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Authors: Feka, Njisuh Zebedee , and Manzano, Mario G.

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Research Article

The implications of wood exploitation for fish smoking on mangrove ecosystem conservation in the South West Province, Cameroon

Njisuh Zebedee Feka[1] and Mario G. Manzano[2]

[1]Regional Centre for Development and Conservation, P.O box 669, Limbe, South West Province, Cameroon. Email feka_nz@yahoo.com

[2] Centre for Environmental Quality (CEQ), Tecnologico de Monterrey (ITESM), Monterrey, N.L. Mexico 64849, Email: mario.manzano@itesm.mx

Abstract

In this study we investigated how the use of mangrove wood for fish smoking by local people in some localities of the South West (SW) Province of Cameroon may be in conflict with the conservation and sustainability of mangrove ecosystems. With the use of socio-economic surveys, from February to July 2006, we established that the amount of the annual fuel-wood harvest for five study sites was about 102,650 m^3 (i.e., an amount equivalent to clearing about 205.3 ha of mangrove forests annually). It is estimated that approximately 62% of this total is used to smoke most of the fish (i.e., about 90.7% of the fish landings) across the five study sites. The quantities of wood seemed to vary proportionately with fish landings across sites, hence indicating a probable direct correlation between mangrove wood harvested and its use in fish smoking. The different uses of mangrove wood were similar in all sites, but the quantities of wood extracted from different sites varied, with sites of high fish landings registering the highest fuel-wood turnover. It seemed that local people were unaware of the need to maintain ecosystem functions despite the close relationship between wood and fish harvesting, and their importance in ensuring the livelihood for local population in the study areas. From the revision of current management policies and field observations, we propose the development of adaptive management strategies aimed at improving policy, creating public awareness, and integrating local communities in the development of a sustainable management plan for the mangrove resources of Cameroon.

Key words: Cameroon, Fuel-wood, Fish, Fish Smoking, Livelihoods, Mangrove

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Introduction

Mangroves are facultative halophytes that occur as forests at the confluence of the land-sea interface and are limited to the tropical and subtropical coastlines of the world. They occur in about 121 countries worldwide where temperature, tidal movements, and salinity are important factors affecting their distribution [1,2,3]. Despite their limited geographical range, mangroves are among the most productive ecosystems in the world [4], with a direct economic value of $US200,000 - $US900,000/ha [5]. This is in addition to their goods and services of: provisioning–food, construction materials; regulatory–water purification and pollution control; providing important carbon sinks; protection of coastal communities from tropical storms; and ecological benefits–breeding and spawning grounds for fish, nesting sites for important migratory birds, and socio-cultural factors, among others [See 6,7,8,9].

While it is now unequivocal that mangroves are important both by the nature of services they provide to humans and other ecosystems, the sustainability of mangroves is seriously uncertain. Like most tropical forests, they are being degraded and destroyed globally. About 50% of mangroves were lost in the first half of the 20th century, and the residual 181,390 km^2 stock continues to be depleted at a rate of about 1% [10, 11]. Although estimates [5] indicate that by 2025 mangrove forests in developing countries will have declined by 25%, a recent study shows that this is an underestimate, because about 25% of the mangroves of coastal West-Central Africa have already been lost in the last 25 years (1980-2005), with Cameroon losing about 30% of its mangrove forests [11]. The consequences of these trends will be enormous and far-reaching, and in West-Central Africa these changes are already being felt; of particular note are the diminishing fish stocks, species extinction, and vulnerability of human communities to tropical storms and surges in the region [12,13,14,] .

While the drivers causing this depletion/deforestation vary from one region to another [15], there is a general consensus that anthropogenic activities are the root drivers of this change. In addition, while the dilemma of mangrove ecosystem conversion for aquaculture is recognized as the greatest threat to mangrove forests, globally pollution, agriculture, and urbanization seem to be making headway among developing countries. Furthermore, exploitation of mangroves for fuel wood, charcoal production, construction, and other uses have been identified as an important pervasive and intrusive threat to this ecosystem [16], particularly within coastal developing countries, where local communities depend on the exploitation and use of these resources for their livelihoods [17, 18,19].

Like many coastal developing countries, Cameroon has extensive mangrove forests, on which local communities depend for their livelihoods [20, 21]. The most important resource drawn from this ecosystem in Cameroon is wood, used for fish smoking, and the magnitude of mangrove wood exploitation has been identified both locally and regionally as a major threat to this ecotone [16, 19, 21]. Since mangrove wood exploitation contributes to mangrove deforestation/depletion, there is a need to understand the dynamics of wood harvesting and its use in order to prescribe management directives [8, 22]. However, empirical data that elucidates the importance of mangrove wood harvesting and its use for fish smoking is scarce for Cameroon and West-Central Africa [16,23,24]. It is important for the purpose of sustainable management of coastal ecosystems to clearly identify and quantify the importance of mangrove wood use in relation to fish harvesting. Such baseline data is relevant for the long-term conservation of these ecosystems [24,25], particularly in developing countries, where dependency on natural resources plays a significant role for the life of populations. Hence, this study quantifies mangrove wood and fish harvesting in five sites of South West (SW) Cameroon in order to demonstrate the direct importance of mangrove wood exploitation and livelihood sustenance for local coastal communities, and the connection of wood harvesting and fish smoking and its collective implications for this ecosystem's sustainability. As a result of this study, conservation practitioners will take cognizance of the needs of local people, identify the importance of associating them in the management of mangrove forests, and hence develop realistic sustainable management agendas for these ecosystems.

Methods

Description of study site

The SW province of Cameroon shares a border forming a continuum of the Gulf of Guinea along the Atlantic Ocean. It is characterized by a maritime to equatorial climate type, and is locally influenced by Mount Cameroon, the highest peak in central and West Africa (4095m). The mountain's rain-shadow effects provide abundant rainfall locally reaching 10,000 mm per year around Debuncha. On the other hand, the northern and eastern sides of Mount Cameroon lie in a relative climatic effect. Average temperatures range from 25.5°C to 27°C during the rainy months, and can reach 32°C to 35 °C during the hottest months from November to December [26].

This study was carried out in five coastal villages of SW Cameroon (Fig. 1), a subset of part of more than 80 villages and/or fishing camps situated within or adjacent to mangrove zones. Study sites included Tiko Creeks (1) and Kangue (2) located in Fako, about 30 and 35 km South of Buea, the administrative capital of the province. These fishing camps are two of the 34 fishing sites located within/adjacent to 19,000 ha of mangrove forests in this administrative unit. The three other sites, Bekerry (3), Bekumu (4), and Bessengue (5), are located in Ndian,which are 85km, 90km and 93km southwest of Buea and also constitute a subset of fishing sites within the 101,500 ha of mangrove forest resources that occur in the Ndian administrative unit. Study sites were selected on the basis of the importance of fish landing and/or mangrove wood use activities, using survey maps complemented by information from Nijifonjou [27] and Mbog, Pers-com, 2006.

