ghana] or West Africa and Cameroon. For instance, Ecology (keywords such as mangrove forest, species, biodiversity), vulnerability (keywords such as pollution, exposure, impacts…), and conservation (keywords such as reforestation, afforestation, protected area). A total of 65 articles were retained for this study, after removing duplicates and selecting only articles for the indicated period and relevance to the themes of interest. Literature was examined to identify research themes—with information/data from research or intervention activities

Table 2. Contributions of coastal fisheries to social and economic well-being of countries across West African and Cameroon.

Country	% Contribution of fishery to GDP	Employment millions)	% Contribution as animal protein	Per capita fish consumption kg)
Senegal	4.1	0.60	47.4	28.8
Gambia	5.7	0.04	61.7	25.7
Guinea-Bissau	4	0.02	40	2.1
Guinea	1.8	0.08	60.2	14.3
Sierra Leone	3.7	0.15	63	12.3
Liberia	4	0.01	23	6.9
Côte d'Ivoire	2.7	0.41	ND	ND
Ghana	3.6	0.53	63.2	29.7
Benin	2.9	0.06	28.5	7.9
Nigeria	ND	0.07	40	5.8
Cameroon	1.7	0.25	33.5	14.3

Values are derived from FAO country fisheries information and World Fish Centre, 2005, centred from 1999-2002. ND = No data.

Table 3. Distribution of interventions and data/information collection approaches across countries.

Country	Government officials interviewed	International NGOs project site visits	National NGO project interview or site visits	Local NGOs project sites	Project reports/articles reviewed	Total assessed
Senegal	0	0	0	0	03	03
Gambia, The	0	0	0	0	03	03
Guinea Bissau	0	0	0	0	03	03
Guinea	1	2	2	0	06	10
Sierra Leone	1	1	1	1	06	08
Liberia	2	1	5	1	02	10
Côte d'Ivoire	0	0	2	0	07	07
Ghana	1	1	4	3	04	14
Benin	0	0	0	0	02	02
Nigeria	0	0	0	0	02	02
Cameroon	1	0	6	01	02	10

carried out in select countries of West Africa and Cameroon. Themes were not predetermined but were determined posterior after article review in a simple logistic manner to group information/data availability on a specific theme or objective. Similarly, the team also considered legal, and policy frameworks used to manage mangroves in-country and across the region to gauge progress towards the development of a legal framework for mangrove ecosystem management

Stage (ii)

A total of 72 project sites and project reports were assessed for this study to identify how different interventions and actions were developed to conserve mangrove ecosystems. These projects were identified during a separate expert-led literature review (USAID, 2014), and updated in 2015. To be considered, projects were expected to address aspects of mangrove and coastal ecosystem management. Project counts as presented in Table 3 are mutually inclusive. The assessment process was effected through; (a) exploratory semi-structured and informal interviews with relevant project stakeholders, local community members, and local government officials in offices connected to mangrove forests/coastal ecosystem management activities or in the field across countries visited. (b) review of project status reports. Full consideration of those projects and interventions can be found in Table 3. This project report gave insights into how planning for mangrove management is initiated, developed and implemented by institutions across the region, particularly at sub-national level. Information from the interviews and reports was analysed qualitatively into tables, percentages, and bar charts using Microsoft Excel. Assessments were aimed to understand intervention strengths over a twelve-year period (2000-2012), as well as the cursory effects of externalities of these response efforts.

RESULTS

Distribution and characterization interventions

The conservation and restoration of coastal ecosystems across the countries of West Africa and Cameroon are of prime interest to a variety of institutions ranging from

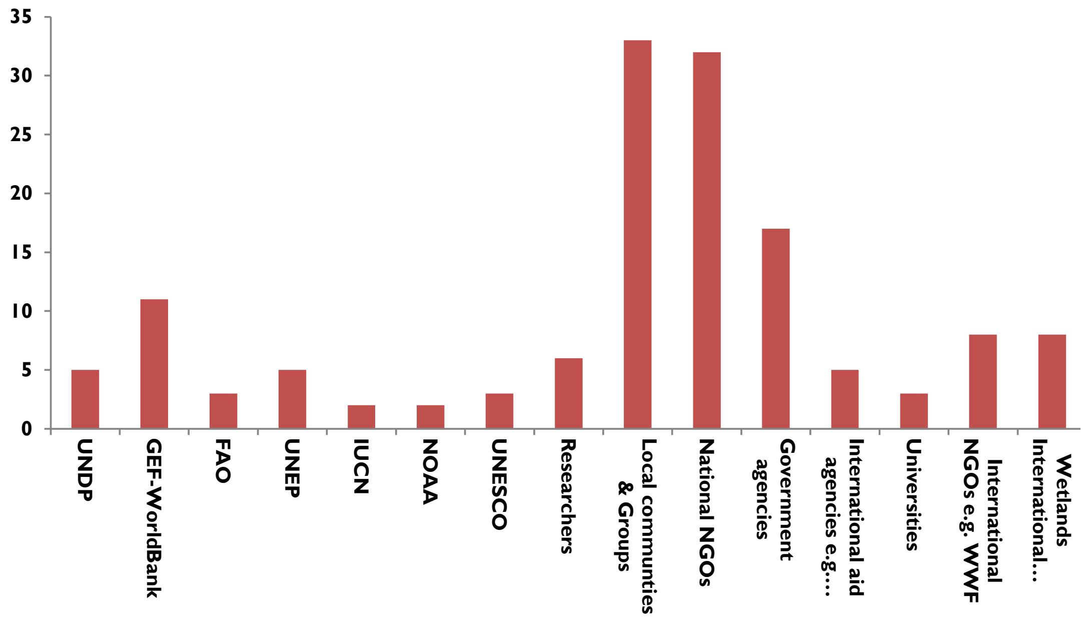


Figure 2. Frequency distribution of institutions with management interests in the coastal of West Africa and Cameroon. Stakeholders that were not immediately involved in the 72 projects assessed by this study were not included. GEF, Global Environmental Facility, UNDP, United Nations Development Programme, UNESCO, United Nations Education and Cultural Organisation, NOAA, National Oceanic and Atmospheric Administration.

governments, multilateral, corporate, international, national, local Non-Governmental Organisations (NGOs) and Community-based organizations (Figure 2). These institutions play various roles, either as funding agencies, intervention implementers, and/or as resource users, to support the sustainability of mangroves in West Africa and Cameroon.

A total of 72 projects were assessed[2] (Annex 1); of which 31(43%) were visited to observe and interview various stakeholders, and 41 (58%) were analysed through the review of articles and project progress reports. These projects were initiated in response to significant environmental problems observed by decision makers or stakeholders' at easily accessible coastal sites (Annex 1). However, 30% of the projects initiated funding proposals, without proper and prior consultation with local communities or broader stakeholder consultations. Most of the multiyear projects (85%) were undertaken by international aid institutions or multilateral institutions in collaboration with local and regional stakeholders (Figure 2). In these projects, identification of demonstration project sites was guided by national or site-specific biodiversity conservation criteria, like the criteria utilized in this research to select countries of study.

About 60% of the national institutions that facilitated the implementation of projects across countries of West Africa and Cameroon did not include mangroves in their strategic development plan. This suggests that mangroves were not previously a priority conservation focus to these institutions, but were instead added later in the process because of increasing prioritization by international organizations. The international and multilateral institutions that were involved in the implementation of interventions displayed substantial financial power and aimed to implement interventions in a consultative manner, trying as much as possible to engage a broad spectrum of stakeholders. These institutions were most often concerned with high-level stakeholders in government or top national institutions. These international bodies employed more bureaucratic project development approaches, and thus, local community stakeholder awareness of their field-based interventions appeared to be quite small, compared to those implemented by local or national institutions.

Although all projects seemed to highlight some form of sustainability in their planning language, only 12% of them demonstrated evidence of post-project lifecycles. At the time of field work in 2014, 95% of the projects had been completed or were in their concluding stages, while only 5% were still in active implementation stages. All projects anticipated contributing to specific thematic areas in the following proportions; 100% (72) focused on biodiversity conservation, 14% (10) on climate change mitigation and adaptation, while 49% (35) saw contribution to climate change mitigation as implicit in the projects implemented activities. This

[2] The sizes of interventions could not be presented because there was no data on the projects operational scope within given complexes; however, the extent of projects areas in the country is provided in Annex 1.

