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The effects of different gender harvesting practices on mangrove ecology and conservation in Cameroon

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Wood harvesting is an important source of income and a direct threat to mangrove forests in West-Central Africa. To understand the effects of this activity on mangrove ecology, it is necessary to assess harvesting practices of local communities. Knowledge on those is scarce for this region; we therefore examined implications of gender roles on the sustainability of mangrove forests in the South West Region (SWR), Cameroon. Socio-economic surveys, focus group discussions and forest inventories were used for the assessments. Mangroves in the studied sites were dominated by *Rhizophora racemosa*. The Simpson's diversity index did not vary significantly between exploitation levels. The current harvesting style by women (compared with men) is characterised by a larger working area but closer to home and more seasonal, intensive harvesting of smaller trees. This enhances mangrove ecosystem degradation, whereby the effect is exacerbated because of the catalytic harvesting practices of men (less frequent, small scale, selective harvesting of larger trees). To help sustain mangroves in this region, further research on wood harvesting practices and implications for factors affecting growth is essential. To improve harvesting strategies, communities need to be provided with alternative sources of livelihood and educated on the values of mangroves and regeneration techniques.

Keywords: harvesting practices; gender roles; regeneration; mangrove forests; wood; ecosystem services

Introduction

Mangrove forests are crucial not only as unique ecosystems with their own inherent qualities, but also for the support they provide to other biologically diverse ecosystems, including humans. Mangroves provide a range of ecosystem services, including providing nursery for fish species, controlling water chemistry in estuaries and coastal zones and protecting human and natural habitats from floods and similar climate disasters (Dahdouh-Guebas, Hettiarachchi et al. 2005; Worm et al. 2006; Nagelkerken et al. 2008). Despite being invaluable, mangroves have often been regarded as 'wastelands' in the past, because of their 'swamp-like' terrain, abundance of insects and pests and unattractive smell. Regardless, many rural and urban coastal dwellers in Cameroon have recognised the value and livelihood benefits available in mangrove-rich areas hence the increasing need for their conservation and further development. These large socio-economic benefits have been extensively documented (Kjerfve et al. 1997; Dahdouh-Guebas et al. 2000; WRM 2002; Walters 2005b; Walters et al. 2008).

The unsustainable use of mangrove resources as a result of increasing population size and loss through ecosystems conversion for development activities is fragmenting and depleting this system on a large scale (Alongi 2002; WRM 2002; Duke et al. 2007). Between 1980 and 2006, the mangroves of Cameroon were reduced by about 30% as a result of human and natural drivers (UNEP-WCMC 2007). There is growing scientific consensus that human-induced disturbances may permanently alter the ecological functioning of mangrove forests (Jimenez et al. 1985; Sherman et al. 2000; Worm et al. 2006). This might affect its capacity to sustain the provision of benefits to humans. However, mangroves have a remarkable natural capacity for regeneration when disturbed or afforested (Ellison 1998; Zuleiku et al. 2003). There are many factors that can impact the rate and quality of a mangrove's self-restorative power (Bosire et al. 2003, 2004). When threatened by human-induced degradation, the mangroves' natural rate of regeneration is unable to keep up. Human cutting of mangroves for use as fuel wood and for construction materials is the most pervasive and intrusive threat to these unique habitats in West-Central Africa for instance (Dodman et al. 2006). Wood harvesting can be seen as the *catalyst* that opens mangroves to other forms of degradation and depletion. However, there are also indirect or hidden changes that take place within mangroves that can jeopardize their natural functions, such as examples of *cryptic ecological degradation* observed in Sri Lanka (Dahdouh-Guebas, Jayatissa et al. 2005).

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It is now commonly recognised that mangrove wood harvesting is a core economic activity for coastal communities in Cameroon and the rest of Central and Western Africa (Kjerfve et al. 1997; Ajonina and Usongo 2001; Macintosh and Ashton 2005). However, without greater knowledge and research into methods of use, there is a high likelihood that current practices will undermine the natural sustainability of the mangroves and hence the livelihoods of local communities that depend on them. To better understand the impacts from mangrove wood harvesting, it is necessary to assess the harvesting customs and practices of local communities and correlate human activity with changes in tree population and forest structure, composition and regeneration patterns adopting trans-disciplinary frameworks (FAO 1994; Sherman and Fahey 2001). A number of studies have examined the use of mangrove wood by coastal communities in Cameroon and beyond (Diop 1993; Ajonina and Usongo 2001; Din et al. 2008; Feka and Manzano 2008). Results of these investigations demonstrate the high economic value of this activity to coastal communities and local governments. However, there is limited empirical information on the impact of wood harvesting activities on mangrove ecosystem structure and regeneration for this region (Ajonina 2008). Furthermore, data on resource use variations by gender in the wood harvesting process are unavailable in Cameroon. A cursory review of the ground-level activities reveals that such information is essential in understanding forest management dynamics (Robert et al. 2006).

Traditionally, studies examining the impacts of gender roles on natural resources management have concentrated mostly on terrestrial forests (Awumbila and Momsen 1995; Ajonina et al. 2005; Fonjong 2008; Inoni 2009). Equivalent research on the impacts of gender roles on mangrove forest ecosystems does not exist, particularly in Cameroon. Moreover, general understanding on the impacts of wood harvesting on the ecology of mangroves is still limited (Walters 2005b; Walters et al. 2008; Alongi and de Carvalho 2008). We therefore contributed to bridging this gap by investigating how gender activities influenced the ecology of the mangrove forests in the South West Region (SWR) of Cameroon. The results of this study will contribute to improving sustainable management practices of mangrove forests in Cameroon and throughout Western Africa.

Methodology

Description of study region

This study was conducted in four coastal villages of the SWR of Cameroon. The coastal border of the SWR falls along the Gulf of Guinea in Western Africa. Its climate zone is characterised as ranging from maritime to equatorial type and is locally influenced by the presence of Mount Cameroon, the highest peak in West-Central Africa. Average precipitation reaches about 10,000 mm per year in Debuncha, while temperatures averages range from 25.5°C to 27°C during the rainy months and can reach 32–35°C during the hottest months from November to December (Neba 1987).

This study was conducted from February to July 2006, and later completed in July 2008. Study sites were selected based on their importance as fish landings and/or the presence of mangrove wood use activities as identified from survey maps complemented by information from Njifonjou (2005) and Mbog Marius (2005 personal communication). Field sites were located in Fako and included Tiko Creeks and Kangue which are located about 30–35 km south of Buea, the administrative capital of the province (Figure 1). These sites are 2 of the 34 fishing sites located within or adjacent to the 19,000 ha of mangrove forests in the Fako administrative district. Two other sites, Bekerry and Bessengue, are located in Ndian and are 85–93 km southwest of Buea. They are among local fishing sites located within the 101,500 ha of mangrove forests that occur in the Ndian administrative district. Coastal fishing and related activities are the major economic activities in the region and the intensity of fish landings dictates the pace at which other economic activities are able to flourish in the study sites.