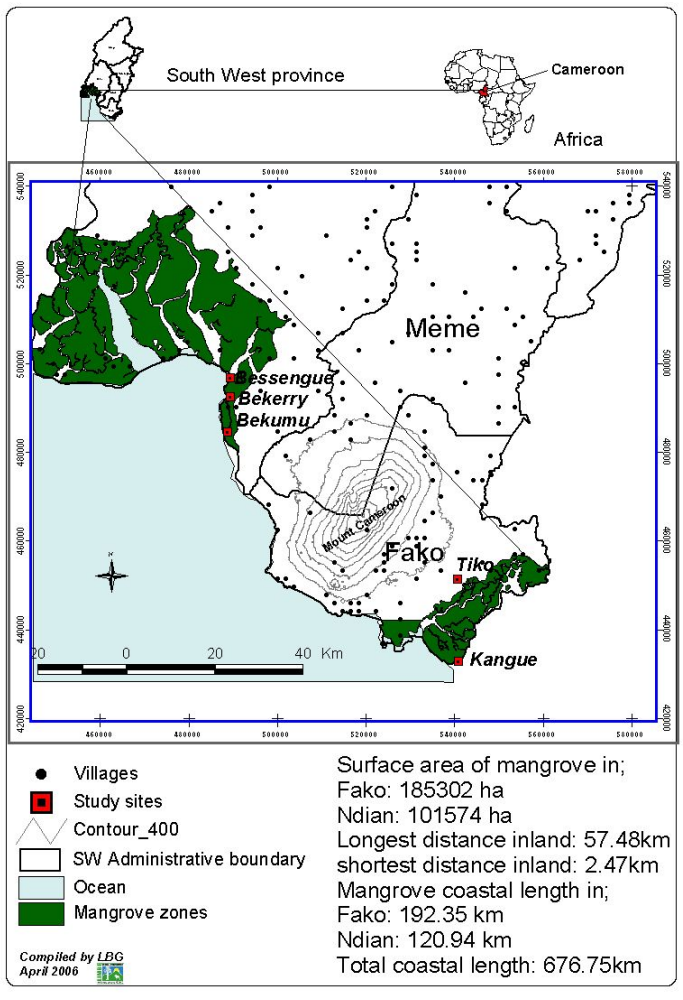

Fig. 1. Map of mangroves of South West Province, Cameroon showing study sites

Besides isolated mangrove ecosystem surveys [e.g., 19,28] and project interventions, such as that by the Food and Agriculture Organization (FAO) which was aimed at conserving the biodiversity of the mangroves of SW Province, management initiatives within the region's ecosystem are insignificant. Mangrove forests are currently under the auspices of the Ministry of Forests and Fauna (MINIFOF), but with limited resources (four forestry officers responsible for over150,000 ha of mangrove land cover, coupled with no offshore facilities) the management of this ecosystem is extremely difficult. However, in recognition of its natural scenic beauty, both above and below the water level, the mangroves of Ndian were proposed to be part of the Ndongore national park at the end of the 2005 FAO mangrove project in Cameroon [27].

The mean household size across sites was estimated using information from [27], complemented by field data from this study. The mean household size across sites was estimated as 2.56 range 0-13, SD 2.98 (See Table 1). The population composition of the sites studied is 62.58% men, 25.66% women, and 11.76% children. This population fluctuates regularly with changes in fishing seasons, since most male fishermen migrate to follow the fish schools along the entire Cameroon coast. Most of the fishermen are from neighboring countries such as Nigeria, Benin, and Ghana, and the latter are considered as strangers by indigenous groups such Bakwerians, Bomboko, Bamusso, Barondo, and Isangele–local ethnic groups along the SW coast. In addition to these strangers are Cameroonians not originally from these localities and mostly from North West and Northern Cameroon. This group makes up about 80-90% of the population of these communities and has been settled in these areas since the 1940s. Each village is headed by a local chief, nominated by the indigenes and installed by local divisional or sub-divisional officers (appointed government officials) and supervised by the village traditional councils.

Table 1: Population distribution in the studied sites of South West Province

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	15000	4000	9500	1500	3000
Bessengue	3100	600	1900	400	1230

Fishing and fish smoking are the major economic activities, and fishing dictates the pace at which other economic activities flourish in the study sites. The Bekumu fishing port is also an important trading area and, according to the traditional ruler there, it is the most important center for the production of smoked fish in West and Central Africa. The adjacent costal areas have limited land available for subsistence slash and burn farming. Most of the agricultural land has been planted with palms or rubber or is held in a tangle of inheritance rights by the Cameroon Development Corporation (CDC). Few crops are well suited to the muddy and sandy acidic soils of the lowland coastal areas, with only *Manihot esculentus* Crantz (cassava) and *Musa* spp (plantain), which are staple foods on which these communities depend, growing well in these areas. Occasional hunting of wildlife and basket weaving are carried out in the off-season for fishing. Access to basic social amenities, such as drinking water, schools and health centers, is scarce and alternative livelihood opportunities are practically non-existent.

Socio-economic surveys

Data were collected using group discussions, informal interviews and semi-structured questionnaires (See Appendix 1), in 143 households across five sites. Only one person per household was interviewed to avoid repetition from members of the same household. Focus group discussions were held with fuel-wood harvesters in all five villages followed by interviews of community heads. Four group discussions were held, to understand group and wood harvesting dynamics. Questionnaires were systematically administered across sites to households, on the basis of involvement in fish smoking and/or wood harvesting activities. We used this sampling approach because the family heads of certain households were not willing to co-operate, 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/fish harvest and purchase frequencies and benefits from wood harvesting.

To overcome hesitancy 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 (e.g., 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 or not. A few problems encountered during the survey related to the current open access of the region's mangroves by local communities for exploitation. Questions dealing with mangrove wood and fish harvesting often resulted in a lot of suspicion, which made the gathering of information by the team rather complicated. Often it took several visits and conversations to gain the confidence of some respondents, who were identified as mostly illegal immigrants.