Table 4. Summary of the intervention features of projects implemented across countries of the region.

Country	Intervention types										
	Restoration/conservation			Biodiversity/climate change			Climate change		Livelihoods		
	Protected area expansion and improvement management, protection, law enforcement	Training and capacity building	Ecosystem health, e.g. resources assessments, pollution reduction, biodiversity monitoring	Fast growing tree lots to reduce mangrove wood use	Improved fish Smoking methods cook-stoves)	Improve salt making methods	Adaptation e.g. capacity building, smart agriculture, adaptive houses)	Mitigation e.g. Mangrove ecosystem rehabilitation. E.g. tree planting, planning to avoid deforestation and enhance carbon stocks	Livelihood enhancement activities e.g. capacity building, improve smoke houses, market information systems	Coastal fisheries management	Women specific example oyster farming, smoking
Senegal	3	3	3	3	3	2	2	3	3	3	2
Gambia	2	1	1	1	1		1	2	2	1	1
Guinea Bissau	3	3	3	0	0	0	0	2	3	3	1
Guinea	3	5	1	2	2	2		4	2	3	2
Sierra Leone	3	7	1	1	1	0	1	3	3	4	2
Liberia	3	9	3	2	2	0	2	4	7	2	2
Côte d'Ivoire	3	1	2	1	1	0	1	2	4	1	2
Ghana	4	15	7	2	2	0	2	8	9	4	1
Benin	2	1	1	1	1	0	0	2	1	1	1
Nigeria		1	1	1	1	0	0	1	1		
Cameroon	3	7	3	3	3	0	2	4	3	0	1

grouping is not mutually exclusive. Table 4 is a summary of the features of interventions implemented by projects across countries.

Monitoring and Evaluation (M&E) of project activities was related to the magnitude of funding and length of the project cycle. M&E strategies for short-term projects (lasting one year or less) were limited to short narratives or end of project reports. Projects of longer life cycles (≥1 years) used a variety of M&E[3] strategies. The use of mapping and remote sensing tools for monitoring happened in 28% of the projects (mainly projects of interventions by international institutions).

Mangrove ecosystem implementation strategies

Field implementation methods

In order to implement various interventions, project staff undertook a range of activities on the ground. The application of these methods varied between projects but not between countries. Using a method or set of method to complete a specific intervention was dependent on the environmental issue at stake, the accessible stakeholders, and the resources available. Figure 3 shows the frequency distribution of implementation methods use in countries. Independent research interventions such as bird or sea turtle monitoring and field surveys were few in numbers, and employed the least number of field implementation methods (1-3), while cross-cutting projects such as "the sustainable mangrove management," used the largest number of methods. All the mangrove projects assessed during this study employed more than one method to complete a given intervention. For this reason, there was no "typical" mangrove response that is common across all countries. The use of a set of responses for a project was dependent on a variety of programming decisions; including ecosystem features, local community needs,

[3] Interventions with lifecycles longer than one year employed target based indicators of results established in the project log-frames such as; mainly reports and field observations, such as; progress reports, rapid socio-economic surveys, mid-term performance reviews and final project performance evaluations.

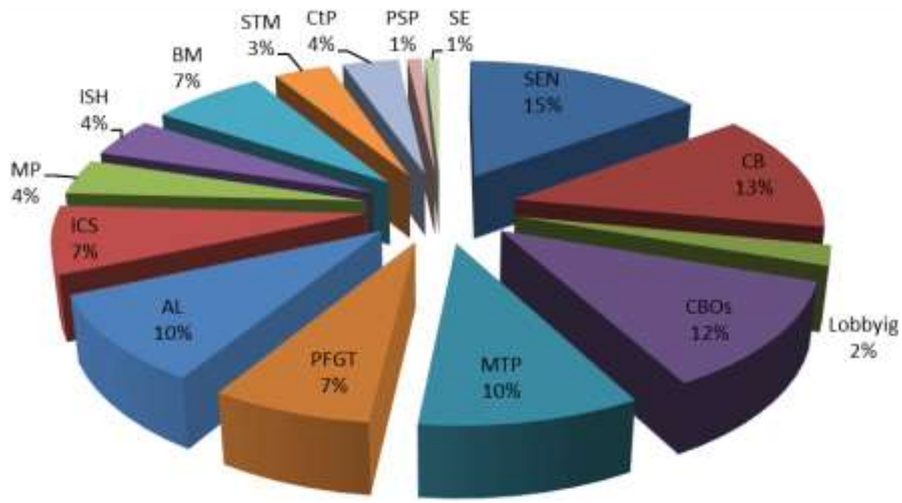


Figure 3. Frequency distribution of methods used to facilitate intervention implementation across Target Countries. SEN, Sensitization; CB, Capacity building; CBO, Lobbying, Community Base Organizing; CBOs, Groups creation; MTP, Mangrove tree planting; PFGT, Planting of fast growing trees; AL, Alternative livelihoods; ICS,, Improve cook stoves; ISH, Improve smoke stoves; MP, Management plans; BM, Bird monitoring; STM, Sea turtle monitoring; CtP, Contribution to policy; PSP; SE, Solar energy.

implementer experience,project length, and budget.

Mangrove intervention types

The study found that the conservation of mangroves between 2000 and 2014 in countries of West Africa and Cameroon involved a variety of overlapping interventions. This paper grouped these interventions into two broad complementing categories; (a) biodiversity conservation and sustainable management and (b) ecosystem restoration. Table 5 highlights a short list of field-tested interventions identified from across the countries of study.

Biodiversity conservation and sustainable management

Protected areas: Data from the World Database on Protected Areas (MCI., 2016: Table 6), highlight about 70 Marine Protected Areas (MPAs) across countries of the region, encompassing an area of about 39,500 km^2 of marine managed area (~3.80 times less than equivalent protected terrestrial forests area across countries of the region), of which mangroves occupy about 4%. About 10% of these are proposed or have no designation information, 21% are national parks, 50% are recognised internationally (either as world heritage sites and/or Ramsar sites), and 30% are IUCN classified. Most of the projects assessed in this study supported MPA sustainability by promoting the reduction of pressure on mangrove resources through various activities (Table 4). Regardless of status, less than 40% are under some form of management or are in the process of developing a management plan. As a result of poor management and pressure from anthropogenic activities, some of these MPAs are in advanced states of degradation, as in the MPAs in Nigeria (e.g. Apoi Creek Forests Reserve, Stubbs Creek Forest Reserve), Guinea (Konkouré Ramsar site) and Benin (Nazoumé MPA). Most of the successfully established MPAs in this region are in Senegal (e.g. Delta du Saloum UNESCO-MAB Biosphere Reserve), Guinea-Bissau (e.g. Bijagós UNESCO-MAB Biosphere Reserve), Sierra Leone (Sherbro Bonthe River Estuary) and the Gambia (Tanbi Wetlands Complex Ramsar Site).

Evidence from this study indicates that the approach to protected area management is moving from a centralized government-led model (with little community involvement) to other forms that have a greater focus on sustainable development goals and governance orientations, such as stakeholder participation and benefit-sharing equity (Cormier-Salem, 2014). This transformation is a result of changing environmental conditions and responses to global environmental agreements and conservation conventions such as the Convention on Biodiversity (CBD, 2009). Because of increasing commitments to these agreements, the number of MPAs and the management objectives of these tools have been changing, across countries and Cameroon (Renard and Touré, 2012; Cormier-Salem, 2014).

Community-based Mangrove conservation initiatives: About 90% of all projects assessed aimed or used some level or form of Community- based management (CBM)

Table 5. Distribution of successful mangrove management interventions[4] across the countries of study.

Country	Mangrove policy	Law enforcement	Improved fish smoke systems	Improve cook-stoves	Improve salt drying solar)	Aquaculture e.g. Oyster culture	Fast growing wood lots	Mangrove tree planting	Protected areas	Sustainable coastal fisheries
Senegal	*	***	***	*	***	***		***	*****	*****
Gambia					*					
Guinea Bissau								**		
Guinea Conakry			**		**	***		*		
Sierra Leone	*	**	**			*		**	***	**
Liberia	*	*					**			
Côte d'Ivoire	*		**	**				**	**	
Ghana	*	***	***	**	*			***	***	*****
Benin								***		
Nigeria			*							
Cameroon	**		***			*		*	*	

Source: Compiled by authors from field observations, expert opinion and review of projects) progress reports. Successful and field tested interventions are selected on the bases of a five STAR ranking scale [0=no successful activity, *= very lowly established, **= more than five established interventions/reports in-country, ***= established intervention with acknowledged benefits and lessons locally, **** = established intervention with acknowledged benefits and lessons locally and nationally and ***** = established interventions with national and regional benefits and lessons].