Socio-economic surveys

Data were collected using group discussions and semi-structured questionnaire in 143 households across 5 sites. However, for the purpose of this paper, we present information for four sites as forest inventory and subsequent follow-up study was not conducted in the fifth locality because of access difficulties. Only one person per household was interviewed to avoid repetition from members of the same household. Questionnaires were systematically administered across sites to households, on the basis of involvement in wood harvesting activities. We used this sampling approach because the family heads of certain households were not willing to cooperate, so this strategy enabled us to talk to as many households as possible in all sites. Some of the households' representatives were hesitant in answering questions for fear of personal information being leaked to immigration services. This exercise enabled us to quantify wood harvest frequencies. To overcome scepticism from the locals, interviews were conducted in 'pidgin English' with the help of local guides hired from the villages. These local guides also facilitated moving around the villages, reducing hostility and suspicion and facilitating reception and a fluent conversation with the respondents in the households visited, particularly among the Nigerian respondents. The information gathered was then filled out on questionnaire forms in English. In situations where cultural inhibitions prevented the respondents from answering questions (for instance, when some women could not answer questions because their husbands had not authorized them), visual observations were substituted as a method of determining whether to continue with the interview. A few problems encountered during the

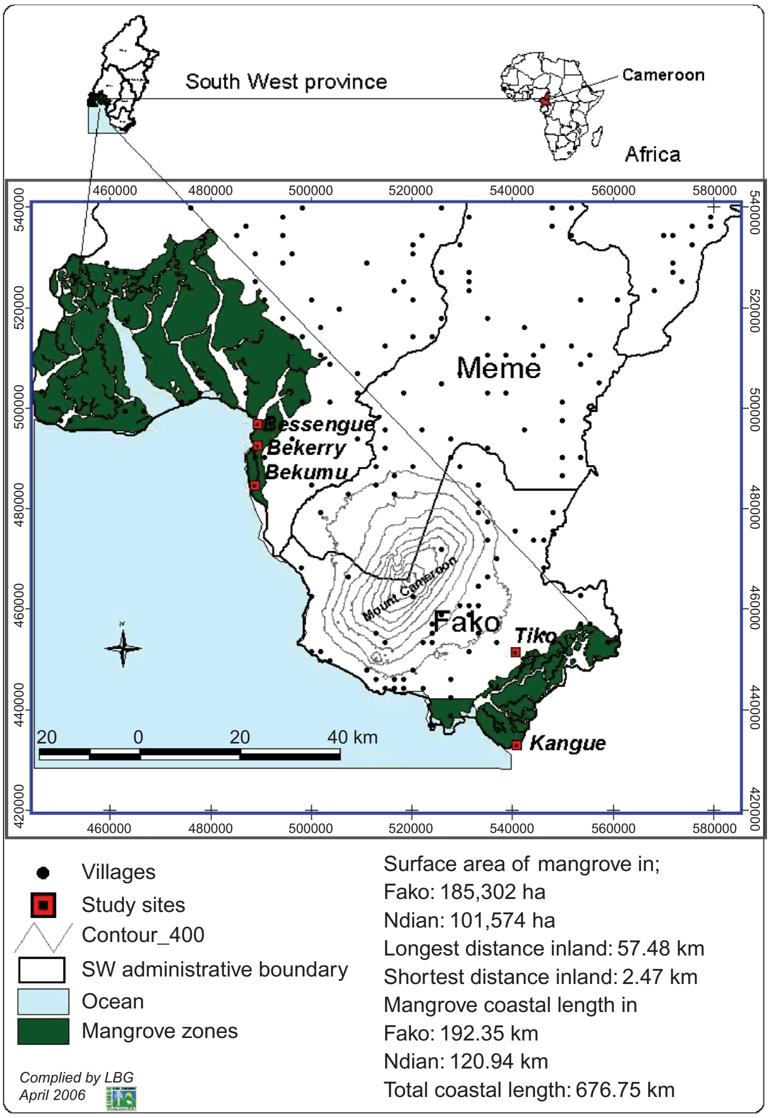

Figure 1. Map showing the distribution of mangroves in the South West Province of Cameroon.
Source: Compiled by Limbe Botanic Garden, Cameroon.

survey related to the current open access of the region's mangroves by local communities for exploitation. Often it took several visits and conversations to gain the confidence of some respondents, who were identified as mostly illegal immigrants.

Assessment of wood harvesting practices and gender characterisation

To complement the village surveys, four groups of wood harvesters (2 male and 2 female, i.e. 16 groups) were monitored from March to April 2006, by accompanying them fortnightly to different harvest sites over a 6-week period to observe how wood harvesting was done by both sexes. These field visits were followed-up in July 2008 with focus group discussions to understand gender group wood harvesting dynamics. Assessment of the types and characteristic of wood harvested by the different groups across the different sites was done using conventional 5 m graduated measuring tape. Wood-piling coefficient (f') and tree-form coefficient (f) were determined following approaches described in Feka and Manzano (2008) to facilitate wood volume calculations.

Assessment of forest structure and regeneration under different harvesting levels

The various wood exploitation levels were categorised using a stratified sampling approach. These were (T_1) for heavily exploited, (T_2) for minimally exploited and (T_3) for no exploitation levels. Criteria for selecting the different levels of exploitation were based on canopy cover, tree size and undergrowth presence of invasive species. The location of field plots was chosen based on prior surveys, the use of maps and with the assistance of experienced local wood harvesters. Four plots measuring 10 m × 10 m were identified so as to represent each of the three exploitation levels at each field location totalling 24 plots in Fako and 24 plots in Ndian.

The systems for plot selection and measuring were based upon the same methods as in Cintron and Schaeffer-Novelli (1984) with plot limits defined using red paint and twin ropes. Trees with a diameter (D_{130}) >2.5 cm were recorded and measured. Tree diameter measurements were taken at a height of 1.30 m (using a diameter tape). For trees with stilt roots above 1.30 m, the diameter was recorded at 0.3 m above stilt root or at convenient distances that facilitated measurements as outlined in studies by Dahdouh-Guebas and Koedam (2006). For all trees with D_{130} <5 cm a calliper was used while a diameter tape was used for trees with a $D_{130} \geq 5$ cm. Only trees rooted within the plots were considered. Tree height was measured from the D_{130} point – formerly referred to as DBH but adapted by Brokaw and Thompson (2000) to D_x (x denoting the height at which the diameter was measured) to the end of the first prominent branch of the tree crown. Height measurements were conducted using Suunto Clinometer for trees ≥5 m and a graduated pole was used for trees ≤5 m. Tree species identification was done in the field using local names, while samples were collected and coded for subsequent identification at the Limbe Botanic Garden.

Seedlings and saplings ≤2.5 cm diameter at the point of measurement from ground level were measured within a single 5×5 m^2 subsection located randomly within each of the 10×10 m^2 plots of T_1, T_2 and T_3 samples. Seedlings and saplings were later grouped into regeneration classes (RCs): RC_1 for diameters ≤0.90 cm, RC_2 for diameters 0.90–1.50 cm and RC_3 for diameters 1.50–2.50 cm. We grouped the classes as such because of the difficulty to distinguish individuals into cohorts since *Rhizophora racemosa* Meyer can exist for several years as suppressed individuals in the undergrowth (McKee 1995).

Data analysis

Seventy four percent (106) of the questionnaires administered were analysed. The remaining fraction was disqualified because respondents were uncooperative during the interviews or questionnaires were submitted with incomplete data. Questionnaires were sorted under gender groups to categorise mangrove wood harvest practices, cost of harvesting and frequency of harvesting. Descriptive statistics such as mean, range, standard deviation (SD) and percentages were also used to the results of this study. Forest survey data were pooled together and compared using a one-way analysis of variance, with exploitation levels considered as treatments. Forest inventory data were transformed into mangrove wood values using the following mathematical relationships:

$$\text{Wood volume} = \frac{\pi D^2}{4} \times h \times f, \tag{1}$$

$$\text{Wood-piling coefficient} = \frac{\sum_{i=1}^{n} \text{kai}}{\frac{\pi D^2}{4}} \times h \times f, \tag{2}$$

$$\text{Number of stems per plot (in ha)} = \frac{\text{Number of stems in plot}}{\text{Plot area (in ha)}}, \tag{3}$$

$$\text{BA} = \frac{\pi D^2}{4}, \tag{4}$$

$$\text{BA}_\text{T} = \sum_{i=1}^{n} \text{BA}i, \tag{5}$$

where h is the height; f the coefficient of form; BA the basal area in m^2; D the diameter; π a constant (22/7); BAi the individual tree basal area; BA_T the total basal area/plot area in hectares; and kai the volume of individual wood piece.

