Economic and Environmental Implications of Wood Exploitation in the Mangrove Ecosystem in Tiko, South West Region of Cameroon

Abstract

Mangroves are vital ecosystems performing myriad functions and providing critical ecological goods and services. However, over the years, population growth and land use mutations have significantly reduced the ecological capacity of mangroves. This study aimed at identifying the economic and environmental implications of wood exploitation in the mangrove ecosystem. Data were collected from the field through the administration of questionnaires and field observations. This study examined the different drivers of wood exploitation which have resulted in the gradual destruction and degradation of mangrove ecosystem. Anthropogenic activities relating to the utilization of mangroves have significantly reinforced the rate of degradation within the study area. The results also show that the exploitation of mangrove forest for wood and fishery resources, fish smoking and charcoal production have also contributed to the daily and monthly income of the exploiters, making them essential to poverty alleviation. However, mangrove exploitation for various economic motives identified in the study have contributed enormously to ecological disequilibrium which has aggravated mangrove degradation. Some of the environmental consequences identified include loss of biodiversity, reduction in fish quantity and water pollution amongst others. To address these issues, it is necessary to promote environmental education, carry out reforestation, and establish community corporation in the wise use of mangroves. This falls in line with Cameroon's 1994 Forestry and Environment Law relating to sustainable exploitation of forest resources and 1972 Ramser Convention on Wetlands as Water Fowl Habitats.

1. Introduction

Mangroves are coastal forest (mangal) that are found or associated with salt or brackish water, estuaries, along river banks and lagoons in the tropical and subtropical regions (FAO 2007, Polidoro, Kent, Lorna, Norman et al., 2010). The term mangrove describes both the ecosystem and the plant families that have developed specialized adaptation to live in this tidal environment (FAO, 2007). They are also considered as intertidal zone of tropical and subtropical latitudes, mostly found in marine tidal forest which includes trees, shrubs, palms, epiphytes and ferns (Tomlinson ,1986). The distinctive community of plants and animals associated with mangroves is sometimes referred to as the mangal (Macnae ,1968). The origin of the term mangrove is well researched by Vanuccil (1989). According to her the word mangue is from West Africa, Senegal, Gambia and Guinea. The English word mangrove is a derivation of the Portuguese or Spanish meaning grove made of mangue. Mangrove ecosystems are heterogeneous habitats with an unusual variety of animals and plants adapted to the environmental conditions of highly saline frequently inundated land surface with soft- bottomed anaerobic mud (Vovides, Bashan, Jorge, Rogers. 2011, Thomas and Baltzer, 2005; Kathiresan & Bingham, 2001).

Not all mangroves are obligated to live in saline intertidal areas. Plants that are confined to the mangrove are called true mangroves. Plants that can also occur elsewhere are called mangrove associates (Clough,1992 and Tomlinson, 1986). Mangrove associates never grow in true mangrove communities and may occur in terrestrial, vegetation. The mangrove fauna includes terrestrial, marine temporary and permanent animal species, all of which have

different adaptions to cope with the mangrove environment. The diversity of mangroves is high but the variety of mangrove ecosystems also makes it difficult to produce general guidelines for conservation and management of mangroves because each system is unique (FAO 2011).

Mangroves are found in depositional coastal environments where fine sediments, often with high organic content, collect in areas protected from high energy wave action. Mangrove are salt-tolerant plants of tropical and subtropical intertidal regions of the world. The specific regions where these plants occur are termed as mangrove ecosystem. These are highly productive but extremely sensitive and fragile. Besides mangroves, the ecosystem also harbour other plants and animal species (FAO 2011, Huff, and Tonui, 2017; Perez, Contanza, Martinez Sutton, Anderson, and Mulder, 2008).