Table 6. Distribution of projects and data/information collection methods across countries of study.

Country	Marine managed areas (Km^2)	Number of MPA	Mangrove area (Pas Km^2)	Estimates of restored mangrove forest area (ha)
Senegal	2746.33	11	48.875	288
Gambia, The	560.68	5	20.3	ND
Guinea Bissau	15720.75	7	745.5	ND
Guinea	2250	7	5.52	23
Sierra Leone	1954.9	7	145	20
Liberia	1386.57	5	0.3375	32
Côte d'Ivoire	1101.83	11	26.631	45
Ghana	1711.5	5	1.86	68
Benin	1391	2	ND	198

Source: Compiled from UNEP, 2007; Ajonina, 2010; Feka and Ajonina, 2011 and USAID, 2014. The restoration values are representative of values culled from literature and not necessarily a true representation of actual efforts across the region.

to manage mangroves. Mangrove CBM initiatives were successfully implemented in Benin, Ghana, and Liberia (USAID, 2014). The factors that contributed to shaping the success of CBM

[4] While these interventions have been identified as successful, it is important to note that its effectiveness is dependent on a variety of programming and context specific variables.

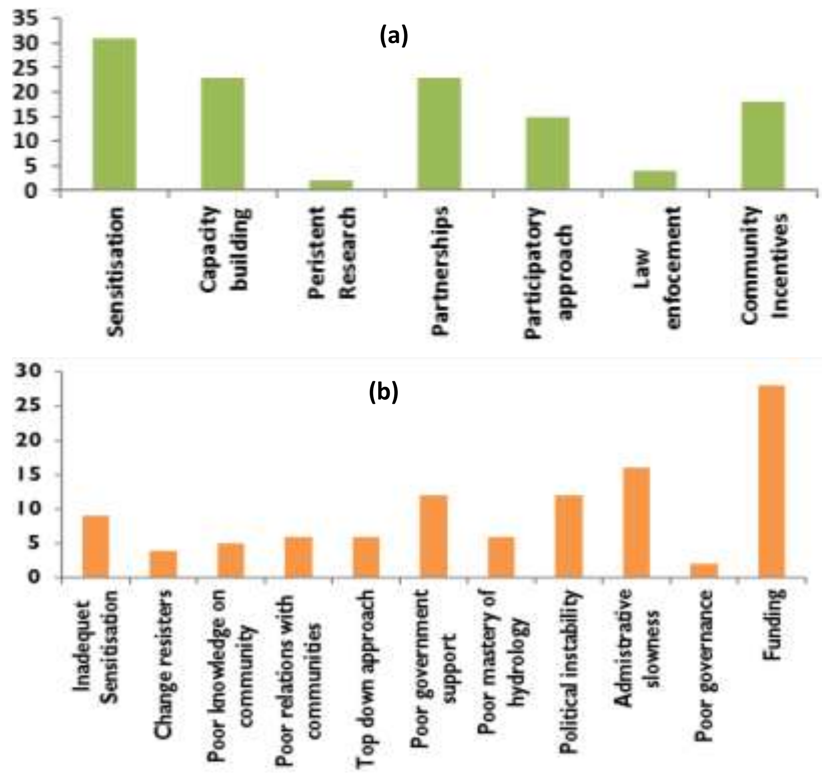


Figure 4. Factors reported to be influencing the implementation of interventions across target countries. a: Factors reported to be contributing to the implementation of successful interventions across target countries; b: Factors reported to be contributing to failures in the implementation of Interventions across countries of the region.

initiatives are summarised in Figure 4a. Because of these achievements, some mangrove areas have been rehabilitated across countries of West Africa and Cameroon (Table 6). Co-management of MPAs is also gaining popularity across some of the countries of study, as in the case of Sierra Leone, where co-management of the Sherbro River MPA has resulted in increased protection of mangroves and increases in fish catch. This has, in turn, stabilised families by reducing the need for male fisher's mobility between villages and between countries (EJF, 2013).

The co-management of MPAs, including mangroves, have contributed to livelihood improvements by introducing community enterprise initiatives such as tomato farming around Songor in Ghana, community micro-lending and fishing schemes in Cayar, Senegal and oyster cultivation and commercialisation in the Greater Banjul area of the Gambia. These initiatives have helped to sustain incomes and motivate communities to engage effectively in the management of mangroves and coastal ecosystems conservation (Diop et al., 2006; Sall et al., 2012). However, CBM mangrove initiatives across countries such as Cameroon, Côte d'Ivoire, Guinea and other countries of the region have not always been successful due to reasons highlighted in Figure 4b.

Ecosystem rehabilitation

Mangrove ecosystem rehabilitation: Restoration is commonly described as an act or process of returning something to its original condition or position (English Cambridge dictionary, 2016). Although, degraded ecosystem can never be returned to its original condition, rehabilitation of degraded ecosystems is a much more manageable task, as it involves returning degraded mangroves to a healthier condition, with ecosystem structure and characteristics that are partially or fully functional. Successful mangrove planting is happening in some countries of the region (Table 6), and community management plans and planting of fast-growing non-mangrove trees for alternative timber sources are conventional approaches to reducing pressure on mangrove ecosystems, thereby allowing overharvested areas to regenerate naturally. A series of factors were identified as promoting the success or failure of these initiatives (Figure 4a and b). About 35 of the projects assessed attempted rehabilitation interventions. Most of these initiatives, however, conflated rehabilitation with mangrove tree planting. Reports indicated that restoration planning deficiencies included lack of prior feasibility studies, lack of post-planting monitoring, and poor community participation in many of the mangrove rehabilitation interventions in most of the countries except for Benin, Ghana, and Senegal.

Enhancement of livelihoods: Several interventions were implemented with the aim of reducing anthropogenic pressures and dependencies on mangroves and other coastal ecosystem resources. This was done by either providing additional or enhanced income streams to community members that are reliant on this ecosystem for subsistence. About 82% of the 72 projects used livelihood enhancement activities as a way to reduce pressure on the ecosystems. Some of these livelihood activities are highlighted in Table 4. The primary types of livelihood activities observed about mangrove preservation activity are improved (more active) fish smoking, improved salt drying technologies, and alternate modes of income generation. Alternative ways of revenue generation were particularly diverse from site to site, with various forms of animal husbandry being common snails, cane rats, and oysters).

Legislative and policy reform: Countries across the region have ratified a series of international agreements that promote biodiversity conservation, including mangrove-specific subsets (CIA, 2016- World-Fact Book country profiles). Agreements such as the Abidjan Convention, Marine Dumping, and Marine Life Conservation refer to the sustainability of marine life, while others, such as …. only implicitly reference marine life and mangroves. The Treaty on Economic Community of West African States (ECOWAS) Environmental Policy and the draft Charter and Action Plan on Sustainable Mangrove Management refer to mangroves. These international and regional instruments aspire to promote the harmonization of policies that promote the sustainable management of coastal resources by setting national and regional guidelines that improve coastal and marine resources governance; including mangroves and fisheries

Many regional institutions and initiatives have been established to facilitate the implementation of these agreements. However, these initiatives do not often engage all countries from the region to participate in the development of resources management guidelines (Table 7). Hence, there is, therefore, need to extend and consolidate the existing regional mangrove draft charter and working groups to all countries of the region. A next logical step will be the domestication of the established regional policies at a national level in a way that will facilitate the development of legislations for mangrove protection, sustainable development, and climate change mitigation and adaptation. Considering the migratory nature of coastal dependent biodiversity (fauna), each country should integrate elements of regional policy frameworks into their national legislations in participation with the regional institutions. One of the strongest challenges for international treaties/regional intuitions in countries of West Africa and Cameroon is that countries adopt them, create focal points and then do not give them the required resources to implement. At the national level, countries such as The Gambia and Cameroon have developed draft policies and legislations for mangrove management (Government of Cameroon, 2010; Government of Gambia, 2015). While in Benin, Ghana, Liberia and Sierra Leone, the management of mangroves is encapsulated within wider Wetland policies.

