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Full Length Research Paper

Logging activities in mangrove forests: A case study of Douala Cameroon

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The Cameroon mangroves are exploited by local communities through fishing, hunting, and especially logging for fuel-wood and charcoal. The changing demographic patterns in the region have increased the need of citizens in the urban centres, which in turn, has accelerated the pressure on the neighbouring forests. The objective of these studies was to assess the impact of local communities on the mangroves' development. Through an eight point semi-structured questionnaire, 120 mangrove loggers were interviewed in the local markets in Douala. The survey data show that 61% of respondents are permanent workers and do not envisage quitting this mode of employment. The surface area destroyed annually approximates 1000 ha. Species of the genus *Rhizophora* are mostly exploited, with about 200,000 trees cut down per year. The declared revenues are about 400,000 Euros per year. Further analysis of information from different sources suggests that the total annual income could amount to four millions euros. These estimates show that the mangroves have a significant economic value and require significant improvement in modes of exploitation to include strategies for sustainable management.

Key words: Anthropogenic impact, deforestation, Douala-Cameroon, economic value, loggers, mangroves, ***Rhizophora***.

INTRODUCTION

The developing countries are confronted by the deforestation problem that has modified phytogeographic landscape and as a corollary has reduced the biological diversity (Duke, 1992; Twilley et al., 1996; Panapitukkul et al., 1998; Puig, 2001). The coastal ecosystems are always the most exploited because most of the world's population inhabits the coastal regions (Pernetta, 1993).

Mangroves play a critical role in the ecology and the economy of coastal communities (Ellison, 1997; Naylor and Drew, 1998; Dahdouh-Guebas, 2000). In Cameroon as well as elsewhere in the world, anthropogenic disturbances promote the dysfunction of these coastal ecosystems. Unlike other countries with coastal ecosystems, Cameroon has a unique situation of having several types of forest ecosystems that contain several woody species. The prediction models (three out of four) on the fate of these forest ecosystems in relation with the climatic changes and the rising of the sea levels suggest their expansion, if the human factor can be controlled (Dixon et al., 1996; Blasco et al., 2001).

The wetland ecosystems are the most vulnerable because of the temporary or periodic variations of the main factors that determine their development. The mangrove forest was naturally protected by the difficulties of access,

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the loose substratum and the abundance of insect pests (mosquitoes, wasps, different flies). The proximity of large modern urban centres has totally destroyed that form of protection. Several coastal ecosystems are directly exploited by local populations, generally through informal activities for survival such as fishing, hunting, logging for fuel wood, and so on.

The Cameroon mangroves have undergone an Industrial exploitation at the dawn of last century (Hedin, 1928). The main species concerned with this exploitation was ***Rhizophora racemosa*** and the signs reminding of this activity are still visible to date at Manoka, where a wood processing plant and the port for export were located. The decline in mangrove wood production, the high exploitation costs and certainly the discovery of substitute species have led to the disappearance of that activity.

There are several and various reasons that account for the deforestation of mangrove ecosystems. To bring forth proposals for effective solutions to limit or control the mangroves deforestations, it is important to catalogue the real causes of this activity in the field, analyze the main socio-economic activities and determine the spiritual relationship, when it exists, between these ecosystems and the neighbouring populations.

The assessment of the informal activities carried out by local populations in the tropical wetland ecosystems is often a determinant to knowing their economic value in developing countries. Not taking into account these values is the major factor under which political decisions often lead to the overexploitation or to the excessive degradation of these ecosystems (Barbier, 1994).

The objectives of the present studies were to:

1) Assess through a single resource, the pressure exercised on the Cameroon mangroves by the local communities.
2) Estimate the real economic value of mangrove forests in the country without introducing their ecological potential.
3) Determine the impact of modernization of logging tools on the development of these ecosystems.

To answer the concerns outlined above, a survey was carried out.

MATERIALS AND METHODS

Study site

The region where this study was carried out is located in the Gulf of Guinea (3° 40'- 4° 11' N and 9° 16' - 9° 52' E). The Cameroon mangroves extend over a surface area of about 2700 km^2 (Figure. 1), divided between the two main estuaries (Rio del Rey in the NW: 1500 km^2 and the Cameroon estuary in the centre: 1100 km^2, where this study was undertaken). The climate is of the particular equatorial type called "Cameroonian" (Din et al., 2002) marked by a lengthy rainy season (at least nine months), abundant rainfall (about 4000 mm per annum), high and stable average annual temperatures (26.7°C).