It has been observed that the presence of mangrove ecosystems on coast lines saves lives and property during natural hazards such as cyclones, storm surges and erosion (Das & Crepin, 2013; Chong, 2005; Nakamura, Sullivan, Bochove, Lauvieren, 2014; Kathiresan, 2012). These ecosystems are also well known or their economic importance. They are breeding, feeding and nursery grounds for many estuarine and marine organisms like fishes. Hence, these areas are used for captive and culture fisheries. The ecosystem has a very large unexplored potential for natural products useful for medicinal purposes and also for salt production, apiculture, fuel and fodder (Ramasubramanian and Ravishankar, 2004; Vovides et al, 2011).

Despite the unique ecological functions performed by mangroves, over the years, mangrove wood has been over exploited for fish smoking, fuel wood, coal production and building materials for local and national use (Atheulli, Din, Essome, Behara, Koedam, Dahdouh-Guebas, 2011; Simon and Raffaelli, 2012). This exploitation has caused the conflict with the sustainability of mangrove ecosystems leading to environmental degradation destroying breeding grounds for fish and other aquatic organisms, shelter for organisms, birds seeking food and shelter from predators (Simon and Raffaelli ,2012; Collins, Carpenter, Polidoro, Norman, Ellison, & Ellison, 2010). An obvious case is the mangrove forest which is along the Tiko coastal region of Cameroon. Estimates show that due to deforestation, during the first half of the twenty-first century, about 50% of global mangroves were lost (Holguin, Gonzalez-Zamorano, de-Bashan, Mendoza & Bashan 2006; IUCN (2004). In the context of the study area, mangrove degradation is caused by population pressure which originates from multiple sources including municipal waste, shipping industries and runoff from the urban area (Mapoko, 2017; Ajonina, Tchikangwa, Chuyong, and Tchamba, 2009). In this regard therefore, this study aims at addressing the following questions: what are the drivers of mangrove wood exploitation in Tiko area? what are the economic implication of wood exploitation from the Tiko mangroves? what are the environmental repercussion of wood exploitation in the Tiko mangrove ecosystem? and, how can wood exploitation be carried in order to maximize the economic benefits while ensuring mangrove ecosystem sustainability?

2. Materials and methods

2.1 Location of the study area

The study site is located in the south-east end of Rio Dey Rey (Cameroon Mangroves Network CMN, 2007). It's found in Fako Division in the Mount Cameroon Region. Fako Division is located between Latitude 4^{o} 28'30''N and 3^{o} 54'26N and Longitude 8^{o} 57'10''East and 9^{o} 30'49''East. Tiko is located at 4^{o} 4'43''north and 9^{o} 22'5''east. It has a surface area of 484000km^2 (Vincent, 2005) (Figure 1).

2.2 Research Design

This study uses a survey research design in which research instruments were prepared to sourced primary data on mangrove exploitation and the attendant economic and environmental effects. Reconnaissance surveys were carried out to the study area and information were gotten on the rate and purpose of mangrove exploitation and the level of mangrove depletion over the past five years.