Capacity building and research: Capacity building activities included the use of public radio announcements, flyers, demonstrations, and workshops promoting changed behaviour and lobbying for policy change. Since the 2000's, research has generated a considerable volume of literature with data that can be used to support the sustainable development of mangroves and other coastal ecosystems in West Africa and Cameroon. Documents, including technical reports and peer-reviewed journal publications, were analysed. Of all these materials, over 24% were technical reports and 76% peer reviewed articles. These articles covered twenty-six thematic/research objectives. About 65% of the articles covered cross-cutting themes. Figure 5 shows the frequency distribution of research topics across studied countries of the region. This information gives a birds-view of the investigation effort and data that could influence behaviour and raise awareness amongst policy makers and promote rational decision making, but it is by no means exhaustive.

Current state of mangrove forests

An analysis of field interviews, literature and reporting data on the state of mangrove forests across countries of West Africa and Cameroon was carried out, to serve as a rough proxy measure of conservation efforts between 2000 and 2014. Results revealed that between 2000 and 2015, about 6% of mangrove forests disappeared (Citation). This value represents an annual depletion of about 79.53 km^2 of mangrove forests, with a mean annual loss of 7.23±10.45 km^2, per country. This rate is 1.59 times lower that the 126.28 km^2 of equivalent loss per year for the previous period (1980-2000), across the same countries this suggests that the loss in mangrove forest may be slowing down, though the gradient remains negative (Figure 6). Côte d'Ivoire, The Gambia, and Liberia appear to have cumulatively gained in mangrove forest area (Table 6). This slowdown in trend implies that cumulative actions undertaken to sustain mangroves and coastal ecosystems across the region may be curbing the rate of mangrove ecosystem loss. However, despite their conservation efforts; Guinea and Sierra Leone appear to be losing significant amounts of mangrove forests (Table 6). Now, however, it is not certain if this changing trend is

Table 7. Regional institutions involved in the management of mangroves and coastal ecosystems across West Africa and Cameroon.

Institution & Participating countries	Objectives	Achievements and impacts
Mano River Union- Côte d'Ivoire, Guinea, Liberia, Sierra Leone	Promote; sustainable utilization and management of natural resources, peace and security and socio-economic development, by designing dynamic frameworks that ensure sub regional integration	Supported the development and co-management of MPAs to reduce illegal fishing, build capacity of governments officials, communities and civil society organizations to effectively manage their marine resources in Sierra Leonne and Liberia
West Arica mangrove charter [Guinea, Guinea-Bissau, Senegal, Sierra Leone]	Promote harmonisation of policies and practices with respect to the sustainable management of mangroves	The draft is ready but not yet operational l
Sub regional commission on Fisheries (SRFC) [Guinea, Guinea-Bissau, Senegal, Sierra Leone]	Promote and enhance cooperation and coordination in the preservation, conservation and exploitation of fisheries resources through the harmonisation of policies, management approaches and capacity amongst member states	Since its creation SRFC has worked with various partners in the region and globally to enhance; governance and monitoring of illegal fishing, relevant capacities, and promoted the protection and sustainable management of mangroves by implementing a program on MPAs as a tool for the sustainable development of West African fisheries.
Abidjan convention [Senegal, Gambia Guinea Bissau, Guinea, Sierra Leone Liberia, Côte d'Ivoire Ghana, Benin Nigeria, Cameroon]	Protect, conserve and sustainably develop the resources of coastal West-Central Africa countries by providing an overarching legal framework for all marine-related resources in the region	Currently cooperating with West Africa Biodiversity and Climate Change Programme (WABiCC) to support the sustainable management of coastal resources, adopted in 2011 a regional contingency plan of preventing and combatting pollution Incidents.
ECOWAS [Senegal Gambia, Guinea Bissau Guinea Sierra Leone Liberia, Côte d'Ivoire Ghana, Benin Nigeria]	Promote collective self-sufficiency for member states, create a single large trading bloc through economic cooperation and integration	This is a political institution, with potentials to better influence policies. For instance, its harmonisation plan on forests is the appears the only regional policy that provides specific actions relating to the identification, mapping and protection of wetlands, including mangroves
Regional Partnership for the Conservation of Coastal and Marine in West Africa (PRCM) [Senegal Gambia, Guinea Bissau, Guinea Sierra Leone Liberia, Côte d'Ivoire Ghana, Benin]	Operate through an extended and sustainable platform to support; capacity building of stakeholders, political advocacy role; partnership between institutions; alignment and harmonization of the various policies and mobilization of resources on a sustainable basis; mobilization and capitalization on research outcome, local knowledge and coordination of interventions at the regional, national and local levels	This is a consortium made up of UICN, WWF, FIBA, Wetlands International and CSRP. They have collectively archived significant strides in building the capacities of various stakeholders in the region and extensively mobilised resources to support the sustainable management of MPAS in the region, amongst others

Source:http://manoriverunion.int/;http://www.spcsrp.org/;http://abidjanconvention.org/;http://www.ecowas.int/; http://www.prcmarine.org/

the result of a lack of conservation efforts or data insufficiencies.

DISCUSSION

Intuitional capacity, Interventions, and Outcomes

With respects to project development and implementation, most of the international institutions had a more structured approach, while most of the national organizations had a rather casual approach. This tendency is however not uncommon in developing countries (Adger et al., 2003; Feka, 2015). Moreover, most of the national implementing institutions exhibited typical governance weaknesses related to staffing and logistic insufficiencies. This finding is a common phenomenon with other developing country institutions such as Kenya (Adger et al., 2003; Gordon et al., 2009). Irrespective of institutional classification, methods (Figure 3) used to implement interventions (Table 5) were like those used by institutions in East Africa and South-East

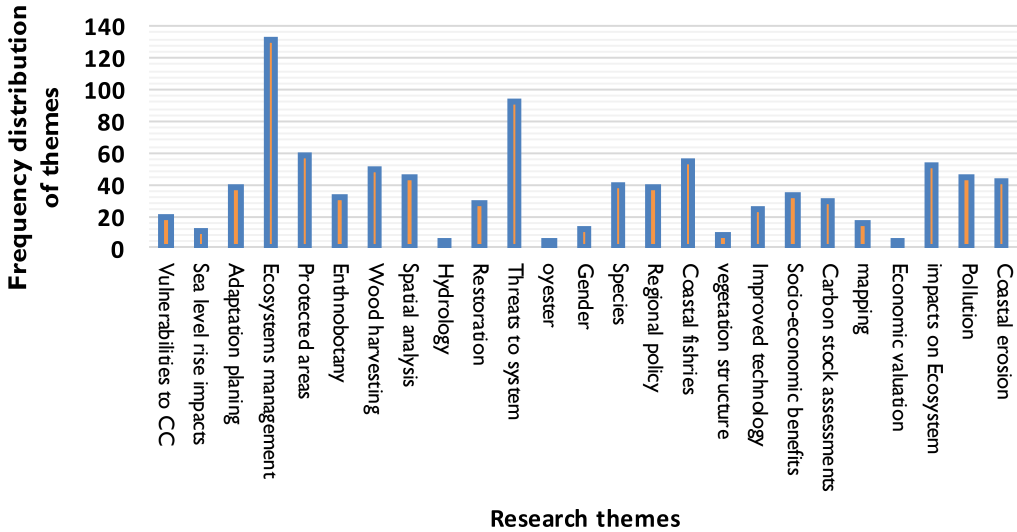


Figure 5. Frequency distribution of research themes across countries of study.