Wood harvesting and fish landings assessments

Seasonal calendars (Fig. 2) indicating wood harvesting patterns at each site were developed based on a five-point ranking system (0 = no activity to 5 = peak activity) to understand variation in wood harvesting trends. Results from this activity pattern were subsequently used to calculate an index for the annual wood harvest per site. Mangrove wood used for particular purposes was assessed through extensive field measurements by youths in each village (site), trained by the researcher for the purpose of this study. The dimensions of fresh wood piles per site were recorded on a weekly basis for three months (February-April) and the mean was extrapolated over a year using the index calculated from seasonal calendars. Measurements were done using conventional 5-meter graduated measuring tapes. Wood used for house construction, fish-smoking rafts, etc., was measured directly—for example, measurements were taken for (n) structures per use type and the mean extrapolated for the number of such structures at the site (See Appendix 2). A wood-piling coefficient (f') and tree-form coefficient (f) were determined following approaches described in [29]. Secondary data were obtained from official local administration records—e.g., the local Ministry of Fisheries and Animal Husbandry Officers (MINEPIA) provided information on fish landings.

Data analysis

One hundred and six questionnaires equal to 74% of respondents were used for numerical analysis. Thirty-seven (37) questionnaires were discarded because respondents were observed not to be cooperative during the interviews or questionnaires were not completed. Analyses were carried out to categorize mangrove wood and fish use, harvest patterns, economic cost of harvesting and purchasing mangrove wood and fish and mangrove wood harvesting as a livelihood strategy.

Mangrove wood parameters were calculated from the following relationships:

Wood log volumes = $\frac{\pi D^2}{4} \times h.f$ (m^3) ---------- (1)

Wood piling coefficient *f*= $\sum_{i=1}^{n} kai$ /volume of whole wood pile---------- (2)

Volume/ha = $\sum_{i=1}^{n} kai$ /area occupied (m^3/ha) ---------- (3)

Stocking density (trees/ area in ha) ---------- (4)
Conversion factor 1m^3 *Rhizophora racemosa* = 624 kg (field mensuration) -- ---------- (5)

Where:
D = diameter, *f* = coefficient of form, π = Constant (22/7), *kai* =volume of individual wood piece and *n*= number of pieces/ pile

Results

Mangrove wood exploitation practices

Mangrove wood exploitation in the SW Province of Cameroon is a delicate activity that requires a proper mastery of tidal movements and adaptation to the muddy and pungent substrate (soil) on which the vegetation grows. Adapting to these conditions has been very difficult for most of the indigenes and thus the domination of this trade by Nigerians, Ghanaians, and Bunnies who were reported to have a cultural affiliation to this type of environment from their countries of origin. Women, helped by their children and "*wood dealers*" were professionally involved in wood harvesting while some men supported their wives in harvesting opportunistically. Women harvested mainly within and around fishing ports, as was the case in Bessengue, Kangue, etc., mostly harvesting small-diameter trees, in the process cutting up to 8.21 m^3, SD=1.8 m^3 per month and ~60-142 saplings or young trees to make a "boat" full 0.86 m^3. The women harvested from June to August during low tides across all sites (See Fig. 2) and operated mostly in groups. Harvested wood was stockpiled in temporary parks in the forest against transportation from mid-August onward during high tides, enabling hand-pulled boats (Fig 3a)–used for transportation–to enter into the interior mangrove forests.

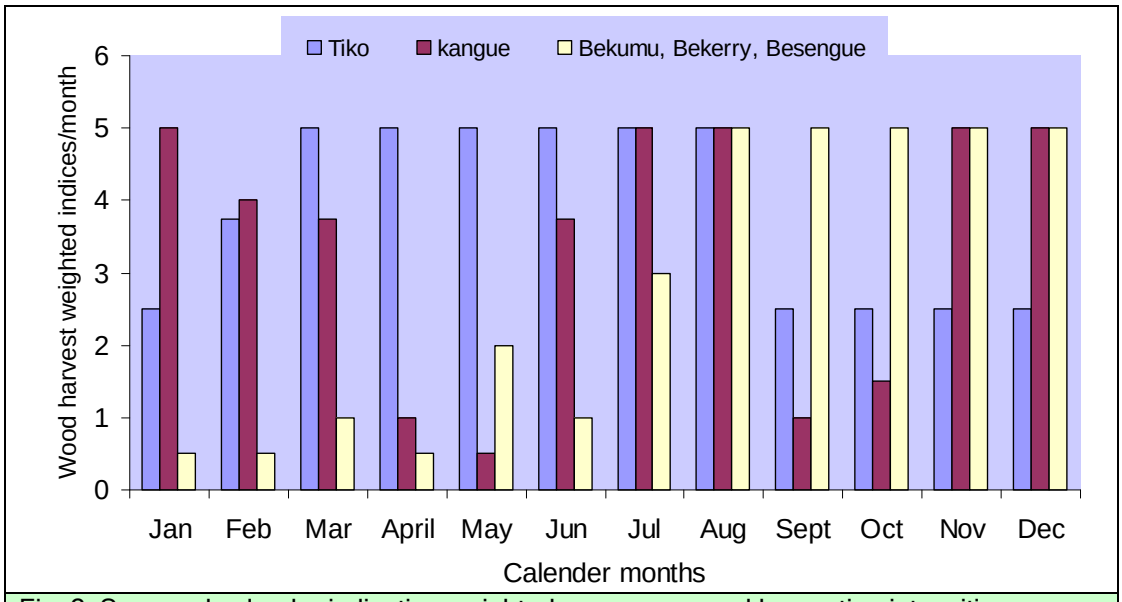

Fig. 2: Seasonal calendar indicating weighted mangrove wood harvesting intensities according to wood harvesters in South West Cameroon

Because wood harvest by women was in anticipation for the fishing season, during low fish harvests, wood could be abandoned, eventually rotting in the forest, and the women often complemented their wood stocks by purchasing larger logs of wood from male wood dealers. The latter transported logs or pieces of logs on their shoulders along established muddy tracts, to "boats" about 100-500m from the harvest points in the mangrove forest. Wood dealers harvested ~1.25 to 4 stems of fully grown trees to make a "boat" full in 6-12 hours spread out over 1-2 days. Men harvested mostly from November-February, mainly to supply fish smokers, and harvesting was done with instruments, such as machetes, axes, and pull boats, in addition to chain saws and motorized boats used by men. Generally, the mean wood harvest load by the wood dealers was 4.80m^3, SD=1.90 m^3 per individual with a maximum of up to 16.50m^3 per month. The unit for wood harvest/sale in this region is "boat" with a volume content varying from 1.37m^3-1.79m^3 depending on the site.