Douala, the largest city in Cameroon, borders the mangroves on about 30% of its current limits. The proximity of more than two million inhabitants heightens the intensity of deforestation of mangroves in that location compared with other sites.

The survey

The methodology is based on the analysis of the survey data initiated among the mangrove loggers. The survey was conducted in all mangrove fuel wood markets in the city of Douala. The questionnaire was of a semi-structured type (Dahdouh-Guebas, 2000) with, on one hand, the use of short proposed answers, and, on the other hand, the use of free open answers where each interviewed individual could provide his/her own opinion on the question, therefore widening the scope of the analysis of the results.

One hundred and twenty (120) active mangrove loggers, chosen randomly, were interviewed. The questions concerned the preferred logging sites, the resources used, the actual appropriated and commercialized quantities of logs, the revenues, the livelihoods of loggers, and their knowledge on the role of mangroves. The survey sheet comprises eight points:

a. The social situation (the agreement of the surveyed logger is mandatory) allows the logger to be identified, details his/her past, present and future activities, and the sources of energy he/she is using;
b. The localization of the exploitation site which concerns at the same time the fuel wood logging points in the field, and the markets in which the produce is sold.
c. The resources used provide information on the tools the mangroves loggers possess and/or use during their activity, including such tools as canoes, engine-powered canoes or boats, chain saws, carpenter saws, machetes, axes, etc.
d. The daily production is a set of raw numbers provided by each logger. This is the fundamental part of this survey that should provide answers about deforestation and estimate the economic value of the mangrove wood resources. It specifies the targeted species, provides the number of trees felled in the field, usually the length of the used part of the fallen tree, as an alternative to the knowledge of the tree heights, the number of logs obtained and their diameter, and the transported quantity. The surveyor did not adjust or modify the information obtained from the mangrove loggers. Thus, despite the untruthful character of the provided figures, they were kept unchanged.
e. The expenditures of the mangrove logger shed light on the overall resources needed for the accomplishment of this activity. They concern the equipment that he/she can rent or the labour used, the cost of food eaten in the field, different types of fuels, etc.
f. The daily incomes of the mangrove logger are inferred from the answers received on the average quantities of daily sales in the market, while taking into account the eventual price fluctua-tions of all the markets according to the universal law of demand and supply.
g. The monthly revenues are a statement provided by the mangrove logger, without any relation with the aforementioned revenues and expenditures.
h. The role of the mangrove is restricted to a unique question that concerns the environmental knowledge of the mangrove logger.

Analysis of the survey

The figures provided by loggers through different responses are aggregated in two tables: one for the quantitative character, and the other for the qualitative character.

Quantitative analysis

Simple statistical manipulations allowed the determination of the average age of the mangrove loggers, the number of trees likely to