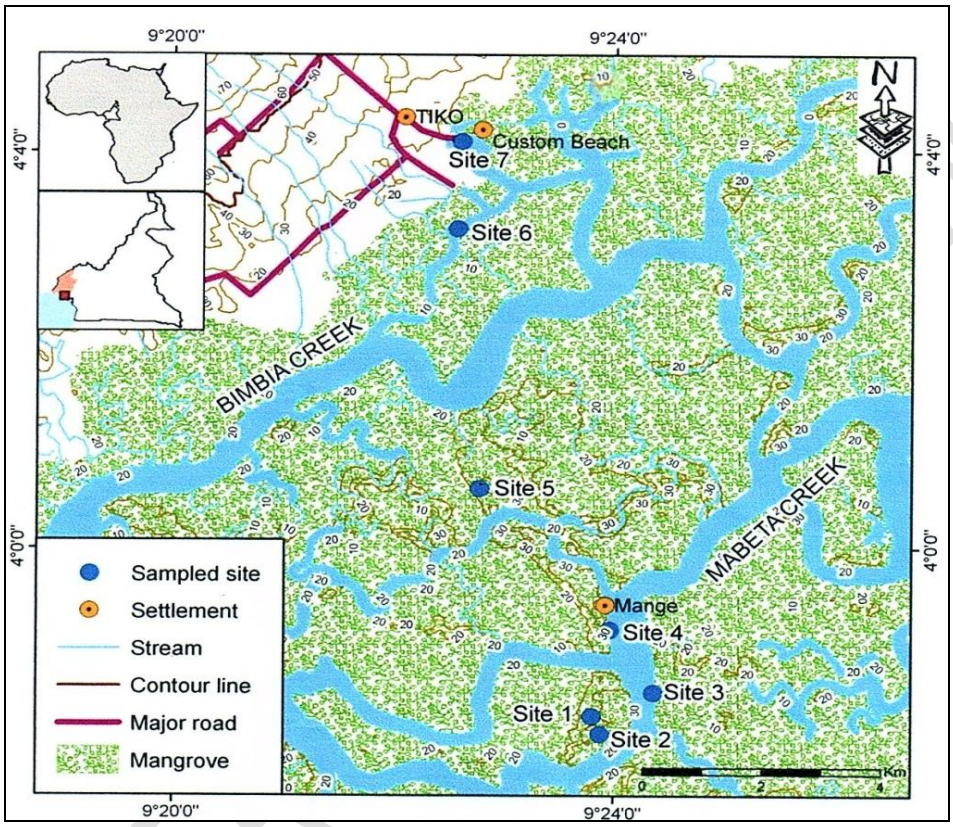

Figure 1: Location of the Tiko Mangroves in Cameroon

2.3 Data collection

Data were collected from primary and secondary sources. Primary data were sourced mainly from field surveys involving field interviews, group discussions, observations and semi-structured questionnaire administration to the study participants (that is, wood feelers, fishermen, fish smokers and charcoal retailers who are directly involved in exploiting the mangrove resources). The data acquired through these sources included drivers of mangrove exploitation, the frequency and intensity of exploitation, what is done to improve on the state of the mangrove ecosystem, level of education on the effects of unsustainable mangrove exploitations. The stratified random sampling technique method was used in the administration of the questionnaires to the participants (Table 3).

Table 1: Distribution of questionnaires to the respondents

S/N	Role/Function	Number administered	Number retrieved
1	Those who extract wood from mangrove	10	10
2	Charcoal retailers	5	5
3	End users		

4	Fish smokers	3	3
5	Household users	8	8
6	Bakeries	4	4
	Total	30	30

The survey population involved 30 mangrove exploiters/users from which semi-structured questionnaires were designed to collect the primary data. Secondary data were collected from published books, articles and journals. These reviewed works aided in acquiring in-depth knowledge on the implications of the exploitation of mangrove forest and adaptive measures that have been implemented in other areas.

2.4 Data analysis

The collected data were analysed using descriptive statistical techniques in softwares such as SPSS and Microsoft excel 2016 and presented in tables and figures. This includes tables on the effects of exploitation on the ecosystem. The tables also show the yearly exploitation of wood against average yearly income of smoked fish, income of logger, charcoal makers and bakeries. Data collected were also represent in figures based on field survey and observation.

3. Results

This section presents the results obtained from the field on the economic benefits of mangrove exploitation and the associated environmental impacts. The data obtained were statistically analyzed using influential statistical methods like the chi- square. Data were also represented in tables and graphs. This results presentation begins with the categorization of participants' demographics and their mangrove related activities.

3.2 Extent of Mangrove Exploitation

The degree to which mangroves are exploited varied among the study participants. Figure 2 presents the responses of respondents on the number of trees felled in a day. According to most of the respondents (50%), 5 trees and above are felled every day. This view, however, opposes 30% of the respondents who indicated that they usually fell an estimate of 3 trees on daily basis while 20% of the respondents estimate the number of trees cut daily at 4. This implies that estimates of 16 and 64 mangrove trees are felled on weekly and monthly basis respectively.