Figure 3: (a) woman transporting wood in hand pulled boat. (b) Women harvesting mangrove wood b

Wood harvesting strategies varied considerably between sites and were gender characterized and resource dependent. In all five sites, men always started exploiting the pristine mangrove forests by cutting large-diameter trees while the women and children followed, because of limited physical strength; and in the process almost clear-felling the forest (Fig. 3b). Because of this limitation, women and children recurrently exploit the same areas, hence increasing the rate of trampling on soils. This practice culminates in the observed compacting of soil that distorts the free landing and lodging of mangrove propagules into the soil within heavily exploited mangrove areas in the region, hence limiting regeneration (Feka and Manzano in preparation). In Tiko, wood harvesting was more selective, with harvesting limited to mature trees and harvesters (exclusively men) organized in groups, while in Kangue and Bessengue wood-harvesting practices followed the pattern described above. In Bekumu, exploitation was done mainly by men. However, field observations indicate an acute degradation of mangrove stands from Bekumu to Bessengue, dominated by the invasive *Nypa fructicans* (Thunb.) Wurmb. All mangrove wood used in Bekumu and Eningue–a neighboring fishing port to Bekumu–was harvested from and around Bekerry-Ekondo titi mangrove forests.

Wood harvest and purchase dynamics

The wood harvesting frequencies per month and per individual varied across sites in a range of 1 to 7, with a mean of 2.52, and SD. 1.46. The highest harvest frequencies were recorded in Bekumu and Tiko. Fuel-wood harvest frequencies by women peaked seasonally (see Fig. 2), and harvest was basically for personal use. And besides fueling the needs of fish smokers–mostly women–other reasons for the increasing wood harvest frequencies included "raising money to meet urgent and basic needs" such as household rationing, purchase of books for children, cigarettes, etc. Wood harvest activities are generally low during low fishing seasons and as a result, the purchase price per m^3 of wood is very low–sometimes as low as 3,500 FCFA or about ~$US7[1]/ m^3. It was difficult to

[1] At the time of this study, 1$=500 FCFA

assess wood harvest cost for women because they relied heavily on family support and house subsidies for harvesting. However, the cost of harvesting for men varied across sites with a mean of $US 16.09, range $US 7.50-33.25 and SD $US 7.18. This money is used to hire labor and instruments and fuel boats for each trip to the forest. Most of the wood exploiters highlighted the important role of employment and financial rewards wood harvesting and hence fish smoking have on their socio-economic well-being. Wood commercialization, particularly during peak fishing seasons, is very lucrative, and wood sale prices varied across sites with a mean of 12,750FCFA or ~$US 23.5/ m^3 , range 5750-10,000 FCFA/ m^3 or ~ $US 11.5- 20.2 / m^3. Almost no wood was sold in Bekerr*y* because all wood users harvested their own wood directly; this is due to its proximity both to terrestrial forests and mangrove forests. Also, the quantities of wood purchased varied across sites, with the highest values (6.38 m^3 per individual per month) in Bekumu, with a mean of 2.82 m^3, SD 1.13 m^3.

Mangrove wood off-take and uses

The quantities of mangrove wood harvested monthly for subsistence or commercial purposes varied across sites with a mean of 4.18, m^3, a range of 2.15-16.97 m^3, and SD 1.82 m^3. A total of 102,650 m^3 of wood was extracted annually from the study sites with Bekumu having the highest harvesting rate, i.e., about 42.19% of the total. However, it should be noted that wood used for construction purposes had turnover rates of 3-6 years, and the quantities of wood allotted for different uses varied considerably, with about 62.49 % of the total estimates in this study being used for fish smoking alone. Determining the quantity of wood used for cooking was difficult in some sites, because the women simultaneously cooked under the fish smoking rafts, while smoking fish. However, it was evaluated that 34.27% of wood harvested was used for cooking and 3.27% for construction (Table 2). The use of alternative sources of fuel wood was facilitated by proximity to terrestrial forests from where alternative wood could be collected, as was the case in *Bekerry* and Tiko. About 75% of the respondents did not use or have access to alternative wood sources for cooking or smoking fish but did purchase timber from other localities to complement for house construction. With the exception of certain construction purposes, *Rhizophora racemosa* Meyer was the most used species of mangrove plant, and it was used extensively for a variety of almost identical purposes across all sites (Fig. 4).

Fish exploitation and dynamics

The Ictyo-fauna within SW mangroves and offshore marine environments has not been comprehensively studied, but from the busy nature of fishers within and around the mangrove environment in this region, these waterways should be a rich repository for important fishing activities. This resource is jointly exploited by both indigenes and immigrants from neighboring countries, who are playing an important role in meeting the animal protein and food self-sufficiency needs of the SW Province and beyond. Fisheries exploiters of the area include Nigerians, Ghanaians, Beninese, and the indigenous Cameroonians represented by the province's coastal dwellers, Bakwerians and Balondos. These groups of people display a wide range of techniques and enthusiasm in the way they exploit and use these resources. Irrespective of cultural affiliations, it was observed that both men and women were involved in the fishing industry, with the latter using artisanal fishing techniques such as: "hooking," "mbara," and semi-industrial fishing "awasha" (Fig. 5a) practiced mostly by Ghanaians in working teams of up to 30 persons. The women fished prawns with small casnets "Ngotto" and were also involved in bivalves and crab harvesting in estuaries or near mangrove forests.

Fish landings varied considerably across sites with a mean of 424.8 tons per year, and a range of 42-1975 tons per year, with Bekumu having the highest fish production (Fig. 6). The quantities of fish purchased by fish smokers varied, with a mean of 1, 260 kg range (0-20, 00 kg and SD 500 kg per individual per week. The cost of purchasing fish varied with a mean of 645 FCFA ~1.25$US, range of 160-1250 FCFA ~ $US 0.32-2.5 and SD 282.2 FCFA ~$US0.056 /kg across sites. The variability in fish prices was due to seasonal fluctuations in quantities and species. A smoking method (Figs. 5b, c) was used to preserve most of the harvested fish, with only about 9.3% consumed and/or sold fresh. Fish smoking was done exclusively by women, aided by their children or paid assistants. The commercialization of harvested fish was done almost exclusively on site either to fish smokers or

restaurant dealers. After the fish were smoked, fishmongers from various areas around Cameroon and neighboring countries such as Nigeria and Gabon purchased the smoked fish for subsequent retailing.