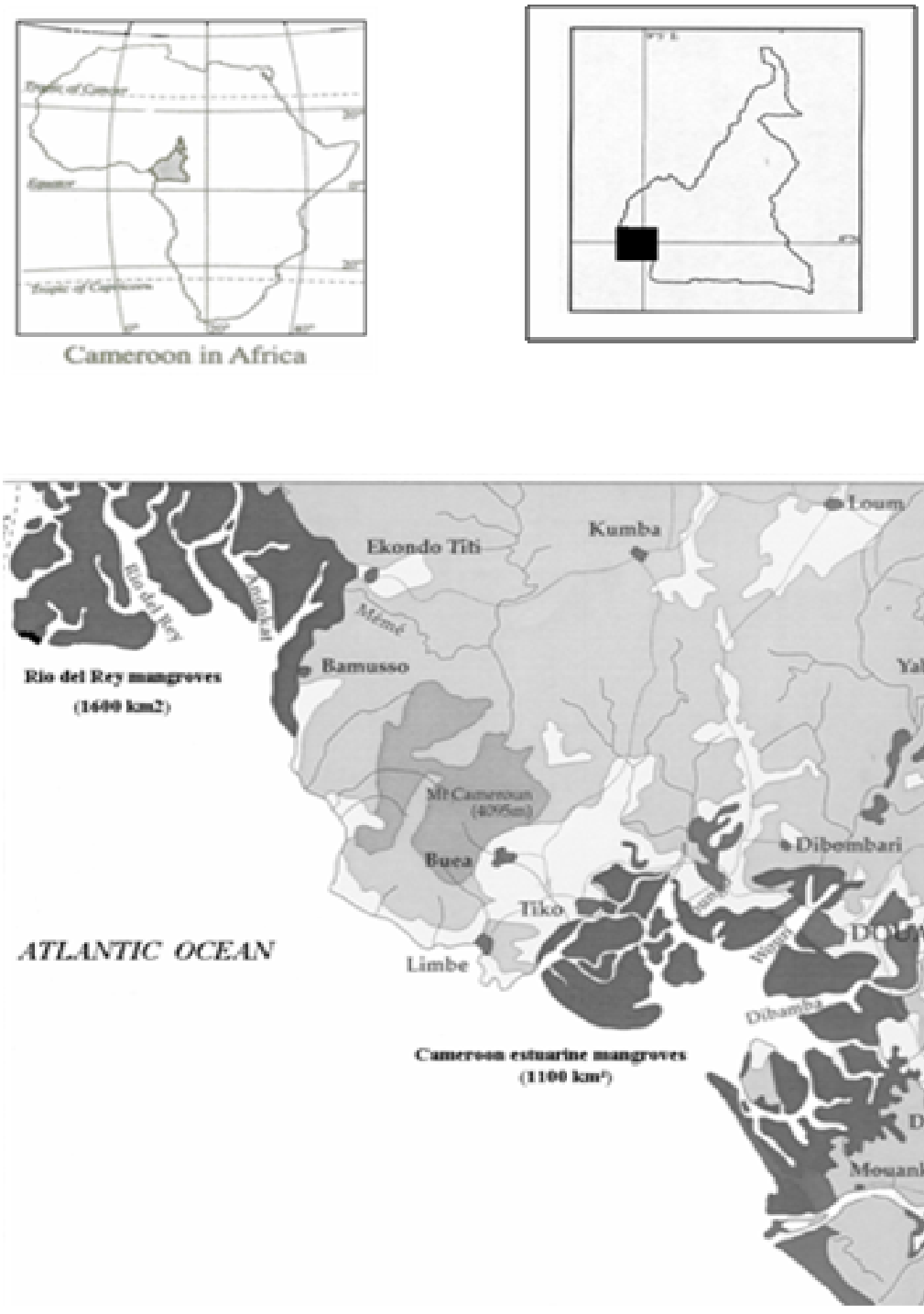

Figure 1. Principal areas (dark) of mangroves in Cameroon. Lowlands and mountain evergreen forests (grey) industrial plantations and cultures (white).(Modified from Din and Ngollo 2002)**.**

be cut down daily, the structural parameters of the appropriated parts and the minimum average diameter of logs found in the market. The largest diameters of logs are difficult to be observed in the market, since the handling operations often force the loggers to split them into pieces that can be easily transported. There is also the problem of boats' equilibrium to avoid high probability risk of sinking.

Using the structural parameters of the trees from the mangroves of the Cameroon estuary (Din et al., 1997), the total surface areas degraded can be estimated. The economic value of mangrove woods is firstly assessed by summing the loggers stated revenues. Being mindful that these revenues are biased for many reasons, other calculation methods have been used when considering the following:

- Because the logs are sold in the market in cubic meters, the estimation of the production using that unit appears to be a reliable information (the maximum average diameter of logs measured by surveyors in the wood markets have been used).
- The daily production being seldom totally transported, one admits that each logger can only knock down trees every other three days, therefore ten (10) business days are considered per month, and 120 business days per year.
- Consequently, the monthly production corresponds to ten times the declared daily production by the logger.

Qualitative analysis

The quality of the exploitation equipment is one of the essential factors of deforestation. It is responsible for the size of the trees to be cut down, the total production and the monthly revenue. The use of different equipment in this activity is assessed to determine the percentage of mangrove loggers who use them, those who own or rent them. In putting together the daily production and the monthly revenue of each logger relative to the average monthly revenue, one can estimate the impact of the equipment on the mangroves degradation.