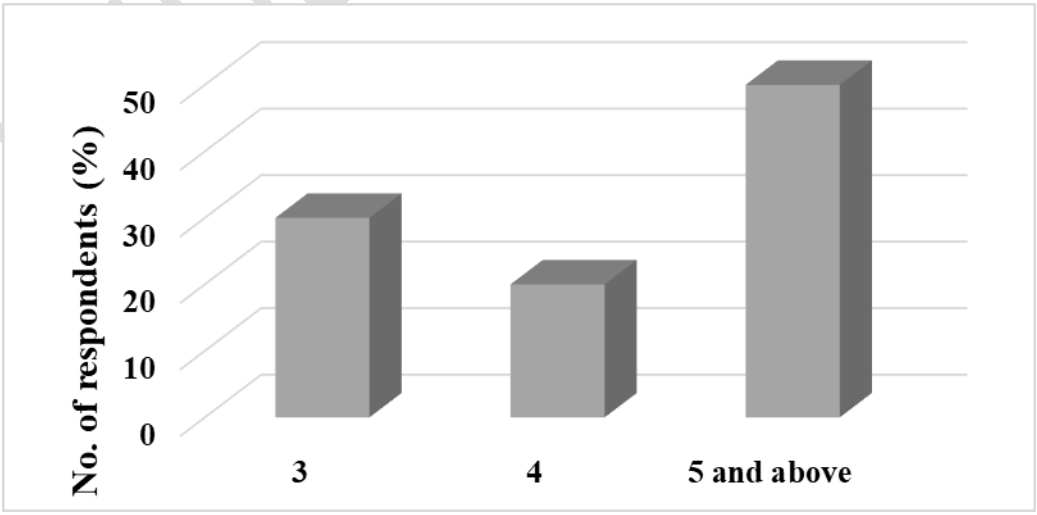

Figure 2: Number of trees felled in a day

Furthermore, Figure 3 shows the frequency of mangrove exploitation. It is observed that a greater proportion (60%) of the respondents harvest mangrove wood more than four times a week. Twenty percent of them indicated to harvest mangrove at four times per week while another 20% of them noted they harvest the mangrove wood three times a week.

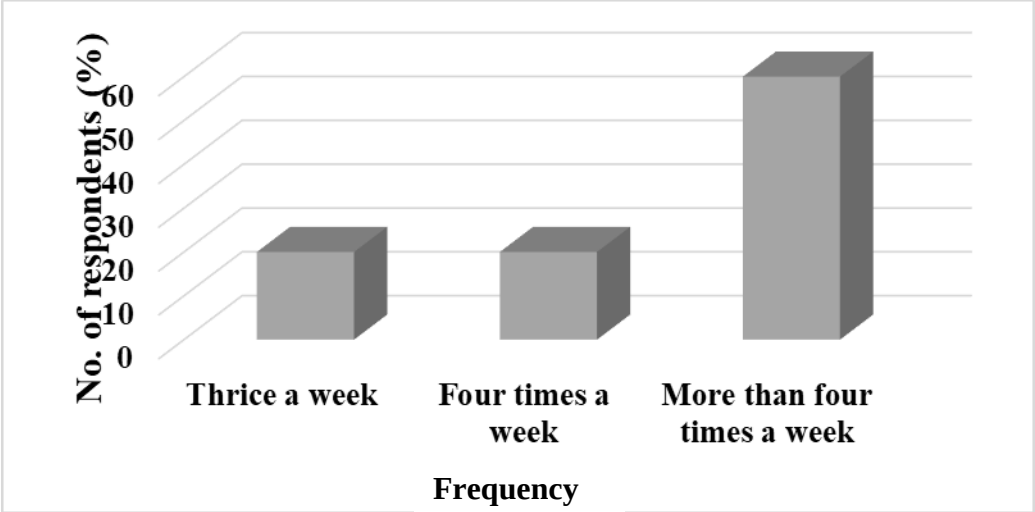

Figure 3: Frequency at which mangrove plants are harvested

In terms of the diameter of mangrove plant harvested, Figure 5 shows the responses on the diameter of mangrove plants usually harvested by loggers. In this regard, the majority (40%) of the respondents reported that they cut plants of about 110 cm and above in diameter while the least (10%) of them pointed out that they cut plants in the range of 41-70 cm in diameter. Although most respondents reported that they only cut the mature trees, a few of the respondents attested that they, sometimes, cut small trees upon demand by builders who use them as poles for construction.