Table 2. Quantities of mangrove wood exploited and used in some localities of SW, Cameroon

Locality/ village	Measured parameters	Quantities used as fuel		Quantities used for construction						
		Fish smoking (1000) m^3/yr	Cooking (1000) m^3/yr	Houses (100) m^3	FS huts (100) m^3	FS rafts (100) m^3	Fish traps m^3	Rest beds m^3	Fence m^3	Poles (100)m^3
Tiko	Number			78	27	29	0	5	6	
	Quantities m^{-3}	1.25	27.68	0.27	0.49	0.26	0	6.25	27.5	428.2
	Consumption/house hold m^3/yr		NA	0.35	1.81	0.89	0	1.25	4.58	
	Consumption/ smoke house m^3/yr	46.29								
Kangue	Number			92	126	252	0	0	0	
		15.92	0.6	0.17	2.72	2.47	0	0	0	
	Consumption/house hold m^3/yr		6.52	0.18	2.16	0.98	0	0	0	
	Consumption/ smoke house holdm^3 /yr	126.3								
Bekerry	Number			61	29	30	1	3	6	
		1.45	0.5	0.16	0.67	0.31	3.52	0.93	17.3	
	Consumption/house hold m^3/yr		8.21	0.26	2.31	1.03	3.52	0.31	2.88	
	Consumption/ smoke house hold m^3/ yr	50								
Bekumu	Number			937	370	740	0	15	0	
		39.78	5.05	2.78	7.43	9.32	0	4.46	0	
	Consumption/house hold m^3/yr		5.38	0.29	2	1.26	0	0.29	0	
	Consumption/ smoke house hold m3/yr	107.5								
Bessengue	Number			312	103	206	0	0	11	
		9.55	0.87	0.61	3.09	1.98	0	0	34.21	
	Consumption/house hold m^3/yr		2.79	0.19	3.01	0.96	0	0	3.11	
	Consumption/ smoke house holdm3 /yr	92.7								
Total all sites	Number			1480	655	1257	1	23	23	
	Wood stock m^3	63.95	34.7	4.01	14.4	14.34	3.52	14.64	79.01	428.2
	Consumption/house hold m^3/yr		22.9	1.16	11.29	5.12	3.52	1.85	10.57	
	Consumption/ smoke house holdm3 /yr	0.43								

Mangrove wood harvesting and fish smoking as a livelihood strategy

Responding to questions on their involvement in mangrove wood harvesting, 85% of the respondents acknowledged that this was a means of livelihood for most of them who traditionally could not be employed in the city because they were early school dropouts. Many of the wood dealers affirmed that their financial gains could be much more substantial if the problems of harassment by government forestry officials and the declining forest stands could be addressed. As explained by wood exploiters in Tiko, more and more people were coming into the business and they expressed their willingness to accept any external aid that was aimed at putting some order into mangrove wood harvesting functionality in the region. As pointed out by one dealer, the several categories of people involved in the wood exploitation process, spread out in space and time, is a *good economic opportunity* that government could exploit to reduce unemployment and poverty. The entire exploitation process for men includes four categories of people (cutters, loaders, transporters, and splitters) involved in activities which are all remunerative (Table 3). The women and children exploited and transported wood to the village by themselves and only occasionally hired male labor to help in the transportation process–neither women nor children get direct financial benefits in this process.

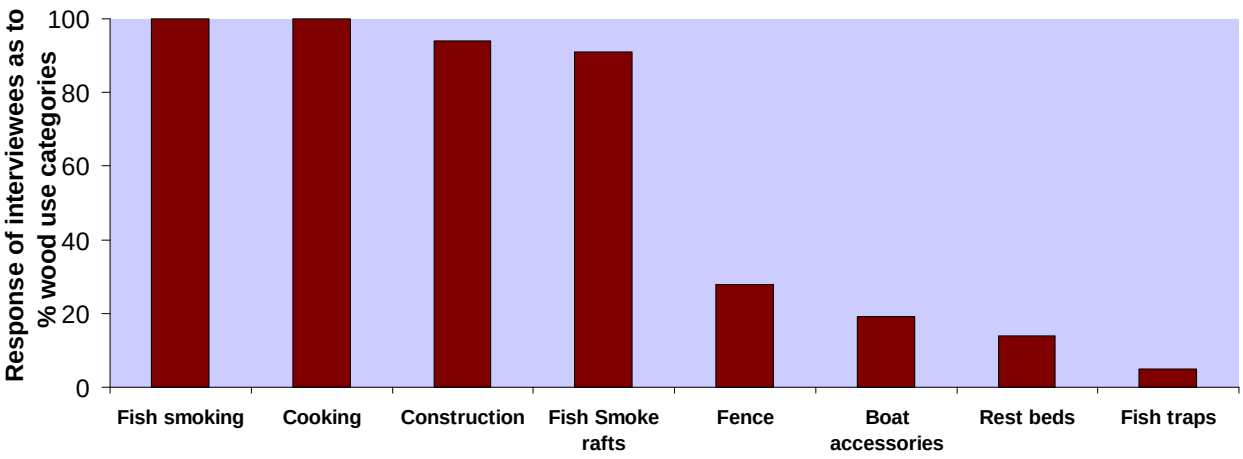

Fig.4. Distribution of wood uses, as a % of 106 respondents in South West Province, Cameroon

Locals acknowledged that revenue generated from wood harvesting was particularly important for livelihood subsistence (Fig. 7). Besides its direct use value, this ecosystem was also observed to have spiritual virtues, particularly among the people of Bamusso, where a small mangrove shrine of ~2 ha was reserved. The Bamusso people used this shrine for performing traditional rites (e.g., offering sacrifices to ancestors and traditional cleansing).

Fig. 5. Dynamics of fish harvest with semi-industrial fishing boats and wood use for fish smoking. (a) Fish landing in semi-industrial fishing botas, (b) traditional fish smoking house, (c) improved fish smoking house..

Discussion

Mangrove wood harvesting and Implications in the South West Province of Cameroon

This work highlights the important effects of gender-specific dependence on mangrove resources exploitation and its effects on the mangrove ecosystem. Limited by physical strength, women recurrently exploit the same forest areas over short time intervals, hence hindering forest regeneration by enhancing soil compaction and destruction of seedlings and saplings [30]. Men have a different effect and are considered less destructive to the forest because of their selective exploitation approach, which reflects an apparent rotation pattern guided by large-diameter trees. The exploitation of this wood is mostly for commercial purposes–selling for use in fish smoking. In addition, although women are the major users of this resource, their involvement in the exploitation process yields no direct financial gains to them because they do not sell wood. Elsewhere, the involvement of women in mangrove wood exploitation, sale, and processing constitutes an important source of direct income to the women [8]. Despite the financial rewards from mangrove wood exploitation in sustaining livelihoods in the area, the impact of increasing wood exploitation may be jeopardizing the ecological integrity of mangroves.

Although the 1994 Forestry Policy recognizes customary exploitation rights, the current harvest and use patterns are not for subsistence only and hence are considered illegal. This state of affairs has resulted in the current uncontrolled and excessive exploitation of mangrove resources and coastal ecosystems in Cameroon. The immediate consequence is that the mangroves of SW Cameroon run the risk of species modification and eventual depletion (Feka and Manzano, in preparation). As pointed out in this work, the mangrove forests of the SW. Province are depleted to the tune of about 0.137% of the 150,000 ha of mangrove per year. Quantitative data on mangrove wood off-take in the province was too scarce to do a comparative analysis. However, the 16,000 ha of mangroves forests of the DEWR area were depleted at 0.33% and 0.47 % annually from 1997-2004 [21, 23]. The discrepancies here are certainly influenced by forest area coverage and the population size of the localities in which these authors carried out their studies. According to [31], the deforestation rate for Cameroon with a population of 16.38 million was ~2,122,450 ha per year or 1% of its forest area. On a per-capita basis this implies 0.13ha of forest cleared in 2005. With an approximate population size of 19,560 for the study sites (i.e., ~ 84-fold smaller than the national population size), projections of current mangrove forest clearance based on national population yields ~ 11.48/ha per capita, far higher than the national values. This means that this ecosystem is under intense pressure from wood exploitation, considering that a systematic survey of all sites was not conducted and wood quantities were extrapolated.