A scale of 1 to 5 (impact factor) was used to express the degree of vegetation degradation:

1. Very weak, impact not noticeable in the mangrove landscape.
2. Weak, manifestations barely noticeable in the vegetation landscape.
3. Average, effect provoking degradation in the vegetation susceptible to be compensated for by a simultaneous reforestation action.
4. Strong, impact enabling medium-term losses. The reforestation cannot compensate for the deforestation activities.
5. Very strong, activities that provoke important short term destruction.

RESULTS

The survey data show that the fuel wood loggers are relatively willing to talk about their activities. All interviewed candidates accepted to participate and fundamental questions have received relevant answers from which the following analyses obtain their authenticity. After revealing the main reasons that attract peoples in the mangroves, the economic value of appropriated mangroves wood is estimated. Lastly, the equipment used in logging activity allows one to understand the role of modernization of this equipment in the sustainable management of mangrove forests.

Distribution of mangrove loggers

The mangrove forests attracted several individuals who work on a temporary or permanent basis. Among the 120 loggers interviewed, 50 (more than 41%) considered that activity as their unique source of income today and in the future. They do not envisage changing their occupation, and talk about retirement as in other activities. They are more or less satisfied with their revenues and find no serious reasons for them to abandon this activity. Instead, they predicted more investment to increase their revenues and warrant their retirement by a commercial activity when their physical strength will no longer allow them to stay in business.

Twenty-three loggers (about 20%) had parallel activities but do not intend to abandon the fuel wood logging activity. They sometimes find themselves in this business for domestic needs in order to lessen the household expenditures, or to increase the household incomes since they find that the sector is highly lucrative. Among parallel occupations, fishing and sand quarry activities are the most abundant; but people from other business activities such are railway workers, mechanics, motorcycle drivers, bricklayers, security guard agents, charcoal makers, soap manufacturers, and government and private sector retirees are also found in this business.

When grouping the above two categories, one realizes that 73 people (about 61%) are permanently exerting pressure on the mangrove ecosystem. This is only a fraction of interviewed mangrove loggers who did not express the possibility of changing their activity despites the multiple dangers that are associated with this business. The most widely used logging equipment (and the most destructive) is confined to this group of people, with their income amounting to 80% of the overall revenues drawn from the logging activities in the mangrove.

Those who considered that activity as temporary are young people who are waiting for an eventual permanent employment (33 people), or unemployed people who are expecting to find another job (12 people), or already retired people (two people) who are waiting for their retirement allowance. The average age of all surveyed unemployed loggers being above 47 years, the chances of finding another job appear to be minimal. The major constraints that could force them to abandon their current activity are: (i) the lack of physical strength, (ii) the high risk associated with this activity, and (iii) the increasing remoteness of the exploitation sites.

Cameroonians mainly belong to the latter category, not because they want to protect their forest resources, but essentially because of the hard working conditions of that occupation and, according to some mangrove loggers, “it speed up the aging process”. Unfortunately, they generally have insufficient revenues to adequately take care of their large family and invest in other sectors.

The age of the mangrove loggers varies between 20 and 67 years with an average of 46 ± 9 years. The mangrove loggers were partitioned into the following five (5) age classes of 10 years (Table 1):

The cumulative monthly revenues of different classes were calculated. The third class ([40:50]) is the most abundant and the first is the least abundant. That distribution can easily be understood by the fact that before 30 years of age, many young people are still actively looking for jobs and do not yet have the heavy family burden compared with those of the third class. One observes a strong similarity in the classes between the percentages of mangrove loggers and their revenues (Table 1).

Almost all mangrove loggers of less than 45 years of

Table 1. Distribution of loggers and revenues by age groups.

Class centres	Age class intervals	Loggers		Percentage of Revenues
		Number	Percentage	
25	[20;30[	7	5.84	5.27
35	[30;40[	21	17.50	19.97
45	[40;50[	46	38.33	39.12
55	[50;60[	34	28.33	28.92
65	[60;70[	12	10.00	6.72
TOTAL		120	100.00	100

Table 2. Daily quantity of wood harvested from the mangroves and revenues of 120 loggers surveyed in Douala (Cameroon).