Results

Gender roles in mangrove wood harvesting

The total population of the field study sites is grouped as follows: 62.58% men, 25.66% women and 11.76% children (Table 1). The mean number of persons per household across studied sites was estimated to be 2.56 with a range of 0–13 and SD of 2.98. Harvesting of mangrove wood is carried out by both men and women. However, while it is almost a year-round activity for men, it is a seasonal activity for most women. The women respondents harvested from June to August during low tides across all sites and operated mostly in groups of 2–10 people (Figure 2a) in a given collection site. Sometimes their children, regardless of their sex, provided assistance. Women harvested using rudimentary tools/equipments such as *machetes* and transported the wood using hand-pulled boats. The women explained that most of the harvesting is supposed to take place before the fishing season from October to May. The harvested wood is stockpiled in temporary ‘parks’ in the forest for later transportation from mid-August onward during high tides. This movement is conducted by the use of hand-pulled boats, used for transportation to facilitate entry into the interior mangrove forests. However, during years of low fish harvests, the women might not completely retrieve harvested wood from the temporal parks; hence, there was an increase of the risk of wood being abandoned, eventually left to decay in the forest. Women harvest mainly around settlements, mostly harvesting small-diameter trees, and often cutting up to 8.21 m^3 (SD = 1.8 m^3) per month. They harvested about 60–142 saplings or young trees to fill a ‘boat’ amounting to a volume of 0.86 m^3 (Figure 2b). In addition, the women sometimes obtained wood by *scavenging*, the branches and small-sized trunks abandoned by the men in accessible areas.

The peak harvesting season for men is from November to February and while some also create wood storage piles

Table 1. Population demography in the studied sites of South West Region (SWR), Cameroon.

Locality	Population size	Female	Male	Children ≤15	Fishermen
Tiko creek	754	250	321	183	112
Kangue	600	350	170	80	150
Bekerry	106	17	81	8	40
Bekumu	15,000	4000	9500	1500	3000
Bessengue	3,100	600	1900	400	1230

Source: Feka and Manzano (2008).

(a) (b) (c) (d)

Figure 2. (a) Women depart for wood harvest; (b) wood pile harvested by women; (c) wood harvested and transported by men; and (d) area under harvest by women.

in the forest, it is less customary for them to do so. The distances men travel from their settlements to harvest varied widely and is primarily related to the specifications and type of wood in demand. No systematic data were collected to properly estimate the distance men travelled to harvest. It was reported that they regularly harvested larger sized logs (Figure 2c). They harvested about 1.25–4 stems of fully grown trees in 6–12 hours over 1–2 days to collect a 'boat' full, equal to approximately 0.92 m^3. The harvested wood was transported manually on their shoulders along established muddy tracts to 'boats' about 100–500 m from the harvest points in the mangrove forest. The majority of the wood harvested is for selling to local fish smokers; however, in some cases men harvested wood for their wives in exchange for cash. This payment as pointed out by some of the men was because their wives were using this wood to smoke fish that would be sold. In addition to the basic tools used by women, the men utilise axes and chain saws for harvesting and motorised boats for transportation of wood. Generally, the mean wood harvest load for men was 4.80 m^3 (SD = 1.90 m^3) per individual with a reported maximum of up to 16.50 m^3 per month.

Irrespective of gender, it was observed that there were 11 'wood business promoters' within the study sites. The 'promoters' comprised 82% men and 12% women and financed wood harvesting activities mainly during the fishing season. The 'promoters' paid all contracted harvesters weekly wages; however, examining wage compensation for harvesting was not within the scope of this study.

Wood harvest patterns

Based on follow-up visits to wood harvesters in the different harvesting areas, it was observed that the men started the exploiting activities in most pristine mangrove forests by cutting large-diameter trees and, in some instances, were then followed by women and children who harvested what was remaining. However, the harvest pattern by women of harvesting sites did not exactly follow that of the men, as the former primarily harvested more closely to the settlements. In instances where women initiated pristine forest harvesting, the focus was on small- to medium-sized trees. This is partially a function of the basic tools and physical strength available to women. The wood harvesting frequencies per month and per gender group varied within a range of 0–25 times for men, with a mean of 6.25 and a SD of 3.16 for any typical month between November and February, and in a range of 2–20 times for women, with a mean of 9.61 and an SD of 4.21 for any typical month from July to August (Figure 3). The highest harvesting frequencies occurred during the peak fish season for men and low fish season for women.

It was observed that the mean wood harvesting area for women was about 2000 m^2, with a range of 400–2500 m^2, whereas for men the mean was about 500 m^2 with a range of 10–600 m^2. The frequency of visits to harvested wood sites varied from a mean of 6, ranging between 4 and 13 times for women, to a mean of 2, ranging between 1 and 3 times for men. Women visited the same exploitation site for as long as wood was available for cutting (see characteristics of wood sites harvested by women above). Although men visited their sites for the same reasons, they seemed to practice selective logging because of the characteristics of wood they harvested. Women acknowledged allowing time for forest rejuvenation, which is during the peak fish season – October–May. This time was assessed to be about 16 months, because as pointed out by women: 'we often start the new harvesting season in an area which we logged twelve months back'. However, men were unaware of the need to consider fallow time because they pointed out that 'it takes too long for trees to mature to the size that we need', so 'we continue trailing the forest as demand arises'.

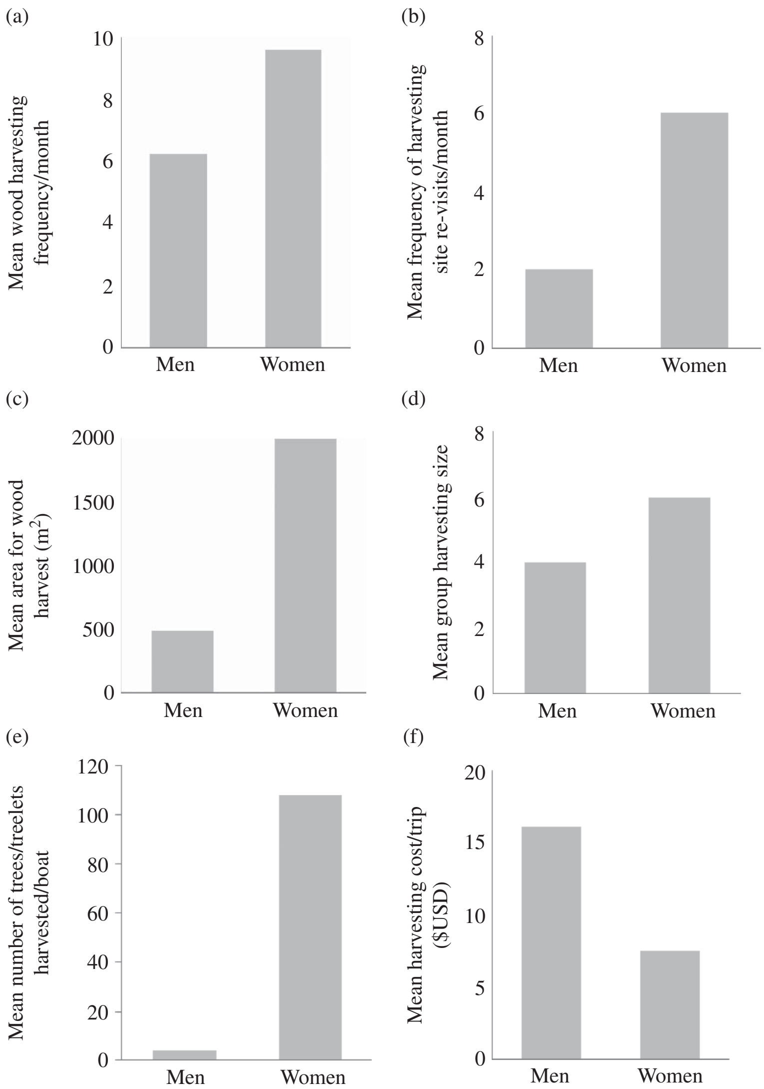

Figure 3. (a) Mean wood harvesting frequencies per month derived from 106 interviewees; (b) mean frequency of harvesting sites revisits derived from focus group discussions with 16 groups – 8 female and 8 male groups; (c) mean wood harvesting area derived from field estimations with groups – 8 female and 8 male; (d) mean wood harvesting groups sizes derived from focus group discussions with 16 groups – 8 female and 8 male; (e) mean number of trees/tree-lets removed to make a boat full derived from 32 wood piles – 16 men and 16 women; and (f) mean wood harvesting cost per trip derived from 106 interviewees and market prices.