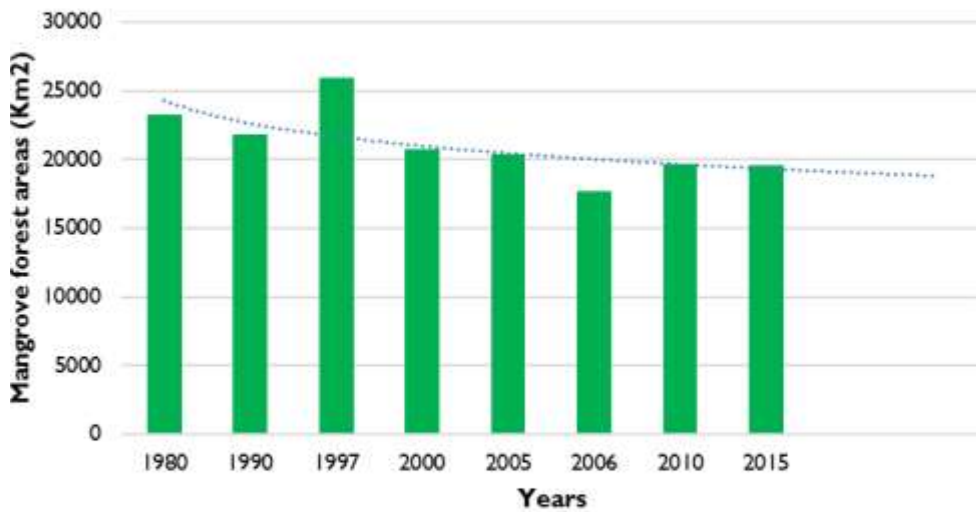


Figure 6. Overview of mangrove forest area change 1980-2015). Data source for this analysis: FAO (2007); https://knoema.com accessed February 2016.

Asia (FAO, 1985; FAO, 2001; Leijzer and Denman, 2013). However, most of these interventions employed various levels of fragmented responses to address threats identified across sites (Tables 4 and 5). Overall, an integrated approach that considers mangrove forest heath as influenced by a wider land/coast/seascape processes would yield better results (Fabbri, 1998; Feka and Ajonina, 2011)

Lack of M&E in many small projects made it difficult to verify outputs and outcomes of field interventions undertaken by some of the national and local intuitions. The international intuitions employed various M&E techniques, but even those were more focused on project managing and building partnerships rather than assessing and measuring field-based conservation outcomes. Moreover, the limited use of satellite- mapping and remote sensing tools for M&E might be linked to the technological challenges common in most of the countries of West Africa and Cameroon (Akegbejo-Samsons, 2009; Salami et al., 2009; Carreiras et al., 2012; World Bank, 2015), exacerbated by a general lack of knowledge on alternative low-cost open source satellite-based mapping technologies. The limited use of these tools indicated that most projects did little spatial planning and subsequent reporting of project outcomes. Regardless of the challenges, mapping and remote sensing has been extensively used to gain insights into spatial and temporal distribution of mangrove ecosystems, species, state of mangroves, biomass, carbon stocks, and vulnerabilities globally (Kovacs et al., 2001, Fromard et al., 2004; Dahdouh-Guebas et al., 2005; Giri et al., 2014; Tang et al., 2014; Dan et al., 2015).

It is essential for prospective mangrove conservation programs to prioritise mapping and remote sensing units into programs to facilitate the monitoring of project outcomes. Such units will significantly improve our understanding of real-time interventions and threats to mangrove ecosystems. Also, there is a general need to empower national and local institutions on the sustainable management of mangroves and coastal ecosystems in the region; taking into consideration current challenges plaguing coastal ecosystems in the region. This capacity development drive must be context specific, after a clear institutional gap analysis. Also, in the future, it is imperative that international institutions engage more with a wider range of community institutions and representatives from project inception. This process should include ensuring knowledge and technology transfer through identification and training of local and government institutions for monitoring and post-project impact evaluation.

Factors driving the successful delivery of mangrove conservation interventions by institutions across countries

This study highlights the deliverables (Table 4 and 5) of 72 interventions[5] undertaken from 2000 to 2014 to sustain mangroves across countries of the region. A variety of factors altered the implementation of these interventions (Figures 4a and b). However, the outcome of each of these interventions was the result of a combination of many field methods, mostly influenced by the governance capacity of the implementing institution. Across the countries of West Africa and Cameroon, there is a growing wealth of information/data (Figure 5) from various stakeholders, but research effort is unevenly distributed across studies countries. This study identified that research from across countries of West Africa and Cameroon was used in support of restoration programs and the development of improved fish-smoking and solar technologies for salt making. This suggests that adequate research could contribute to the identification and support of other sustainable management strategies for mangroves and coastal ecosystems. These results are consistent with the findings of CEC (1992), Diop et al. (2006) and Diop et al. (2014). Overall, most of the articles reviewed by this study appear to be managerial and superficial in nature. Moreover, this literature review and research effort identified a gap in knowledge and lack of information/ data on the ecology of mangrove species, regeneration of species, remote sensing and distribution of species, ecological processes, economic valuation of mangroves and the implications of climate change on species and human well-being across countries of the region remains limited and scarce.

This lack of information makes it difficult to support informed decision-making for coastal ecosystems management in countries of West Africa and Cameroon. It is, therefore, essential for funding institutions to be more flexible with project implementation strategies by enabling implementers to proactively collect data and monitor ecosystem change in the interests of identifying and effecting adaptive changes when they occur during a project's life, rather than being dogmatic (BSP, 1993). This approach offers better opportunities to identify how interventions are making progress towards goals and what ecosystem changes are occurring if any. Hence, there is a need for continuous research across all countries of the region to holistically understand the socio-economic and ecological values of mangroves and coastal ecosystems. Research within mangroves and coastal ecosystems in East Africa and South East Asia have led to the development of strategic management plans that have attracted sustainable funding for development and conservation initiatives (Spalding et al., 2010; Fischborn and Herr, 2015). Adopting similar approaches in the West African and Cameroonian coastal ecosystems would be equally beneficial.

This study identified that sensitization activities were also central in the implementation of field activities across all countries of West Africa and Cameroon (Figure 4a). Similar approaches (e.g. use of workshops, leaflets, and radio messages), have been used to change patterns of human activity and behaviour towards mangroves and coastal ecosystem in other developing countries (FAO, 1994; FAO, 2001; World Bank et al., 2004). As reported by interviewees during this study, sensitisation was an essential tool for capacity building that caused local people around the Ebiere Lagoon in Cote D'Ivoire to understand that planting of fast growing trees was a feasible alternative for mangrove wood as a source of affordable energy. Moreover, active engagement of stakeholders through the participatory approach was reported as a facilitating strategy for success across some interventions in target countries of the region. This approach led to the successful co-management of MPAs in Sierra Leone and community restored mangrove areas in Benin and Ghana. The importance of the participatory approach in intervention facilitation lies in its ability to support the development of transparency, fairness and partnership creation among local institutions (FAO, 1994). These virtues were observed in all the successful interventions assessed by this study. Most of the implementers that employed this approach credited it with building stakeholder interest in participation in the conservation process while creating opportunities to generate additional funding and hence project sustainability.

[5] Although this study is the single most comprehensive account of mangrove-oriented interventions in West Africa and Cameroon, it should not be regarded as exhaustive, as there are likely several other responses active in the area that are not captured in this study.

Similarly, the use of participatory approaches in mangrove initiatives have contributed to policy reforms, biodiversity conservation and livelihood improvement among local communities in Kenya, Indonesia the Philippines (FAO, 1985; Kairo et al., 2001; McShane and Wells, 2004; Fischborn and Herr, 2015).

The execution of feasibility studies to understand the root causes of mangrove ecosystem degradation was limited to some interventions in Benin, Ghana, and Senegal. These countries have delivered successful restoration programs (FAO, 2007; Ndour et al., 2009; Sall et al., 2012). The study identified some restoration planning deficiencies, which have previously been reported in countries of this region and other places around the world (World Bank et al., 2004; Primavera and Esteban, 2008; Egnankou, 2009; Ajonina, 2010; Lewis and Brown, 2014). Most of the implementing institutions conflated mangrove restoration to tree planting. However, mangrove rehabilitation should be principally understood as a process of reducing the primary stressors, which collectively act on mangroves, to create improved environmental conditions for plant regeneration and growth. These stressors, and how they influence mangrove regeneration and growth have been extensively studied (Kairo et al., 2001; World Bank et al., 2004; FAO, 2007; Diop et al., 2014; Lewis and Brown, 2014). However, this study identified that this information is scarce in countries of West Africa and Cameroon. Regardless, of the constraints, the decision to rehabilitate a given mangrove area should grow from the recognition that the ecological characteristics and functions of that particular ecosystem cannot continuously auto-sustain (World Bank et al., 2004). In this event, rehabilitation should be a process that is not necessarily synonymous with tree planning but encompasses a series of basic steps and technical procedures that will ultimately inform what field actions are necessary and possible (Lewis and Brown, 2014). It is only when indispensable that restoration may be facilitated by human planting and natural regeneration support using approaches that reduce the anthropogenic impact as a by-product of other preservation activities such as establishment and enforcement of protected areas.