	Trees cut down (Number/day)	Maximum diameter (cm)	Wood production (m^3)	Revenues (euros)
Total	569	-	470	11710.37
Average	4.75	31.36	3.92	97.58
Standard deviation	4.36	11.92	3.87	61.38

age are temporarily engaged in this activity, or have it as a parallel activity. They are looking for finances to switch to another activity. They rent modern performing equipment (chain saw, boat) to increase their revenues, those results in a more important deforestation. That age class generally lasted the least in the mangroves logging business. But if one considers that this parameter varies up to 40 years of age, it is clearly not a short-term pressure. The mangrove ecosystems should therefore be considered as being under high human pressure resulting from the increasing number of fuel wood loggers and their rejuvenation.

Assessment of resources

Degraded surface area estimates

The appropriations in the mangroves essentially concern the tree trunk, the crown being abandoned in the field because it requires too much work, in addition to the fact that the branches are less rewarding. Each mangrove logger cuts down an average of five trees daily (4.75 ± 4.36), of a maximum diameter of 32 cm (31.36 ± 11.92 cm), and collects an average length of 10 m (10.28 ± 4.86 m). He extracts 3.92 m^3 (3.92 ± 3.87 m^3) on average, and carries a third from the logging site, while the remaining logs are removed the following two days (Table 2). This survey affected 23 sales outlets of mangrove woods in the city of Douala with about 15 loggers involved at each site. The total number of loggers in this area is estimated to be 350.

Previous surveys on structural parameters of mangrove species on the Wouri estuary show that the average diameter of ***Rhizophora*** spp. was estimated to 18 cm with an absolute density of up to 310 trees per hectare (Din et al., 1997). Considering that the absolute density of a mangrove stand is inversely proportional to the average diameter of the trees, when the mean diameter of ***Rhizophora*** spp. passes from 18 cm to 25 cm and to 31 cm, the density decreases respectively from 310 to 223 trees per hectare and to 180 trees per hectare.

The target species belonging to this genus, and the daily number of trees cut down being 569 of 25 cm average diameter, the surface areas degraded is about 2.55 to 3 hectares. The annual potential degradation is around 900 ha with a maximum surface area degraded of about 1100 hectares.

Economic value of mangrove wood

The mangrove loggers declared average monthly revenue in the order of 97.58 euros. Overall, 350 loggers would make about 35,000 euros monthly and more than 400, 000 € of annual revenues. That assessment continues to show that mangrove wood, the main resource from these ecosystems, constitutes a product of lower economic value that can only be useful for the informal sector. A thorough analysis of the results of the same survey gives figures that are ten times greater than the above declared value.

Impact of logging material

The survey revealed no engine-powered canoe user for the transportation of logs. This mode of wood transport exists anyway as it was observed in other circumstances. The least impact that is devoted to that type of equipment

Table 3. Equipment used during logging operations in the mangroves of the Cameroon Estuary. The values of impact factor represent the level of degradation (1 = very weak, 2 = weak, 3 = average, 4 = strong, 5 = very strong).

Equipment	Users		Owners		Those who Rent		Impact factor
	Number	% Total	Number	% Users	Number	% Users	
Canoes	120	100	94	78.33	26	21.6	2
Powered-engine Boats	0	0	0	0	0	0	1
Chain saws	31	25.83	18	58.1	13	41.9	5
Carpenter saws	103	85.83	103	100	0	0	3
Machetes	120	100	120	100	0	0	2
Axes	48	40	48	100	0	0	4
Hammers	4	3.33	4	100	0	0	1

(Table 3) is in relation with the results of the survey and not in relation to its real efficacy. Almost in one case out of four, the production of the loggers is left in the exploitation site. The introduction of the engine-powered canoe would undoubtedly allow the removal of the entire daily production of logs and even increase the number of logging days, especially if this tool is associated with a chain saw.