The cost of harvesting for women was almost constant at 3750 Fcfa (€5.02) per trip. This was derived using a substitute market prices method because women relied heavily on family support and house subsidies. The cost of harvesting for men varied with a mean of 8050 Fcfa (€10.75), ranging from 3750 Fcfa (€5.02) to 16,750 Fcfa (€22.23), SD 3550 Fcfa (€4.80). The money was used to hire labour, for tools and to purchase fuel for boats for each trip into the forest.

Harvesting levels and the ecology of mangroves

The species *R. racemosa* was the dominant in all pure stands and was the species most used as fuel across all sites of the SWR. In this paper, unless explicitly indicated, results are based on *R. racemosa*. The population structure of mangrove stands under different exploitation levels is shown in Figure 4, and only T_2 and T_3 had trees of diameter ≥20 cm. The population characteristics of T_1, T_2 and T_3 are shown in Table 2. There was no significant difference in the tree density per hectare within T_1 ($F_{4,48} = 0.45$; $P = 0.052$) and T_2 ($F_{4,48}$; $P = 0.74$) (Table 2) when compared between sites. The basal area, standing volume per hectare and mean stand height varied significantly between exploitation levels (Table 2).

Mangrove stands in the field study sites were generally poor in floral species diversity; with the stands in Fako exhibiting absolute dominance of *R. racemosa* in all exploitation levels sampled (Table 3). In addition, there was a clear exhibition of a zoned pattern, with *R. racemosa*, *Rhizophora mangle* (L.) and *Avicennia germinans* (L.)

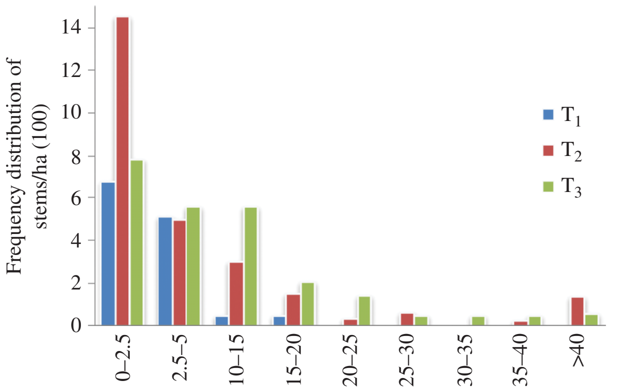

Figure 4. Population distribution measured at D_{130} ≥5 cm of live mangrove trees under different harvesting levels. T_1, heavily exploited; T_2, minimally exploited; and T_3, no exploitation levels.

Stearn forming pure stands. However, from field observations, the introduction of anthropogenic activities seemed to alter such patterns leading to more species diversification. In Ndian, *R. racemosa* was a principal species but other species were equally observed. Simpson's diversity index was almost the same 0.32 for T_1 and 0.35 for T_2, but *Nypa* spp. was observed to play the role of an invasive species as it dominated most of the previously logged areas, particularly in Ndian.

The number of seedlings and saplings per hectare varied between harvesting levels (Figure 5). However, within T_1, there was no significant difference between the different RCs pooled together ($F_{4,48} = 14.49$; $P = 0.00154$). In addition, population densities of seedlings and saplings within T_1 across sites seemed to vary because of different harvesting intensities. Similarly, within T_2 there was no significant difference between the different RCs ($F_{4,48} = 102.47$; $P = 6.42 \times 10^{-7}$), but there was variation in the population densities of the different RCs across sites. With reference to T_3, there was no significant difference within and between the RCs of T_3 pulled together from the different sites ($F_{4,48} = 10.31$; $P = 0.0047$). Based on our definition of seedlings used here and different RCs it was observed that there was a strong variation in propagule establishment and recruitment from RC_1 to RC_3 within T_1. Similar variations were observed for T_2 and T_3, with a general decline in the population size from RC_1 to RC_3 within and between treatments (Figure 6).

Discussion

Implication of wood harvesting practices for mangrove forest sustainability

There are various reasons for mangrove wood harvesting within the studied sites in SWR (Feka and Manzano 2008), but wood harvesting for fish smoking is the most important along the Cameroon coastline (Ajonina and Usongo 2001; Din et al. 2008; Nfotabong Atheull et al. 2009). Mangrove wood harvesting for fish smoking is an activity that involves both men and women. However, it is a seasonal activity for the women, as observed in this study. This partial occupation conforms to the multiple roles and responsibilities that women play in local societies (Awumbila and Momsen 1995). In this case, the women readily switch from wood harvesting to fish smoking and vice versa.

Table 2. Characteristics of mangrove stands, measured under different harvest levels.

Stands characteristic characteristics	T_1 ($n = 16$)	T_2 ($n = 16$)	T_3 ($n = 16$)	F-values	P-values
Mean trees ha^{-1}	744.00	2350.00	1841.00	228.90	0.00
Mean basal area ha^{-1}	2.53	27.26	32.85	524.38	0.00
Mean stand volume ha^{-1}	40.46	283.30	481.37	2972.11	0.00
Mean stand height	3.05	16.21	20.32	N/A	N/A
Number of branched trees ha^{-1}	123.00	712.00	349.00	N/A	N/A

Notes: T_1, heavily exploited; T_2, minimally exploited; and T_3, no exploitation levels.

Table 3. Frequency, density, dominance and importance value for different mangrove wood harvesting levels in Ndian.

Heavily degraded (Ndian)								Minimally degraded (Ndian)							
Species	Number of plots	Frequency	Relative frequency (%)	Dominance (%)	Relative dominance	Simpsons diversity index	IV	Species	Number of plots	Frequency	Relative frequency (%)	Dominance (%)	Relative dominace	Simpsons diversity index	IV
Rhizophora racemosa	8	8	0.33	0.47	0.47	0.16	1.59	*R. racemosa*	8	8	0.44	0.822	0.00822	0.19	2.22
Avicennia germinans	8	6	0.25	0.2	0.20	0.05	0.89	*A. germinans*	8	6	0.33	0.146	0.00146	0.06	1.35
Nypa spp.	8	8	0.33	0.32	0.32	0.11	1.30	*Nypa* spp.	8	4	0.22	0.32	0.0032	0.09	1.45
Conocarpus erectus	8	2	0.83	0.006	0.06	0.00	0.98	*C. erectus*	8	0	0.00	0	0	0.00	0.00

Note: IV, importance value.