Reliance on the current extent of MPA coverage (Table 6) as an indicator for the protection of mangroves is no guarantee for this ecosystem's sustainability. The number of MPAs might not be a valid indicator because the creation, enforcement, and management of MPAs in West Africa and Cameroon are heavily constrained by financial and governance challenges (Akegbejo-Samsons, 2009; Renard and Touré, 2012). Furthermore, efforts to create and improve management of MPAs are also being undermined by climate change. Janes et al. (2015) point out that most of the birds, amphibians, and mammal species found in the MPAs outlined in Table 6 are vulnerable to the effects climate change. These challenges are also being compounded by high dependence levels on mangroves and coastal ecosystem resources by various stakeholders, as a result of low living standards (Tables 1 and 2).

Some of the regional partnerships highlighted in Table 7 are promoting the development of coastal ecosystems by triggering the required political support and financial resources for the sustainable management of MPAs in countries of the region. However, these partnerships are limited to a few West African countries. MPAs have a proven track record for biodiversity conservation, as well as acting as safe grounds for regeneration, gene banks, research, and tourism (FAO, 2001; McClanahan et al., 2005; Salami et al., 2010). It is essential for all countries of West Africa and Cameroon to commit and improve political and financial support for the sustainable development of MPAs in the region.

Institutional and externalities that antagonise mangrove and coastal ecosystems conservation across countries

This study has shown that many factors cumulatively contribute to the successful management of mangroves in countries of West Africa and Cameroon. However, internal institutional deficiencies and external drivers may influence efforts directed towards the conservation of mangrove ecosystems in these countries. This study identified and broadly categorized these factors into four groups.

Institutional insufficiencies: Some of the institutional inadequacies have been discussed (Figure 4a). Additionally, some of the regional institutions (Table 7) are only active nationally or in a limited number of countries, although they may have a regional mandate to sustain mangroves. Within these countries, there are too many administrative intuitions with overlapping or devolved roles, and no clear collaborative platform between institutions (Macintosh and Ashton, 2002; Gordon et al., 2009; Lawson et al., 2012). These issues are common in many developing countries (FAO, 1994; World Bank, 2015), but are especially prevalent in Cameroon, Côte d'Ivoire, Guinea and Nigeria. It is important to address these failures because doing so will create conditions that are likely to attract suitable investment/interest for a sustained conservation and management of coastal ecosystems across the region.

Political marginalization of mangroves: The establishment of adequate support policies and appropriate legislation is an essential step in the management of natural resources (World Bank et al., 2004). As observed by this study, government staff contributed to the management of mangrove and stocks in countries such as Liberia, Sierra Leone, and Ghana by supporting the implementing institutions' right to enforce natural resource laws. This enforcement was strengthened at the community level by sensitised groups in Ghana and Sierra Leone, who actively reported illegal activities such illegal mangrove wood harvesting, poaching of sea turtles and the presence of illegal fishing fleets close to community fishing areas. Regardless of these collective efforts, there are no legally established policies for the management of mangroves across all countries of the region (Feka, 2015). This lack of specific legislation on mangroves and its embodiment, within more general natural resource management frameworks, institutionalizes jurisdictional ambiguities and hence undermines the strong protection of mangroves by legal means (Walters et al., 2008; Van Lavieren et al., 2012). Countries such as Kenya, Tanzania, and Mozambique have developed sound policies guiding the management of mangroves in in their specific countries (Macintosh and Ashton, 2002; World Bank et al., 2004). Countries such as Malaysia, Thailand, Philippines and Pakistan have for a long time guided the management of mangroves using specific legal policies (FAO, 1985; FAO, 1994; Spalding et al., 2010). These policies were initially promoted to develop economic industries such as the production of; poles, pulp, logs, chips, charcoal fuel-wood and conversion for aquaculture (Choudbury, 2002). However, the frameworks of these initial policies improved over time to include social components (for example community participation, poverty reduction), and environmental components like mangrove conservation, protection, and restoration (World Bank et al., 2004). This suggests that (recognizing deficiencies from previous policies), those initial frameworks did guide developments towards the contemporary legal management of mangroves in these countries particularly when coupled with emerging challenges such as climate change and the importance of mangroves to food insecurity.

This lack of legal frameworks for the management of mangroves in countries of West Africa and Cameroon is a clear indication that while political perceptions on the value of mangroves might be changing elsewhere (Spalding et al., 2010; Van Lavieren et al., 2012), governments across this region have not yet realised the true value of these ecosystems.This continuous marginalisation of mangroves is rooted in the inability of governments in the region to perceive direct economic benefits from mangrove ecosystems (Feka and Ajonina, 2011) coupled with the relatively small size of mangrove forests, which are about thirty-nine times smaller than terrestrial forests (Table 1), in the area. Global financial institutions such as the World Bank and the African Development Bank were central to the emergence of legislative and policy frameworks for terrestrial forest management in these countries during the early 90's. With the increasing importance of mangroves and other coastal ecosystems for food security, poverty alleviation and the management of climate risks (Dahdouh-Guebas et al., 2005a; UNEP, 2007; Lawson et al., 2012; Adite, 2013), it is vital that these financial institutions intervene to promote policy reforms for mangrove management across these countries. These reforms to the sustainable management of mangroves and coastal ecosystems are particularly urgent because coastal areas are hosts to major industries and infrastructure such as seaports that generate over $150 billion in trade annually across this region (UMOUA and IUCN, 2010). This slow pace of policy reform is accentuating the depletion of coastal ecosystems because mangroves are continuously being treated as "open access" resources (UNEP, 1999; IUCN, 2007; Feka and Ajonina, 2011; Diop et al., 2014). Moreover, this lack of legislation makes it extremely difficult for a conservationists to conserve and protect mangroves and gives developers an incentive to generate economic justifications to convert mangroves and coastal ecosystems for business purposes, rather than for conservation (FAO, 1994).

Unsustainable socio-economic trends and population growth: The aesthetic scenery of coastal ecosystems is exploited for tourism, a sector that generates substantial revenue to countries such as Senegal, the Gambia, and Ghana among others (Leijzer et al., 2013). Other development initiatives spanning across this coastal edge include; ports[6], dams and petroleum exploitation developments established to support the socio-economic prosperity in some countries of the region such as Cameroon, Ghana, Liberia and Nigeria (Kjerfve et al., 1997; UMOUA and IUCN, 2010; USAID, 2014). These developments are attracting various stakeholders, which seek to benefit from employment opportunities offered by these industries. Thus, the coastal population of this region is increasing (Table 2), but this trend is not limited to this coastal region, as more and more people are moving closer to coastal zones globally (MEA, 2005).

This growing coastal population is increasing pressure (Figure 7a) on the coastal ecosystem resources, particularly mangroves across countries of West Africa and Cameroon. For instance, coastal agriculture is expanding, and most of these countries depend on farming and the exploitation of other natural resources for economic posterity. Crops which are commercially cultivated in and around coastal ecosystems in the region include cashew nuts, coconuts, rice, and palms. In 2012, cashew plantations accounted for 2,230 km^2 of the agricultural landscape of Guinea-Bissau, of which over 60% are mangrove swamps (Catarino et al., 2015), and clearing of mangrove forests for rice-cultivation have transformed over 2,280 km^2 of mangrove forests across six countries of this region (Agyen-Sampong, 1994). Palm oil expansion is a known threat to the mangroves of South East Asia (Giri et al., 2014; Richards and Friess, 2016), and this study also identified that this threat is gradually creeping into the mangrove swamps of Benin, Cameroon, Ivory Coast and Sierra Leone. As mangrove

[6] Expansion of the port of Kamsar in the bay of Sangaréya (Guinea) led to the loss of 0.7Km2 of mangrove forests.