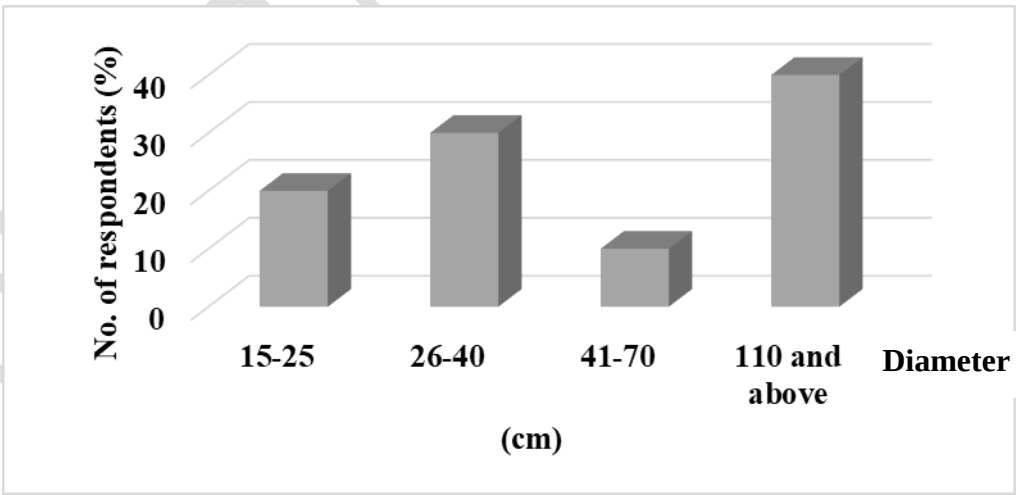

Figure 4: Responses on the diameter of mangrove plants usually harvested by loggers

4.4 Economic Implications of Mangrove Exploitation

Field surveys showed that mangrove exploitation generates income for those involve in different activities ranging from logging, fish smoking, charcoal production and bakeries (Figure 6). Results show that 40% of sampled loggers earn an average daily income of 5000

FCFA; 40% of them equally indicated to earn an estimated daily income in the range of 3000 - 4000 FCFA while 10% of them estimated their daily income range of 1000 - 2000 FCFA. Most (66.67%) of the fish smokers report an estimated daily income range of 1000 - 2000 FCFA against 33.33% of them who reported an estimated daily income of 3000-4000 FCFA. A similar trend was observed for charcoal makers in which 60% of them reported an estimated daily income range of 1000 - 2000 FCFA while 40% reported an estimated daily income of 3000 - 4000 FCFA. All the bakeries sampled reported an estimated daily income of 5000 FCFA and above.

3.3 Environmental Implications

The exploitation of the Tiko mangroves for economic purposes has implications for the environment. Participants expressed various views whether or not the mangrove has changed over time due to their activities. The results obtained show that 73.5% of the respondents is unaware of any change in the mangrove over time as a result of their activities. Contrary to this view, 14.7% admitted that they have noticed changes in terms of reduction in the areal extent of mangroves over time. This was captured in an interview with the secretary of the beach, Mr. Epie, in pidgin English which is widely used by the locals in Tiko. According to him:

"*people them di over cut mangroves for corner forest now. Mangrove done finish; na only small trees them remain. Because of this, man get for enter right inside forest for harvest big big tress them.*" [there has been the over exploitation of mangrove at the periphery of the forest; this has led to mangrove depletion leaving just the immature trees. This therefore requires entry into the heart of the forest in order to harvest mature trees].

A major driver to mangrove deforestation in the area is the growing demand for fuel wood (Figure 6) which is one of the main energy sources used in homes. Apart from the environmental adversities to mangroves, such exploitation and use by the population predispose them to both long and short term health hazards (such as asthma) as they constantly inhale carbon from burning the mangrove wood.