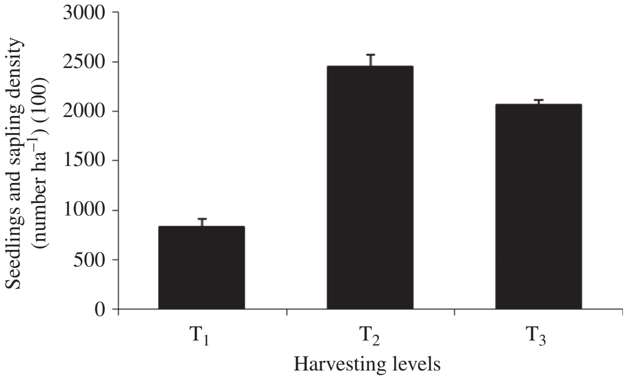

Figure 5. Graph showing the variation of seedlings and saplings density under different exploitation levels. T_1, heavily exploited; T_2, minimally exploited; and T_3, no exploitation levels.

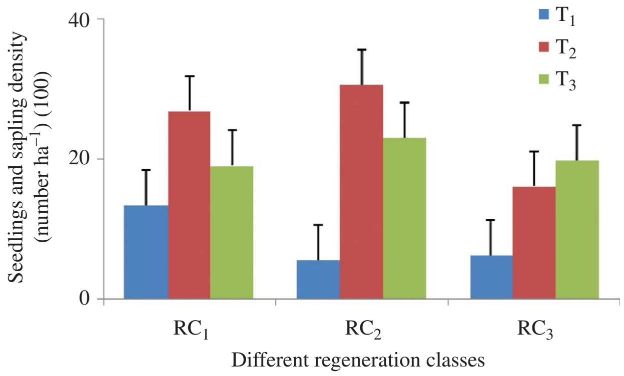

Figure 6. Graph showing variation of seedlings and saplings density amongst different regeneration classes in different exploitation levels. RC_1, regeneration class one; RC_2, regeneration class two; RC_3, regeneration class three; T_1, heavily exploited; T_2, minimally exploited; and T_3, no exploitation levels.

An evaluation of the effect of the harvesting activities by both men and women on the sustainability of the mangrove wood resource reveals the strong impact of the wood harvesting practices carried out by both sexes. Due to the harvesting pattern (larger area, smaller trees, less selective), women removed a significantly higher number of trees to fill a boat as opposed to men for the same purpose (smaller area, larger trees, selective) (Figure 4). This quantity and type of trees (small to medium trees) harvested by women has implications for the ability of the mangrove forest to develop properly because in the areas where the women harvested, most medium-sized trees were absent (Figure 4). In addition, the focus of men on large diameter trees might affect the availability of propagules for regeneration.

Women concentrated their harvesting activities closer to settlements and/or easily accessible areas, because of physical limitations. On the other hand, men harvested over a wider range and in a more selective manner. This is the because of the higher frequencies of harvesting and number of visits to harvesting sites by women over men (Figure 3). Moreover, the comparatively higher frequency might be the result of the low harvest cost incurred by women, which means that during the harvest season there are very few constraints to the number of trips women can make to harvest. This is further enhanced by the little to no enforcement of regulations regarding wood harvesting in this region, a phenomenon that has also been observed elsewhere (Walters 2005b).

While some of the gender differences in wood harvesting strategies may be linked to variations in the seasonal occupation, inventory data from this study indicate that the repetitive and higher harvest frequency by women relative to the men also affects the population dynamics of mangroves by reducing the number of available trees/tree-lets per stand. This conforms to findings that some roles of women in the exploitation of natural resources may undermine ecosystem sustainability (Gadio and Rakowski 1999; Cruz-Torres 2000).

Despite these negative impacts, women might also play important roles in the conservation of natural resources, both by their collective and by their individual actions (Kiørboe et al. 2005; Arya 2007). For instance, as ‘scavengers’ women assist in cleaning the ecosystem and enhance the efficient use of resources. However, this leads to the removal of available nutrients from decomposing vegetation (Alongi and de Carvalho 2008). Although allowing wood to decay in the forest is good for the ecosystem because nutrients are kept intact, paradoxically, resource use efficiency is undermined. On the other hand, while men might be viewed as practicing more sustainable wood harvesting, they are indeed *catalysts* because they set the stage for women to start harvesting. In addition, their year-round involvement in wood harvesting means over-exploitation of resources is taking place because wood is dumped for as low as about 3500 Fcfa ($USD 7) per m^3 from a mean of about 8000 Fcfa ($USD 16.09) per m^3 during low fish season (Feka and Manzano 2008).

As pointed out by Walters et al. (2008) and also observed in this study, it is typical for excessive exploitation of mangrove wood to occur close to settlements. This is a common phenomenon amongst mangrove wood harvesting communities all over the world (Walters 2005a, 2005b; López-Hoffman et al. 2006). This pattern is the result of material poverty of coastal communities and their widespread dependence on mangrove wood products to meet basic subsistence. Hence, as a result of the combined actions of men and women, mangrove wood is over-exploited, depleting the ecosystem and lengthening the time women spend in fetching wood compared with men, and also increasing their workload.

However, when taken independently, both men and women have common but differentiated positive and negative impacts on the health of mangrove forests. But, their cumulative effects have the potential to drastically undermine mangrove ecosystem sustainability (Figure 7). Without proper management measures, these combined actions might transcend the mangrove stands structural impairment to influence soil quality, forest productivity and physio-chemical properties of nutrient cycling (Ellison 1998; Ross 2006). Although not all of these parameters were measured in this study, similar investigations

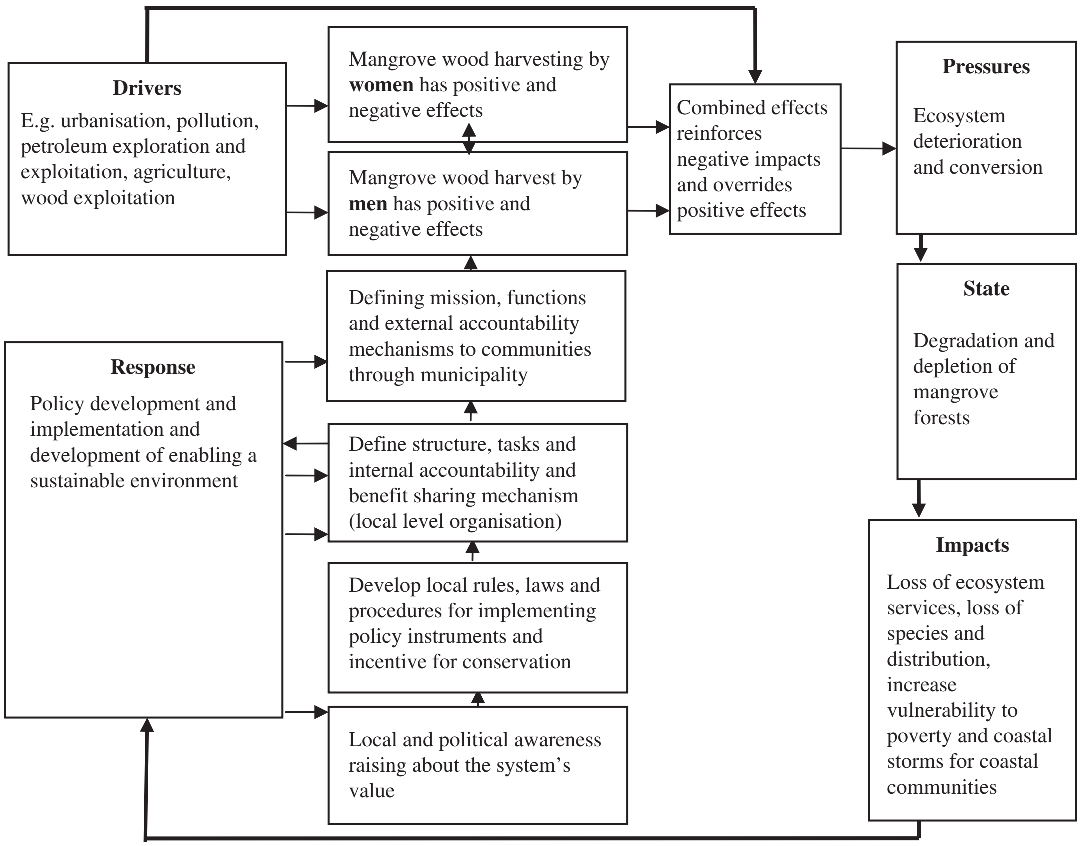

Figure 7. Conceptual framework illustrating the implications of gender involvement in mangrove forests exploitation and prospects for sustainability.