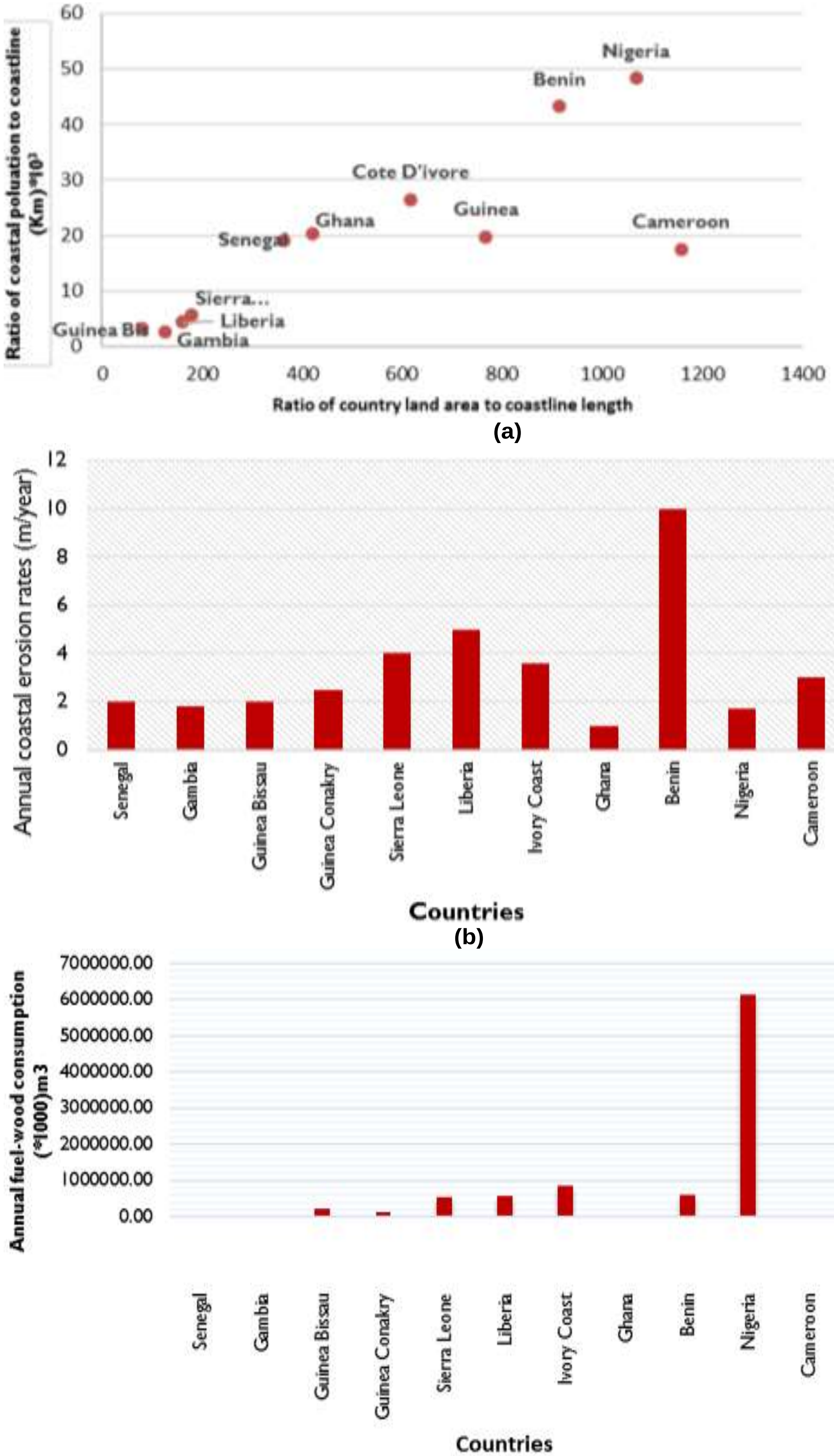
forests are cleared, the land is exposed and eroded by rising sea tides and precipitation at varying rates (Figure 7b), with a mean loss of 3.33±2.50 m $year^{-1}$ in countries of West Africa and Cameroon (USAID, 2014a).

In countries of West Africa and Cameroon, increasing demand for fisheries has led to reduced catch per unit effort across countries of the region (Lenselink and Cacaud, 2005; Béné et al., 2007). Thus, there is increasing scarcity of fish in these coastal waters, which is forcing local fishers into migratory lifestyles, as they begin to move from country to country to meet up with household and economic needs (UNEP, 2007; Duffy-Tumasz, 2012). These dwindling fish stocks, coupled with the migratory behaviour of coastal fishers increases the vulnerabilities of local households to poverty, disease and instability (Béné et al., 2007; USAID, 2014a). Mangrove wood is also persistently depleted by the fishing sector as a source of energy for basic household needs such as fish-smoking and cooking as seen in Figure 7c which shows the current fuel-wood quantities consumed annually in countries of the region. National data on the use of fuel-wood from mangrove forests and other coastal ecosystems is either scarce, or unavailable, but the exploitation and use of mangrove is well documented as a primary driver of mangrove forest loss across countries of the region (CEC, 1992; Kjerfve et al., 1997; Macintosh and Ashton, 2002). It is, therefore, essential to focus on improving national and regional data on mangrove wood exploitation and use, as well as to develop a database to make this information publicly available to the right stakeholders.

This establishment of coastal; industries, infrastructural development, agricultural expansion coupled with the parallel increases in coastal population has direct implications on the effectiveness of conservation efforts. These developments cumulatively increase the need for adequate amenities to meet needs of industries and human welfare at this environmental edge. These additional pressures are compounded by poor design or poor planning in the construction of these amenities (UNEP, 1999). This lack of strategic planning comes from inadequate or ineffective environmental policies across countries of the region (Diop et al., 2014). These policy failures facilitate poor practices, such as the voluntary discharge of solid or liquid material into coastal ecosystems by industries and domestic households (Abe et al., 2002). The effects of these discharges synergize with the already pressurized ecosystems to accelerate the chemical modification of coastal waters. For instance, over 2,571,114 m^3 of oil was spilt into the Niger Delta since the 1980's (Egberonge et al., 2006). These oil spills can have acute and chronic effects on coastal biodiversity, with a resident time of up to ten years and a probability to drastically reduce sea turtle populations in the Niger Delta (Luiselli et al., 2006). Oil spills are damaging the aquatic environment by loading the water, sea animals, plants and adjacent farm soils with toxic heavy metals. This spillage is potentially dangerous to humans and their livelihood strategies as it leads to contamination and destruction of fish and farmlands (Nwilo and Badejo, 2005). These spills, coupled with oil exploitation operations have depleted about 40% of the mangrove forests in the Niger Delta in Nigeria (Langeveld and Delany, 2014).

At the household level, the Ebrié Lagoon in Abidjan is host to about 3.5 million people, who dump destructively large quantities of untreated domestic sewage into this site (Abe et al., 2002). Consequently, the Ebrié lagoon is facing drastic increases in eutrophication, especially in the bays, which affects marine and coastal biodiversity. Continued disposal of plastics, discarded fishing gear, packaging materials, and other debris, has led to an estimated 4.0 million tonnes of solid waste across the Gulf of Guinea (Ukwe et al., 2006). Immediate implications resulting from these increasing levels of pollution include high Biological Oxygen Demand (BOD), estimated at 47,269 tonnes in the Gulf of Guinea (UNEP, 2000). These effluents affect the development of coastal ecosystems and may impede conservation efforts.

Climate change: The effects of climate change are already visible in the coastal zones of countries of West Africa and Cameroon, and the IPCC (2001); IPCC (2007) predicts that in the coming years, events resulting fromclimate variability will be more frequent and intense when compared to previous years. However, the effects of climate variability on the coastal ecosystems of the region predate the 1990s when serious droughts caused the depletion of vast areas of mangroves in Senegal and Guinea-Bissau (Jallow et al., 1996; Jallow et al., 1999; Sakho et al., 2011). Over time, increasing precipitation levels, compounded by pests and crop diseases around rice paddies led to widespread losses of agricultural productivity in 70% of the cultivable land, and losses of coastal biodiversity in Guinea-Bissau (Da Silva et al., 2005; FAO, 2007). Sea-level rise and oceanic temperature increases have from the warming atmosphere have become a prominent threat to the coastal zone of West Africa and Cameroon (UMOUA and IUCN, 2010; Diop et al., 2014). Rising sea levels, coupled with increased levels of precipitation will increase the risk of flooding in low-lying coastal cities from Ghana to Nigeria and result in property losses, human displacement, dislodging of economic infrastructures and upsetting the coastal fishing industry and tourism (Ibe and Awasiko, 1991; Gabche, 2000). Flooding has already destroyed agricultural lands, salinized drinking water sources and deformed landscapes in Cameroon and the Gambia (Jallow et al., 1996; Munji et al., 2013). Also, even slight changes in average temperature are causing dieback to mangrove forests of Benin and Cameroon (Government of Benin, 2007; Ellison and Jouah, 2012). Climate change is impacting local coastal livelihood strategies of coastal communities and infrastructures



(c)

Figure 7. Data for this figure was culled from USAID 2014b, Feka, 2007; UEMOA and IUCN 2010. a: Relative index for overall population pressure on coastal zones in countries of study; b: Rates of coastal erosion across countries of study; c: Fuel-wood consumption across countries of study.

across countries of the region as elucidated by this study. These climate change effects are also synergising with anthropogenic drivers to exacerbate coastal ecosystem loss (Gabche et al., 2000; IPCC, 2007; Dickinson, 2015). In this way, climate change undermines the planning implementation and conservation outcomes of interventions.