Figure 5: Exploitation of mature mangroves for fuel wood. The high demand for fuel wood as a principal source of energy results in mangrove degradation

The major change reported was the fact that the distance to the area where they cut these mangrove plants has increased over time. This implies that all the desired species and sizes closer to settlement have all been cut down and as a result of this, loggers have to travel far into the mangrove forest to exploit unexploited areas. Despite this scenario of mangrove depletion, there is growing ignorant of the harm that is caused on mangroves from various exploitation activities (Figure 7). Indeed, as high as 82.5% of the participant were ignorant of the environmental stressors on mangroves from their activities while only 5.9% of them were aware of them.

A B

Figure 6: Forest exploitation of Mangrove for wood (A) and use of wood for canoes used in transportation in the mangroves.

The reduction in the size of mangroves in the area signify significant losses in biodiversity as well as the critical ecosystem services and functions performed by these wetlands in terms of carbon sequestration, shoreline stabilization and prevention of flood and wind disasters in the area. Indeed, the mangroves in Tiko have been instrumental in serving as windbreaks, thus reducing the effects of tornadoes on the inland CDC banana plantations on the Tiko Plain.

4. Discussions

Mangroves are used as an important source of fuel wood and charcoal in response to the increase in the domestic needs for energy by urban and local communities in developing countries. Wood exploitation constitutes one of the main causes of the degradation of mangroves in the world and the logging of mangroves remains an activity which is not yet successfully controlled by governments, causing the ecosystem to lose its ecological value.

The studied shows that there are five mangrove end-users related activities exist in the study area. These include loggers, fish smokers, charcoal makers, bakeries, household users. Logging and fishing served as main sources of income for many of the participants. The exploitation of mangroves in Tiko is predominantly undertaken by local residents. Logging was done mostly for commercial purposes to be used in for fish smoking, in bakeries and for cooking in households. The sale of mangrove wood was consistently observed at the Apollo's, Mokorolo, Douala –koto beaches in Tiko. Indeed, participants reported that mangrove wood is mostly preferred over other woods because it burns even when wet and it produces more heat which helps in fast drying of the fish. Earlier studies equally underscored the economic importance of mangroves (Salem & Mercer, 2012). In addition, Feka and

Manzano (2008) and Din, Saenger, Priso, Dibong, & Basco, 2008) equally observed that mangrove wood used for fish smoking imparted the fish with its golden brown color.

However, the constant use of mangroves for economic purposes in the area is a significant threat to their sustainability. Similar studies (Purvaja & Ramesh, 2001) confirmed the mangrove threats from anthropogenic activities such as wood extraction. The preference for mangrove wood has been driven by demographic growth in the region. This has resulted in uncontrolled clearing of this mangroves. Most of the changes that have occurred in the mangrove wetland of Tiko have been as a result of over exploitation of this ecosystem. The number of mangrove trees felled and the drop in fish quality and quantity remain some of the direct repercussions of mangrove degradation due to various pressures. The species of mangrove widely exploited by loggers in the area are the same as those identified by UNEP (2007) and include red mangrove, white mangrove and Nypa plants. However, Adekanmbi and Ogundipe (2009) reported more than 11 mangrove species exploited in Nigeria.

Policy Options

The logging of mangrove plants for fuel wood, fish smoking and construction is the main driver of change in the Tiko mangrove wetlands. Logging in this study area has result in the removal of significant mangrove degradation. Changes in the ecological conditions include changes in nutrients level which comes about with changes in the distribution, quantity and quantity of organisms such as fish. The continuous exploitation of the mangrove wetland and pollution activities from adjacent settlement areas expos them to serious degradation. Protecting and restoring these critical ecosystems is thus necessary in fighting coastal erosion and coastal hazards (Sow, 2012) as well as enhancing ecological services and functions such as carbon sequestration and biodiversity conservation.