indicate that persistent human interference in the mangrove forests has multiple impacts, including alteration of microhabitat structures along the forest floor, physical destruction of plant organs, disequilibrium of biological associations, indirect impacts on recruitment as well as interference with important macro-fauna significant to the structure and functioning of mangrove ecosystems (Cannicci et al. 2008; Rajkaran and Adams 2009). Persistent harvesting over short time periods culminates in the compacting of the soil (FAO 1994), and hence altering the stable substrate required for seeds to take root and carry-out regeneration. This disruption distorts the adaptive regenerative strategy of free landing *R. racemosa* propagules into the soil substrate (Harun-or-Rashid et al. 2009). This excessive removal of trees means that eventually, propagule sources (seed carriers) will disappear. All of these are critical factors in the regeneration of mangrove forests (McGuinness 1997; Krauss and Allen 2003; Thi-Ha et al. 2003).

Implications of harvesting levels for mangrove stands ecology

The observed stand density for the pristine mangroves is different from results obtained by Ajonina and Usongo (2001), Kairo et al. (2002) and Feka (2005). This discrepancy could be attributed to the fact that these authors considered trees from diameter >1 cm in their census. However, harvesting of mangrove wood has impacts on both the forest structure and ecology (Walters 2005b; López-Hoffman et al. 2006). Results of this study indicate that because of harvesting patterns, the number of stems per hectare decreased by up to 60% for T_1, but increased by 27% in the case of T_2. Similarly, the basal area per hectare decreased by 90% for T_1 and 15% for T_2, while the standing volume decreased by 92% for T_1 and 41% for T_2 (T_3 is the baseline for this comparison).

This observed variation in stand characteristics between the various exploitation levels is due to the various exploitation intensities, which have resulted in the removal of all trees $\geq$20 cm diameter from the heavily exploited mangrove stands. Nevertheless, the minimal exploitation of stands enhanced the density of small to larger classes while still ensuring the survival of trees $\leq$20 cm. This implies that some level of harvesting is necessary in order to improve the regenerative capabilities of mangrove forests as pointed out by Alongi and de Carvalho (2008). This is because the creation of gaps through either natural or anthropogenic processes is necessary to ensure better growth conditions for mangroves (Clarke and Kerrigan 2000; Clarke 2004). However, chances for successful natural regeneration within mangrove ecosystems usually decrease as the canopy gap size increases (Clarke 2004).

There is little empirical information on the leverage gap sizes or thinning levels that will enable such conditions. It is vitally important to better understand these relationships for community management initiatives where informal mangrove harvesting is taking place – as in this study – and for silviculture purposes. Uncontrolled harvesting greatly alters the microhabitat and the physio-chemical processes required for productivity of mangrove stands (Tomlinson 1986; McKee 1995; Di Nitto et al. 2008). It is probable that excessive harvesting of wood within heavily harvested mangrove stands caused trees and saplings to appear stunted in the study sites of SWR Cameroon. The consequences of the current harvesting patterns within heavily exploited stands are the likely depletion of such stands if no initiatives for sustainable management are applied. Mangroves of the region are dominated by *R. racemosa*, because the genus *Rhizophora* has a very limited ability to rejuvenate using vegetative strategies. Moreover, mangrove species do not possess a persistent soil seed bank (Tomlinson 1984; Harun-or-Rashid et al. 2009).

The implications of harvesting on the composition of mangrove forests are typically a function of its initial composition, presence of invasive species, ability to regenerate and further develop the intensity of harvesting (Tomlinson 1986; Kairo et al. 2002). Other studies (Eusebio et al. 1986; Walters 2005b) point to the importance of species sensitivity to recovering from such disturbances. However, this study reveals that the composition of mangroves was altered because of harvesting or initiation of anthropogenic activities. It is important to note that in Ndian, there were stands where species diversified as harvesting intensity increased (Table 3) while mangrove stands in Fako remained monospecific. This is in contrast to observations by Walters (2005b) and López-Hoffman et al. (2006) that harvested stands of *Aviccennia marina*, *Rhizophora appiculata*, *Rhizophora muconata*, *Sonneratia* spp. and *R. mangle*, respectively, are characterised by a loss in species diversity, although their findings correlate in the case of true mangrove species. In this study, it was observed that pure mangrove stands were monospecific. This is in conformity with Tomlinson's (1986) classification of pure mangrove stands as being monospecific. This condition is, however, altered by the onset of disturbances. According to Harun-or-Rashid et al. (2009) persistent disturbances limit incoming propagules from adjacent forest stands, hence facilitating gap invasion by non-mangrove and mangrove associate species. This alters speciation, hence altering ecology of the system. For instance *Acrostichum* spp. limits regeneration of *Rhizophora* spp. by either competing for nutrients and/or acting as a barrier to the free landing of propagules (Dahdouh-Guebas, Jayatissa et al. 2005). In Ndian, *Nypa* spp. were similarly invasive in heavily disturbed sites (field observation). It is difficult to conclude, however, how wood harvesting is implicitly affecting the composition of mangrove stands in this region because of lack of historical information and data about these forests.

Implications of harvesting practices for the regeneration of mangrove seedlings and saplings

Seedling establishment and recruitment were best in minimally exploited stands, and least in heavily exploited stands, where harvesting intensity was optimal. This is because initiation of exploitation creates gaps, which offer better growth conditions (Clarke and Kerrigan 2000; Clarke 2004). However, as gap size increases due to excessive exploitation the soil hardens; its aggregate stability diminishes and favours propagule wash by tides limiting the chances of natural regeneration (FAO 1994). Regeneration was moderate in the pristine, non-exploited stands because under shade, seedlings, saplings and poles remain suppressed with inadequate light supply (Tomlinson 1986). The high stocking density also favours competition for nutrients, hence the relatively low performance of seedlings in T_3 areas. Natural regeneration after intensive exploitation in mangroves is generally poor. This is because interference in the system alters the substrate and makes it difficult for free-floating propagules to come to undisturbed rest, before the seed loses vigour. Intensive wood harvesting also promotes the death and decline in the population of young trees and seedlings (Robert et al. 2006), while submerged slash emanating from branches and leaves in such areas can facilitate propagule implantation (Hamilton and Snedaker 1984; Stieglitz and Ridd 2001; Krauss et al. 2005). It was identified in the study that scavenging activities of women resulted in such debris being removed, while the combined action of men and women altered the normal food supply to visiting and residential fauna, hence enhancing the probability of predation on mangrove propagules (Cannicci et al. 2008).

While there is scientific consensus that in order to develop a sustainable management plan for mangroves, there is need for regeneration data; there is still too few data as to which factors influence exactly the establishment and early development of mangrove (Jimenez et al. 1985; Krauss and Allen 2003; Di Nitto et al. 2008; Krauss et al. 2008). However, this study elucidates that the interaction of men and women within mangrove areas influences the regeneration of seedlings and saplings to varying extents. However, their combined actions can have multiplier negative implications on the development and performance of these seedlings.

Conclusions

The growing body of research on mangrove wood harvesting has largely excluded the West and Central African region and has also not focused much on the consideration of gender roles. While such studies have enriched our understanding of the pervasive effects of small-scale cutting on mangrove population ecology and nutrient cycling, only a few have looked at the implications of such activities on regeneration.