Conclusions

Coastal ecosystems in the countries examined in this study continue to represent a source of socio-economic and ecological opportunities to various local and international stakeholders. Regardless of these possibilities, these ecosystems are now, more than ever, under mounting anthropogenic pressures of different types. These threats are undermining the very existence of these ecosystems as well as the opportunities they offer to humanity. Various institutions have been taking actions to address these threats in countries of West Africa and Cameroon. These institutions implemented a series of mangrove focused interventions with a broader aim of sustaining coastal ecosystems. This study argues that focusing on the efficient management of mangroves, has the advantage of enabling practitioners to monitor and collect information and data that can be used as bio-indicators to predict the overall health and provide clues to the management of other coastal ecosystems and biodiversity.

Interventions implemented to manage mangroves across countries of West Africa, and Cameroon varied considerably in scope and type (Table 5 and Annex 1). How these interventions contributed to overall mangrove and coastal ecosystem sustainability was influenced by various internal (that is, implementing institutions) and external factors (that is, economic, political and climate). The most important drivers of intervention successes included; growing international interest in mangrove ecosystems across the region, and financial support, coupled with a research interest in some of these countries. At the same time, lack of adequate monitoring and reporting of intervention results and lack of basic data to support informed decision-making, along with the lack of sound sustainability strategies in conservation interventions, poor collaboration between local and national institutions, and governance deficiencies were major constraints that restrained institutions from delivering successful field interventions.

Outside the institutional frames, the lack of sustainable funding by implementing institutions and lack of enabling policies promoting mangroves and other coastal ecosystem management favoured and catalysed unsustainable practices that deteriorated these ecosystems and prioritised infrastructural development over conservation and preservation initiatives. Past and ongoing initiatives undertaken to curb drivers causing coastal ecosystem change across countries of the region are slowing the rate of mangrove forest loss as elucidated by this study. However, this recovery of mangrove forests is not reflected in the state and health of other coastal ecosystems across countries of the region. The connecting role of mangrove forests at the coastline interface to other coastal ecosystems means that this inconsistent recovery may have external links on other systems. This study has identified that this might be the result of factors outside the scope of conservation interventions such as; unsustainable economic trends, pressure from population growth, lack of inadequate legal policies and ineffective enforcement of existing legislations. These governance failures are promoting the unsustainable exploitation of coastal resources, pollution, coastal erosion and hence depletion of coastal ecosystems across the region. Also, the effects of these direct anthropogenic drivers are exacerbated by climate change and are anticipated to have far-reaching implications on local livelihoods and economic development across countries of the region.

These findings suggest that to effectively address current threats affecting coastal ecosystems across countries of the region, business-as-usual conservation actions are no longer sufficient. Institutions need to improve the effectiveness of traditional conservation practices, and redouble their conservation efforts as well as develop integrated strategies that broadly consider all activities that affect these systems, vertically and horizontally, within and outside countries. For this to happen, the governments of these countries and international organizations will need sustained political and financial support. This support must be a collective effort by national governments, international agencies, regional institutions, academia, national and international NGOs and corporate institutions working through a common platform. Indicators of this concerted effort should include legislative reforms on policies that promote; efficient management of mangroves, other coastal ecosystems, and improved environmental governance by industries operating at this coastal edge. Failure to expand current conservation efforts and facilitate legislative reforms for the systems under which mangroves and other coastal ecosystems are managed is likely to undermine the potentials of these systems in other national strategies.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Annex 1. Distribution of mangrove interventions across some West-African countries and Cameroon.

Country	Major mangrove locations in country	Conservation status	*Distribution of interventions across locations in country										Size of mangrove areas Km^2)
Senegal	Delta du Saloum	R PA	Si1	Si2	Si3								730
	Casamance estuary	RPA	Si1										20150
	Somone and Joal	R	Si1										ND
	Sine-Saloum Delta	RPA	Si1										650
Gambia	Casamance-Gambia saloum	RPA	Ga1										50
	Bao Bolong	R PA	Ga1	Ga3									200
	Camaloo Corner												ND
	the Gambia River estuary												700
	Tanbi wetland complex	RPA	Ga1	Ga2									45
Guinea Bissau	Ilhas Formosa, Nago and Tchediã Urok)		Gb1		Gb3								545
	Bijagos Archipelago	RPA	Gb1	Gb2	Gb3								1012.3 including marine area)
	João Vieira Poilão	RNP	Gb1										495
	Orango National Park		Gb1										160
	Cacheu River Mangroves		Gb1										576.19
Guinea	Rio Pongo	R	Gu1			Gu5	Gu6		Gu8	Gu10			300
	Rio Kapatchez	R	Gu1	Gu2	Gu4	Gu5							200
	Tristao Island	R						Gu7					850
	Konkouré		Gu1										900
	Alcatraz Island		Gu1						Gu9				ND
Sierra Leone	Leone River Estuary,		Si1		Si3		Si9	Si10					295
	Western Area	R		Si2			Si9	Si10					7.2
	Yawri Bay	PPA	Si1	Si5	Si6	Si7	Si9	Si10					60.0
	Sherbro River Complex	PA	Si1				Si9	Si10					99.8
Liberia	Lake Piso	R	Li1	Li3	Li6	Li7	Li8	Li9	Li9	Li10	Li11	Li8	76.1
	Marshall –wetland	R			Li6				Li9		Li11		12.2
	Mesurado Wetlands				Li6				Li9		Li11		6.8
	Bafu Bay				Li6				Li9		Li11		ND
Côte d'Ivoire	Complexe Sassandra-Dagbego	R	Co1										194.0
	Fresco	R	Co1										105.51
	Ébrié Lagoon Grand Bassam	R	Co1	Co2	Co3	Co4	Co5	Co6					402.1
	Îles Ehotilé-Essouman	R	Co1						Co7				27.274

Annex 1. Contd.

	N'Ganda N'Ganda	R	Co1										144.0
	Parc national d'Azagny	PA	Co1										15.5
Ghana	Anlo-Keta lagoon complex	R	Gh2	Gh3			Gh9						12.8
	Densu delta	R	Gh2	Gh3			Gh9	Gh10	G13				4.6
	Muni Lagoon	R	Gh2	Gh3	Gh5		Gh9	G11	G13	G14			8.70
	Owabi	R	Gh2	Gh3			Gh9				G15		7.3
	Sakumo Lagoon	R	Gh2	Gh3			Gh9		G12				1.3
	Songor Lagoon	R	Gh2	Gh3		Gh6	Gh9						28.7
	Côte d'Ivoire and Cape Three Points	RTr	Gh2	Gh3			Gh9				G15	G16	12.8
Benin	Low Valley of Couffo	R	Be1										475
	Low Valley of Ouémé	R	Be2										916
Nigeria	Niger delta also host to 11700 km^2 of fresh water swamp)		Ni1	Ni2									6600 km2
	Cross River estuary system												ND
Cameroon	Estuaire du Rio Del Rey	RPATr	Ca1										100.0
	Douala Edea landscape	PA	Ca1	Ca2	Ca3	Ca4	Ca5	Ca6		Ca8	Ca9	Ca10	88.0
	Campo Maa'n	PA	Ca1	Ca2				Ca6	Ca7				2.0

R, Ramsar site; PA, protected area; PATr, Proposed protected area in a trans=boundary Location, RTr, Ramsar site in a trans-boundary location * a specific intervention is represented by the first two letters if the country, followed by a number assigned by the authors to the intervention in country. For instance, Se1, intervention one in Senegal. Source: Compiled by authors from FAO, 2007; UNEP, 2007; Feka and Ajonina, 2011; USAID, 2014.


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