Table 3: Mangrove wood exploitation stages, actors and financial remunerations *

Exploitation stage	Actors involved	Male	Female	Materials	Cost/m^3
Cutting/Felling	Chain saw operators	yes	yes	Axe, Machete, chain-saw	5,000 ($US 10)
Cross cutting	Chain saw operators	yes		Chain-saw	1,000 ($US 2)
Wood piling	Harvest aids	yes		Machete	2500 ($US 5)
Boat loading	General labor	yes	yes	----------	2,000 (US
Transportation to beach	Boat owners	yes	yes	Boat	3,000 ($US 6)
Wood splitting	Wood splitters	yes		Axe	4,000 ($US 8)
Transportation to house	Truck pushers	yes	yes	Trucks	1,500 ($US 3)

*These values are per individual, and an individual can produce up to 2, 5 m^3/day, but not every day of the week nor month.

The most common method of preserving fish among coastal communities in Cameroon is by smoking [32] and as pointed out in this study, this method is gaining more popularity among coastal communities living within or adjacent to mangrove forests in SW Cameroon. It contributes to preserving about 90.7% of the total fish landings from the different study sites. The smoking process was done exclusively by women, aided by their children or paid assistants, and was carried out over open fish-smoking rafts constructed within *Nypa* thatched huts (Fig. 5 b, c). This fish smoking system has been shown to be of low energy efficiency [23, 33]. In addition to its inefficiency, this system exposes the women and children to heat and smoke fumes, hence causing a series of health problems among women and children, mainly respiratory ailments, anemia, and stillbirths (field observation). One hundred percent (100%) of the interviewees preferred mangrove wood for smoking fish because of the golden brown color it imparted to the fish, enhancing its marketability and its "*strong heat*" high calorific value.

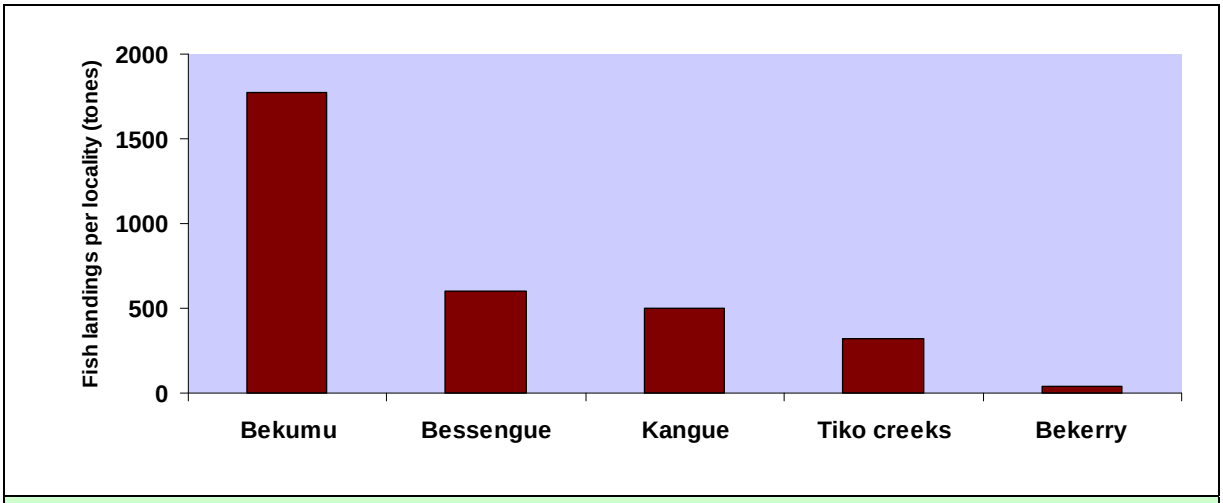

Fig. 6. Fish landings for the different mangrove harvesting localities in South West Province, Cameroon

The major reason for wood harvesting at each site had a direct link with demands by fish smokers or women preparing for the fishing season. According to one source (MINEPIA personal communication, 2006) the intensity of the wood business in the region fluctuates to suit the fishing seasons. This further confirms findings by [21,23] that increasing fisheries activities, number of smoke houses, and the speculative harvest of fuel wood by the locals are key factors contributing to mangrove forest vegetation clearance in Cameroon. Furthermore, observation of fish landings and wood off-take data presented in this study, gives the impression of a relational pattern in the harvesting of these resources across sites (χ^2 =16.084, (0.05, DF = 16) (Appendix 3). However, considering the limited data set it is difficult to assume a correlation of harvest patterns between these resources, although there is an apparent correlation (Pearson correlation of Fish (tons) and Wood (tons) = 0.628 P-Value = 0.257). While this study begins to ascertain this fact, it should be noted that the use of wood for fish smoking is an art determined by expertise, the fish smoking system, and its efficiency. It should have required about 7,370m^3 of wood to effectively smoke 90.7% of the fish to 38% moisture levels [23], based on smoked fish moisture levels calculated in the study sites. Hence there are further parameters linked to the fish smoking industry that need to be probed to make an effective conclusion with respect to mangrove wood exploitation and fish smoking.

The exploitation and use of mangrove wood offers a fairly good livelihood strategy for the rural poor communities of the region, offering the youths and unemployed an income and subsistence opportunities. However, increasing dependency on this system is putting pressure on this ecosystem, hence affecting the mangrove vegetation and its dependent fisheries, as well as the livelihoods of the coastal communities. About 30% of the interviewees acknowledged that their financial earnings from wood exploitation were dwindling as a result of the degradation of mangrove forests in their respective sites. Beyond the relational spheres, the consequences on the ecosystem's sustainability can be wide and far-reaching. For instance excessive human interactions within mangrove stands–as was the case with female harvesting patterns in this study–have been demonstrated to drastically reduce mangrove wood yields in the Sunderbans [34]. The reduction in productivity results from soil compaction, which limits nutrient flow and in the process also makes it difficult for the free-landing propagules to establish easily [30]. Information on similar studies in this region is scarce. However, mangrove vegetation depletion and species modification is already very visible in Bekumu and Bessengue.