This study highlights the conflicting, but complementary gender roles in the management of mangrove resources in the SWR of Cameroon. The current harvest style by women is characterised by a larger working area, seasonal harvesting, smaller tree size and more abandoned wood. This enhances mangrove ecosystem degradation, whereby the effect is exacerbated because of the catalytic harvesting practices actions of men (less frequent, small scale, selective harvesting of larger trees). Hence, it is increasingly evident that the conservation of mangroves in this region cannot be done without considering the varying impacts of gender roles and resource utilisation patterns. This is because although all groups are aware of the direct economic benefits of the system to their social and economic wellbeing, they are largely unaware of the need to sustain the ecological foundations of the system for posterity.

This study elucidates the direct implications of current harvesting practices by gender groups on the population ecology of mangroves. However, it is difficult to establish how much of the original mangrove population structure or composition has been altered because to the lack of baseline data and the limited sample size of this study. Notwithstanding, the intensity of harvesting practices influences seedling establishment and recruitment, because subsequent development of the former is influenced by complex factors (McGuinness 1997; Clarke 2004; Dahdouh-Guebas et al. 2006; Cannicci et al. 2008; Krauss et al. 2008). The stability of these factors is seriously altered by intensive harvesting practices, and this destabilisation might dampen the power of this system to rejuvenate to its original status (Sherman et al. 2000). This study also points out that some level of harvesting is required to promote better stand stocking density (Table 2). However, it is not known what exploitation levels are compatible with ecosystem sustainability in this region. Hence, to help sustain mangroves in this region, further research on wood harvesting levels and implications on factors affecting growth is essential. Communities need to be provided with alternative sources of livelihood, educated on the values of mangroves, harvesting strategies, mangrove regeneration techniques and overall improvements in the management of mangrove forests.

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References

Ajonina GN. 2008. Inventory and modelling mangrove forest stand dynamics following different levels of wood exploitation pressures in the Douala-Edea Atlantic coast of Cameroon, Central Africa [PhD thesis]. [Freiburg (Germany)]: University of Freiburg.

Ajonina GN, Usongo L. 2001. Preliminary quantitative impact assessment of wood extraction on the mangroves of Douala-Edea Forest Reserve, Cameroon. Trop Biodiv. 7(2 & 3): 137–149.

Ajonina PU, Ajonina GN, Jin E, Mekongo F, Ayissi I, Usongo L. 2005. Gender roles and economics of exploitation, processing and marketing of bivalves and impact on forest resources in the Sanaga Delta region of Douala-Edea wildlife reserve, Cameroon. Int J Sustain Dev World Ecol. 12:161–172.

Alongi DM. 2002. Present state and future of the world's mangrove forests. Environ Conserv. 29:331–349.

Alongi DM, de Carvalho NA. 2008. The effect of small-scale logging on stand characteristics and soil biogeochemistry in mangrove forests of Timor Leste. Forest Ecol Manag. 225:1359–1366.

Arya SL. 2007. Women and watershed development in India: issues and strategies. Indian J Gend Stud. 14:199–230.

Awumbila M, Momsen HJ. 1995. Gender and the environment: women's time use as a measure of environmental change. J Global Environ Change. 5:337–346.

Bosire JO, Dahdouh-Guebas F, Kairo JG, Cannicci S, Koedam N. 2004. Spatial variations in macrobenthic fauna recolonisation in a tropical mangrove bay. Biodivers Conserv. 13(6): 1059–1074.

Bosire JO, Dahdouh-Guebas F, Kairo JG, Koedam N. 2003. Colonisation of non-planted mangrove species into restored mangrove stands in Gazi Bay, Kenya. Aquat Bot. 76(4): 267–279.

Brokaw N, Thompson J. 2000. The H for DBH. For Ecol Manage. 129:89–91.

Cannicci S, Burrows D, Fratini S, Smith TJ, Offenberg J, Dahdouh-Guebas F. 2008. Faunal impact on vegetation structure and ecosystem function in mangrove forests: a review. Aquat Bot. 89:186–200.

Cintron G, Schaeffer-Novelli Y. 1984. Methods for studying mangrove structure. In: Snedaker SC, Snedaker, JG, editors. Mangrove ecosystem research methods. Paris (France): UNESCO. p. 91–113.

Clarke PJ. 2004. Effects of experimental canopy gaps on mangrove recruitment: lack of habitat partitioning may explain stand dominance. J Ecol. 92:203–213.

Clarke PJ, Kerrigan R.A. 2000. Do forest gaps influence the population structure and species composition of mangrove stands in Northern Australia. Biotropica. 32:642–652.

Cruz-Torres ML. 2000. The dynamics of natural resources degradation: rural households and women's strategies for survival in North Western Mexico. Ann Arbor (MI): Women and International Development Program, University of Michigan. Working Paper No. 270.

Dahdouh-Guebas F, Hettiarachchi S, Lo Seen D, Batelaan O, Sooriyarachchi S, Jayatissa LP, Koedam N. 2005. Transitions in ancient inland freshwater resource management in Sri Lanka affect biota and human populations in and around coastal lagoons. Curr Biol. 15(6):579–586.

Dahdouh-Guebas F, Jayatissa LP, Di Nitto D, Bosire JO, Lo Seen D, Koedam N. 2005. How effective were mangroves as a defense against the recent tsunami? Curr Biol. 15(12): 443–447.

Dahdouh-Guebas F, Koedam N. 2006. Empirical estimate of the reliability of the use of the Point-Centred Quarter Method (PCQM): solutions to ambiguous field situations and description of the PCQM+ protocol. For Ecol Manage. 228:1–18.

Dahdouh-Guebas F, Mathenge C, Kairo JG, Koedem N. 2000. Utilization of mangrove wood products around Mida Creek (Kenya) amongst subsistence and commercial users. Econ Bot. 54(4):513–527.

Dahdouh-Guebas F, Verneirt M, Tack JF, Van Speybroeck D, Koedam N. 2006. Propagule predators in Kenyan mangroves and their possible effect on regeneration. Mar Freshw Res. 49:345–350.

Din N, Saenger P, Priso RJ, Siegfried DD, Basco F. 2008. Logging activities in mangrove forests: a case study from Douala, Cameroon. Afr J Environ Sci Technol. 2:22–30.

Di Nitto D, Dahdouh-Guebas F, Kairo JG, Decleir H, Koedam N. 2008. Digital terrain modelling to investigate the effects of sea level rise on mangrove propagule establishment. Mar Ecol Prog Ser. 356:175–188.

Diop S. 1993. Conservation and sustainable utilisation of mangrove forests in Latin America and Africa Regions. Part II. Africa. Nishihara (Japan): ISME & ITTO. Mangrove Ecosystems Technical Report No. 3; ISME/UNESCO Project.

Dodman T, Diop IJ, Mokoko DD, Ndiaye A. 2006. Priority conservation actions for coastal wetlands of the Gulf of Guinea: results from an Eco-regional workshop, 2005 Apr 19–22; Pointe-Noire, Congo. Dakar Yoff (Senegal): Wetlands International Dakar.

Duke NC, Meynecke JO, Dittmann S, Ellison AM, Anger K, Berger U, Cannicci S, Diele K, Ewel KC, Field CD, et al. 2007. A world without mangroves? Science. 317:41–42.

Ellison JC. 1998. Impact of sediment burial on mangroves. Mar Poll Bull. 37:420–426.

Eusebio MA, Tesoro FO, Cabahug DM. 1986. Environmental impact of timber harvesting on mangrove ecosystem in the Philippines. In: National Mangrove Committee, editor. Mangroves of Asia and the Pacific: status and management. Quezon City (Philippines): Natural Resources Management Center, Ministry of Natural Resources. p. 337–354.