The canoe and the machete are essential tools. All the loggers possess a machete and no one works without having a canoe; more than 21 percent rely on the rental of that equipment. The survey did not assess the size of the canoes, the important parameters in the estimation of revenues. Its impact is nevertheless low because the canoes do not directly impact the deforestation process and in an optimistic perspective, they protect the coastal formations already adversely affected by the urbanization phenomenon.

One person out of four uses a chain saw in the logging operations. In association with an engine-powered canoe, this tool appears as the most important forest destroyer. The greatest quantities and the most important diameters were found with the loggers who use this tool. Its destruction capacity is significant and its introduction in the logging activities must be the origin of the increase of the mangrove surface areas destroyed.

The carpenter saw is also an important tool in logging. Besides the chain saw owners, all the other loggers' possess the traditional carpenter saw. It is an essential tool for the extraction of the product to be marketed. The use of a machete or an axe provokes the losses of about 10% when sectioning off the stem into marketable units. The saws are also present in the logging sites where their efficacy is estimated greater than that of machetes, which are essential tools in clearing the paths.

The axe is essentially used in the knocking down of the trees. This is the tool that is responsible of the greatest losses because of the size of the notch. When it is operated by an experienced and vigorous logger, it is capable of destroying as much as a chain saw as far as the knocking down of mangrove trees is concerned.

DISCUSSION

The mangroves are used as an important or potential source of firewood and charcoal, in response to the increase in domestic needs of energy by urban populations in developing countries. The wood exploitation (logging) constitutes one of the main reasons for the degradation of these ecosystems in the world (Hamilton and Snedaker, 1984; FAO, 1994; Ellison, 1997; Dahdouh-Guebas, 2000; Din et al., 2001). Wood appropriation in the mangroves remains an activity which is fully controlled by the informal sector causing that ecosystem to lose its market value.

The major risks from logging activities in the mangroves of Douala are canoe capsizing and loggers' drowning, which are frequently recorded. The main reasons are often the overloaded canoes (Figure 2), lack of protective material (life vests) and the minimal swimming ability of the loggers. The lure to gain overshadows the risks that could have protected the mangroves from intense logging activities.

The direct analysis of the results shows that at least 569 trees are knocked down daily in the mangroves of the Cameroon estuary, hence a potential annual destruction of more than 100,000 trees of ***Rhizophora*** spp. When taking into account these results and considering the above quantitative analysis, given 120 business days per year and the entire mangrove loggers' community in the city of Douala to consist of 350 people, this amounts to approximately 200,000 trees.

Considering the fact that other activities (especially urbanization) produce an irreversible degradation, the mangroves of the Cameroon estuary for which the current surface area is estimated to be 1,000 km^2 have less than 100 years for the actual luxuriant forest to become transformed into plantings without ***Rhizophora*** trees.

In terms of volume in the local market, the mangroves produce 470 m^3 of logs daily (Figure 3). The structure of trees knocked down in the mean time shows that one harvests less than the useable part (for firewood, all parts of the tree are useable except the leaves). The branches

Figure 2. Overloaded canoes with mangroves wood in the Wouri River (Douala).

Figure 3. A mangrove wood market behind the Douala international airport.

and leaves are seldom of interest to the loggers (less than 2 percent). Consequently, they constitute an important loss during the mangroves exploitation. The real production of mangroves is greater than half million cubic meters per annum, but it is mostly discarded as litter.

When taking into account the price of the real cubic meter of mangrove wood in the market (25 - 30 €), the declared monthly income in relation with the produced quantity of wood should oscillate between 100,000 € and 200,000 €. That assessment shows that the real monthly revenues are in the order of 150,000 euros for the sample used, hence almost 2,000,000 euros per annum. Under this new basis (the average monthly revenues: 150,000 €), 350 loggers will have as monthly revenues 455,000 €, hence more than five millions euros annually. In the above evaluation, only the quantities of wood sold were taken into consideration. It was demonstrated above that these quantities represent at least half of the total production of the trees knocked down. If we consider a ***Rhizophora*** tree from the branches down to the roots as producing fuel wood, the aforementioned economic value must in reality express mostly the losses provoked by the loggers in the mangroves than the real revenues coming from the logging activities in these ecosystems. In other words, the possible revenues that could be gained annually from the controlled and sustainable logging of the mangroves would be about 12 millions euros.