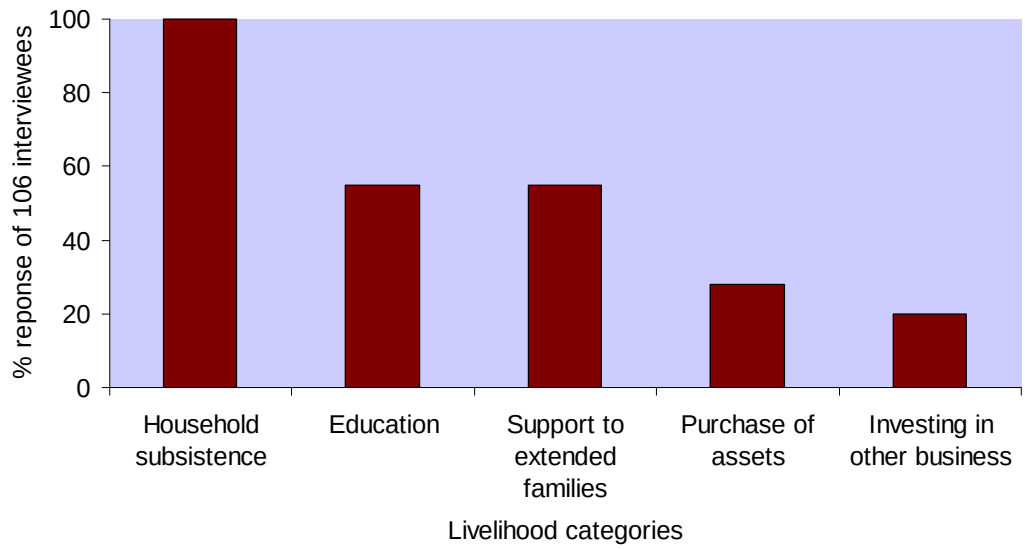

Fig. 7. Partitioning of revenue generated from mangrove wood sales for livelihood as a % response from 106 interviewees.

Implications for conservation

The Cameroon Forestry, Wildlife and Fisheries Legislation of January 1994, coupled with the Environmental Policy Document of 1995, clearly defines the framework for the management of forestry, wildlife, and fisheries resources in Cameroon [35, 36]. These documents highlight the legal procedures required in case of willingness to use and/or exploit terrestrial forests, fauna, and fisheries resources. While these policies grossly neglect mangrove management issues–only making mention of mangrove surface area ~250,000 ha and management actions that can be taken to sustain it–the current exploitation trends are illegal, since no wood exploiter has a commercial exploitation permit in the entire area (field observation). The current pattern of mangrove wood exploitation, as pointed out in this study is unsustainable and hence is affecting the ecological integrity of this system. However, the exploitation and use of mangrove wood, particularly for fish smoking, is obviously important for the socio-economic well-being of coastal communities in this region, as is the case with most coastal communities in West-Central Africa [17, 18]. Hence there is a need to develop adaptive management mechanisms that take into consideration the socio-economic needs of the local people, while maintaining ecological integrity.

Considering the current context of poverty in Cameroon, the development of adaptive management strategies for mangrove ecosystems requires that information be available on such things as wood

harvest patterns and use, harvesting practices, and the effects of gender-specific dependence on resources exploitation as elucidated in this study. The current uses of mangrove resources in the region indicate a clear conflict between fishing and forestry. The very mangrove trees that serve as breeding grounds for fisheries [37, 38] are contradictorily being sacrificed as fuel for fish smoking. All of this information is important for forestry administrators because it is useful in developing exploitation quotas, monitoring systems, taxing commercial exploiters. and predicting the dynamics of potential harvest patterns. Considering the relation between wood harvest and fish curing in SW Cameroon and West-Central Africa, it is therefore clear that mangrove management cannot be developed singly without considering coastal fisheries. Both resources are complementary in contributing towards the livelihood strategy of the local communities.

Unfortunately the communities are typically unaware of their own long-term need to maintain mangroves because 85% of the interviewees reported that in the outcome of mangrove disappearance they would resort to farming. This is an issue because their lands are currently marginal for agriculture and also demonstrates the acute lack of knowledge on the functions of mangrove forests to their well-being. This is contradictory, because about 30% of wood harvesters ascertained that mangrove forests were degraded and/or depleted and as a consequence they were losing out on income and had to travel further distances to harvest wood.

With the current policy deficiencies in the management of this ecosystem in SW Cameroon, this study offers a base to define management prerogatives and strategies on how to equitably consider stakeholder interests, roles, and responsibilities that will contribute effectively toward the sustainability of the mangroves in Cameroon. However, because of the current lack of financial resources and staff by the forestry administration, the development of co-management initiatives between these communities and the government is an option to be seriously explored. This opportunity is provided in the 1994 Forestry law on “community forests.” Co-management (CM) with communities relies on customary authority, local rule making, and local level enforcement to operate, working on consensus, self-regulation, and social sanctions. Communities manage their own resources, define their needs and aspirations, and make decisions affecting their well-being.

This approach will, however, be more effective in a context where indigenes are real custodians of the land. In the case of the SW Province, custodianship among mangrove land dwellers is difficult to discern and it will be important to fully understand these dynamics before moving into this process, because it is important for institutional management purposes [30]. Further difficulties in this approach may emanate from inadequate capacity of communities to plan and manage the legal and managerial status of members, and the issue of land tenure. For this reason, co-management involving local Non-Governmental Organizations (NGOs), community members, and researchers under the supervision of government authorities is a perfect combination. Despite all odds, community forests have contributed to biodiversity recovery and livelihood improvements in the Bamenda highlands of Cameroon [39], and mangrove community forest programs in Thailand have contributed to restoration of ecosystem services, biodiversity, financial autonomy, social cohesion, and accountability in the Trand communities [40]. The importance of such an approach is that lessons learned, testimonies, and local monitoring procedures can easily be transformed into policy with very little effort.

While it may be common knowledge that coastal communities are dependent on the exploitation of mangrove resources for their well-being, illustrating the connectivity of resources and how these dynamics can be used for management purposes is very important in ecosystem sustainability. Given the current economic situation and the scarcity of alternative income-generating activities, mangrove wood harvesting and fish smoking are a necessity for local people to meet their needs in the face of scarce financial resources. This study has elucidated that the variation in wood harvest, purchase frequency, and related financial investments were influenced by demand from fish smokers.