Feka NZ. 2005. Perspectives for the sustainable management of mangrove stands in the Douala-Edea wildlife reserve, Cameroon [MSc thesis]. [Buea (Cameroon)]: University of Buea.

Feka NZ, Manzano MG. 2008. The implications of wood exploitation for fish smoking on mangrove ecosystem conservation in the South West Province, Cameroon. Trop Conserv Sci. 1(3):222–235.

Field C. 1997. The restoration of mangrove ecosystems. International newsletter of coastal management, Intercoast, special edition No. 1: 11 Narragansett, Rhode Island, U.S.A.

Fonjong LN. 2008. Gender roles and practices in natural resource management in the North West Province of Cameroon. Local Environ. 13(5):461–475.

[FAO] Food and Agriculture Organization. 1994. Mangrove forest management guidelines. Italy (Rome): FAO. FAO Forestry Paper No. 117.

Gadio CM, Rakowski CA. 1999. Women's changing roles and status Thieudeme Senegal: the impact of local and global factors. Women and International Development Program; February 1999; Ann Arbor (MI): University of Michigan. Working Paper No. 267.

Hamilton LS, Snedaker SC. 1984. Handbook for mangrove area management. Gland (Switzerland)/Honolulu (HI): UNEP/East West Centre Environment and Policy Institute.

Harun-or-Rashid S, Biswas RS, Bocker R, Kruse M. 2009. Mangrove community recovery potential after catastrophic disturbances in Bangladesh. For Ecol Manage. 257:923–930.

Inoni OE. 2009. Effects of forest resources exploitation on the economic wellbeing of rural households in the Delta state, Nigeria. Agric Trop et Subtropic. 41:1.

Jimenez JA, Lugo AE, Cintron G. 1985. Tree mortality in mangrove forests. Biotropica. 17(3):177–185.

Kairo JG, Dahdouh-Guebas F, Gwanda O, Ochieng P, Koedam N. 2002. Regeneration status of mangrove forests in the Meda Creek, Kenya: a compromised or secured future. Ambio. 31 (7 & 8):562–568.

Kiørboe D, Vinding M, Salazar V, Tuxen H, Munk H. 2005. Integrating indigenous and gender aspects in natural resource management. Gland (Switzerland): World Wide Fund for Nature.

Kjerfve BB, de Lacerda D, Diop SH. 1997. Mangrove ecosystems studies in Latin America and Africa. Paris (France): UNESCO.

Krauss KW, Allen JK. 2003. Factors influencing the regeneration of mangroves *Bruguiera gymnorrhiza* (L.) Lamk on tropical pacific Island. For Ecol Manage. 176:49–60.

Krauss KW, Doyle TW, Twilley RR, Smith III TJ, Whelan KRT, Sullivan JK. 2005. Woody debris in the mangrove forests of South Florida. Biotropica. 37(1):9–15.

Krauss KW, Lovelock CE, McKee KL, Lopez-Hoffman L, Ewel SM, Sousa WP. 2008. Environmental drivers in mangrove establishment and early development: a review. Aquat Bot. 89(2):105–127.

López-Hoffman LE, Monroe IE, Narváez E, Martínez-Ramos M, Ackerly DD. 2006. Sustainability of mangrove harvesting: how do harvesters' perceptions differ from ecological analysis? Ecol Society. 11:14.

Macintosh JD, Ashton CE. 2005. Report on the Africa Regional Workshop on the sustainable management of mangrove forest ecosystems, Centre for African Wetlands; 2003 Feb 17–19, Legon, Accra, Ghana. Legon (Ghana): University of Ghana.

McGuinness KA. 1997. Seed predation in a tropical mangrove forest, a test of dominance-predation model in Northern Australia. J Trop Ecol. 13:293–302.

McKee KL. 1995. Seedling recruitment in a Belizean mangrove forest: effects of establishment ability and physico-chemical factors. Oecologia. 101:448–460.

Nagelkerken I, Blaber S, Bouillon S, Green P, Haywood M, Kirton LG, Meynecke JO, Pawlik HM, Penrose A, Sasekumar V, et al. 2008. The habitat function of mangroves for terrestrial and marina fauna: a review. Aquat Bot. 89(2): 155–185.

Neba AS. 1987. Modern geography of the Republic of Cameroon. 2nd ed. London (UK): Longman.

Nfotabong Atheull A, Din N, Longonje SN, Koedam N, Dahdouh-Guebas F. 2009. Commercial activities and subsistence utilization of mangrove forests around the Wouri estuary and the Douala-Edea reserve (Cameroon). J Ethnobiol Ethnomed. 5:35.

Njifonjou O. 2005. Gestion participative et conservation de la diversité biologique des mangroves Camerounaise, unpublished. Papier présenter au séminaire de Tiko/Douala; 2005 Jul 15–17; Yaoundé, Cameroun (Projét TCP/CMR/2908(A)).

Rajkaran A, Adams JB. 2009. The implications of harvesting on the population structure and sediment characteristics of the mangroves at Magazana Estuary, Eastern Cape, South Africa. Wetlands Ecol Manag. 18(1):79–89.

Robert H, Katherine E, Jason J. 2006. Tracking human disturbance in mangroves: estimating harvest rates on a Micronesian Island. Wetlands Ecol Manage. 14(2):95–105.

Ross PM. 2006. Macrofaunal loss and microhabitat destruction: the impact of trampling in a temperate mangrove forest, NSW Australia. Wetlands Ecol Manage. 14(2):167–182.

Sherman RE, Fahey TJ. 2001. Hurricane impacts on a mangrove forest in the Dominican Republic: damage patterns and early recovery. Biotropica. 33(3):393–408.

Sherman RE, Fahey TJ, Battles JJ. 2000. Small scale disturbance and regeneration dynamics in a neotropical mangrove forest. J Ecol. 88:165–178.

Stieglitz T, Ridd PV. 2001. Trapping of mangrove propagules due to density-driven secondary circulation in the Normanby River estuary, NE Australia. Mar Ecol Prog Ser. 211: 131–142.

Thi-Ha H, Carlos M, Duarte CM, Terrados J, Borum J. 2003. Growth and population dynamics during early stages of the mangrove Kandelia candel in Halong Bay, North Viet Nam. Estu Coast Shelf Sci. 58:435–444.

Tomlinson PB. 1986. The botany of mangroves. Cambridge (MA): Cambridge University Press.

[UNEP-WCMC] United Nations Environmental Programme–World Conservation and Monitoring Centre. 2007. Mangroves of West Africa. Biodiversity Series 26. Cambridge (UK): UNEP-WCMC.

Walters BB. 2005a. Patterns of local wood use and cutting of Philippine mangrove forests. Econ Conserv Bot. 59(1): 66–76.

Walters BB. 2005b. Ecological effects of small-scale cutting of Philippine mangrove forests. For Ecol Manage. 206:331–348.

Walters BB, Ronnback JM, Kovacs B, Crona SA, Hussien R, Badola JH, Primavera E, Babier E, Dahdouh-Guebas F. 2008. Ethnobiology, socio-economics and management of mangrove forests: a review. Aquat Bot. 89:220–236.

[WRM] World Rainforest Movement. 2002. Mangroves livelihoods vs corporate profits International Secretariat Maldonado 1858 [Internet], Montevideo (Uruguay); [cited 2009 Apr]. Available from: http://www.wrm.org.uy.

Worm B, Barbier BE, Beaumont N, Duffy E, Folke C, Halpern BS, Jackson J, Heike K, Lotze MF, Stephen R, et al. 2006. Impacts of biodiversity loss on ocean ecosystem services. Science. 314(5800):787–790.

Zuleiku SP, Ewel KC, Putz EF. 2003. Gap formation and forest regeneration in a Micronesian mangrove forest. J Trop Ecol. 19:143–153.