When taking into account the fact that charcoal produced from the household using mangrove woods represents about one quarter of the initial volume, purchasers earned $1m^3$ of charcoal when buying 4 m^3 of wood. Considering that the price (in volume) of charcoal is about three times that of wood, the real economic value of this resource would be around 21 millions euros. While working under the same basis, the economic value of all the logs from the mangroves of the Cameroon estuary could be estimated at nearly two billion euros.

In the environmental economy, the total economic val-

ue of a natural resource such as a mangrove ecosystem comprises two main sources of revenues: the wealth coming from the direct valuation of its biological production and services, and the more complex properties that derive from its role in the environment (Barbier, 1994; Spaninks and Beukering, 1997). Among the resources and services to be assessed the forest products have an important value.

The survey method used in this study is closer to that of the supply and demand analysis proposed by Spaninks and Beukering (1997) to assess the mangroves forest resources. The demand can be expressed here by the time needed to sell the goods supplied to the market. Despite the fact that this question has not been explicitly asked of the loggers, the demand remains sufficiently high because the loggers always succeed in selling their production to the retailers. Another indicator is the variation in the price of the cubic meter of wood in the local market, which certainly responds to the universal law of supply and demand.

The household consumption is difficult to assess in developing countries. The proliferation of energy sources used does not favour the estimations. Households that use firewood and/or charcoal generally do not have specific ordered budget lines for their expenditures. Thus, the households are not able to provide reliable data on the consumption of the firewood from the mangroves. In addition, the populations are not aware of the origin of the fuel wood they consume and many people cannot distinguish mangrove logs from firewood of other origins.

The mangroves' future is the balance between the various anthropogenic activities and the regeneration processes. ***Rhizophora racemosa*** shares space mainly with ***Avicennia germinans*** of which the natural regeneration processes are relatively well-known (Din et al., 2002). The regeneration for colonization of new spaces is prevailling at the level of estuaries. The important telluric contributions caused by the abundant rainfall accelerate sedimentation. Intertidal surfaces are quickly colonized by the ***R. racemosa*** seedlings. This species has a remarkable colonizing capacity, even the wrecks of the old boats are used as substrate. It is rare to meet the shrubs under the trees of ***R. racemosa***. The development is through cohort waves.

The scarcity of wind fallen woods in the mature settlements would cause the disappearance of young individuals which are less resistant to the harsh environmental moisture and to the gloomy conditions. The replacement regeneration is consequently feeble in the mangroves and this species almost never takes part in it since the regeneration is carried out in zones where the circulation of organic matters is low because of the frequency and amplitude of the tides.

Generally, the trees are cut within the formation, behind the colonization facade. Apart from the geomorphology which limits the mangroves extension in the Cameroon estuary, human beings appear to be the principal unfavorable factor to this ecosystem regeneration. All the mangroves that surrounded the city of Douala are damaged, thus preventing any possibility of regeneration.

There exist no specifications which determine the age or diameter necessary to cut down a tree. The main factors which intervene in the choice are on the one hand the localization of the settlement (urban zones being most vulnerable) and the nature of the logging material on the other hand (cf. 3.2.3). In all the cases, the anthropogenic activities remain the principal factor of mangroves degradation in the Cameroon estuary (Din et al., 2002; Din and Ngollo, 2002).

Conclusion

The mangrove forest resources are considerable in Cameroon in spite of the fact that they are not embedded in the local or government financial policies. The survey used in these studies has allowed the loggers' revenues gained from the exploitation of mangrove forests to be assessed. Similarly, it supports the hypothesis that the mangroves have considerable potentials and resources that only require to be used in a sustainable development perspective.

The total economic value of the mangroves was not assessed because these studies did not estimate the services, and to the lesser extent the function of these ecosystems in the coastal system. The biological resources were not entirely evaluated and only forest products provide important revenues that can be used in a perspective of sustainable development.

The economic value of mangroves is real and sufficiently important for that ecosystem to merit greater interest from different acting parties. To date, marginalizing the mangrove plantings is mostly due to ignorance. The loggers who are harvesting the visible resources of that ecosystem are far from acknowledging the actual revenues they get from it. They have always been sur-prised to learn that some of their peers had revenues greater than the national average.

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