Considering the relation between wood harvest and fish curing in SW Cameroon and West-Central Africa, mangrove management cannot be developed singly without considering coastal fisheries and the local communities. Both resources are complementary in contributing toward the livelihood strategy of the local communities. Unfortunately, the communities are typically unaware of their own long-term need to maintain mangroves, as shown by the statements of 85% of the interviewees that in the outcome of mangrove disappearance they would resort to farming. This situation creates a conflicting trade-off between preserving the ecological integrity of the mangrove forests and responding to human needs. Resolving this situation necessitates creative and practical management solutions. But with current policy gaps, overexploitation of resources and improper understanding of the ecological and economic value of this system in Cameroon, it becomes critical to address the issues in terms both of poverty alleviation and biodiversity conservation. Proper sensitization, and the use of information like that highlighted in this study to improve policy and enforcement, are vital in effectively addressing the current state of this ecosystem in the region.

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Appendix 1. Mangrove socio-economic survey questionnaire, South West Province, Cameroon

1) Background

- Name of village ----------
- Household size **Adults ≥ 21-------- Children ≤ 15----------**
- Gender **Male** ☐ **Female** ☐ (**Tick one**)

Uses

- Do you use 'matanda' mangrove wood **Yes** ☐ **No** ☐
- If No What other source of wood do you use ----------
- **If yes**, what do you use it for? Please tick use types and indicate quantities used (round logs, split wood, dried, stored from previous year).

Use types		**Quantity (**logs/week**) Condition**	
Fish smoking	☐	----------	----------
Cooking	☐	----------	----------
Building Banda	☐	----------	----------
House construction	☐	----------	- ----------
Beds	☐	----------	----------

Others (please specify) ----------

- Do you prefer '*matanda*' to other fuel wood? **Yes** ☐ **No** ☐
- Why----------

Fuel wood acquisition

- Where do you get your fuel wood (Tick one) Buy ☐ **Harvest** ☐
- If from the **wood dealer**, what is the cost---------- quantity---------- ----------?

How often do you buy fuel wood? **Weekly** ☐ **Monthly** ☐ **Daily** ☐

- When is wood most abundant in the market? ----------Why ----------
- If you **harvest** from the forest.
- How often do you go and harvest? **Daily** ☐ **Weekly** ☐ **Monthly** ☐
- About what quantity do you harvest per trip. **No of logs--------length------Diameter-------**
- How much do you invest to go and harvest for a single trip----------
- What time of the year do you do most of your harvesting? ---------- Why ----------
  ----
- Do you sell-use all wood harvested? **Yes** ☐ **No** ☐
- Where do you sell the wood harvested? ----------
- Do the forestry officials ask you for any thing for harvesting? **Yes** ☐ **No.** ☐
- **If yes** what and for how long? ----------
- When did you start harvesting this kind of fuel wood? Year----------
- Do you think that the forest is decreasing away from the village? Yes ☐ No ☐

3) Fish Survey.

- How do you acquire the fish that you smoke? **Buy** ☐ **Harvest** ☐
- If you **buy**, what quantity do you purchase?

  Daily amount (Kg) --------Weekly amount (Kg) ----------
- After buying if any fisherman brings in fish, can you take in on borrow? **Yes** **No** ☐ ☐
- Do you smoke all fish bought? **Yes** ☐ **No.** ☐
- If no what quantity is sold or eaten----------

4) Health

- Since you started smoking fish have you ever suffered from any health problems? **Yes** ☐ **No** ☐
- If yes what kind of health problems----------?
- Of all these problems which one is the most common one----------?

5) Livelihood strategy.

- Do you make any benefit from the '*matanda*' business? **Yes** ☐ **No.** ☐
- If yes what kind of benefit? ----------
- How does this benefit help you? ----------
- Do you think that 'matanda' is disappearing? **Yes** ☐ **No** ☐
- If yes how is it affecting your business----------?
- In the event of the complete disappearance of '*matanda*' what will be doing?
- Apart from wood do you know any other importance of '*matanda*'? ----------

Appendix 2. Field-measured statistics on some mangrove wood use categories in study *sites*

Sites	Wood use categories	Measured statistics (m3)			
		n	*mean*	*Range*	*SD*
Tiko creek area	House construction m^3	6	0.35	0,02- 1,03	0.05
	Fish traps m^3	0	/	0 - 0	/
	Fish smoke rafts m^3	7	0.89	0,41 - 1,23	0.24
	Fish smoking huts m^3	4	1.77	1,38 - 3,00	0.37
	Fish smoking/ Month m^3	15	4.23	0,57 - 2,43	2.63
	Cooking/ Month m^3	15	0.79	0,32 - 0,78	0.32
Kangue	House construction m^3	15	0.18	0,41- 2,33	0.12
	Fish traps m^3	0	/	0 - 0	/
	Fish smoking huts m^3	9	2.15	0,94 - 2,81	0.42
	Fish smoke rafts m^3	12	0.98	1,68 - 3,26	0.08
	Fish smoking/Month m^3	15	9.86	4,57 - 17,63	2.23
	Cooking/Month m^3	15	0.54	0,22 - 0,72	0.31
Bekumu	House construction m^3	15	0.26	0,11- 1,93	0.14
	Fish traps m^3	0	/	0 - 0	/
	Fish smoking huts m^3	10	2.15	1,54 -3,61	0.34
	Fish smoke rafts m^3	12	1.00	0,92 - 2,86	0.36
	Fish smoking/Month m^3	15	14.03	6,77 - 19,83	3.23
	Cooking/Month m^3	15	0.68	0,42 - 2,86	0.32
Bessengue	House construction m^3	15	0.29	0,81- 2,67	0.04
	Fish traps m^3	0	/	0 - 0	/
	Fish smoking huts m^3	12	1.25	1,24 - 2,41	0.82
	Fish smoke rafts m^3	6	2.01	1,63 -2,89	1.21
	Fish smoking/Month m^3	15	8.43	4,57 - 12,41	3.04
	Cooking/Month m^3	15	0.45	0,32 - 0,78	0.04
Bekerry	House construction m^3	15	0.19	0,01- 1,43	0.08
	Fish traps m^3	1	3.52	0 - 3,52	0.96
	Fish smoking huts m^3	3	2.99	1,04 - 2,61	1.81
	Fish smoke rafts m^3	12	0.96	0,98 - 2,66	0.36
	Fish smoking/Month m^3	15	3.21	1,57 - 5,43	1.02
	Cooking/Month m^3	15	0.36	0,32 - 0,78	0.04

Appendix **3** Chi square tabulated statistics: Fish, Wood

Rows: Fish Columns: Wood	1297.9	6864.0	10608.0	20779.2	25771.2	All
42	0	0	0	0	0	1
56	0	0	0	1	0	1
183	0	0	1	0	0	1
668	1	1	0	0	0	1
2075	0	0	0	0	1	1
All	1	1	1	1	1	5
Cell contents	Counts					
Pearson Chi-Square	= 20.000, DF = 16					
Likelihood Ratio Chi-Square	= 16.094, DF = 16					