In recognition of the ecological value of mangrove wetlands in the Tiko Sub-division, mangrove exploitation should be done while taking cognisant of the following policy option:

- The government of Cameroon should reinforce the Forestry Law of 1994 and 1995 (MINEF, 1994; MINEF,1995) in the coastal zones in order to properly manage and mitigate the mangrove ecosystem.
- As stated in the 1994 Forestry Law, local rulers and local communities should be in charge of the mangrove communities. The government should assist by educating the exploiters on the different accepts of the forestry law so as to locally manage the mangrove ecosystem which is their basic livelihood.
- There should be senigeral co-management involving local non – governmental organisations (NGOs), community members and researchers under the supervision of the government authorities to locally monitor and contribute to the restoration of ecosystem forestry programme, biodiversity financial autonomy and accountability in the communities

Resolving this situation necessitates creative and practical management solutions. However, addressing the current policy gaps over exploitation of resources and improper understanding of the ecological and economic value of this system in Cameroon is critical to address the issues in terms both of poverty elevation and diversity conservation. Proper sensitization and the use of this information in this study to improve policy and enforcement are vital in effectively addressing the current state of this ecosystem in Tiko.

Conclusion

Mangroves remain critical ecosystems in Tiko Coastline of Cameroon. They do not only constitute part of the Ramser Sites in Cameroon stabilising the coastline and reducing the dual adversities of coastal inundation caused by sea level rise and coastal flooding from over flowing rivers from land, but are equally a major source of livelihood to more than 50 thousand people residing along the coastline. Indeed, mangrove wood exploitation has been a major activity engaged upon by a significant proportion of the population. Its exploitation has thus been very essential in poverty alleviation in a dominantly agrarian rural and urban milieu. However, while we acknowledge the importance of such exploitation, there is the need for regulation and strict adherence to the 1972 Ramsar Convention on Wetlands which underscores the importance of the wise of use of wetlands in general given the fundamental ecosystem services they perform. The starting point has to be with the sentisiation and training of sustainable mangrove exploitation methods as well as the engagement of the municipal authorities in ensuring the protection and conservation of mangroves given their ecological importance.

References

Adekanmbi, O.L. and Ogundipe, O. (2009). Mangrove diversity in the restoration and sustainability of the Nigerian Natural environment. Journal of Ecology and Natural Environment 1(3):064-072

Ajonina, G., Tchikangwa, B., Chuyong , G. and Tchamba, M. (2009).The challenges and prospects of developing a community based generalization method to access mangrove ecosystems vulnerability and adaption to climate change impacts . Experience from Cameroon in FAO (2009). The relevance of mangrove forest to African fisheries, wildlife and water resources. Nature and Faune 24(1): Pp143

Atheulli, A.N., Din, N., Essome, G. K., Kaedam, N. and Dahdouh- Guebas, F. (2011).Accessing forest products usage and local residents perception of environmental changes in peri-urban and rural mangroves of Cameroon , Central African . Journal of Ethnoboilogy and Ethnomedicine, 7:41

Cameroon Mangrove Conservation Network (CMN) (2007). Chapter of the African Mangrove Network (AMN) . Matanda News.

Clough, B.F. (1992). Primary productivity and growth of mangrove forests. In: Robertson, A.L. Alongi, D.M.(Eds.), Tropical mangrove forests ecosystems American Geophysical Union, Washington, Pp. 225-249

Collins, L., Carpenter, K.E., Polidoro, B.A., Norman, C., Ellison, M.A., Ellison, J.C. (2010). The loss of species: mangrove extinction risk and geographic areas of global concern. Journal. plos/one.org

Chong, J. (2005). Protective values of management and coral ecosystem: a review of methods of evidence. IUCN, Gland, Switzerland

Das, S. & Crepin, A.S. (2013). Mangroves can provide protection against wind damage during storm, estuarine, coastal and shelf science. http://dx.doi.org/10.1016/j.ecss.2013.09.021

Din, N., Saenger , P., Priso, R. J., Dibong, D.S. and Basco, F. (2008) . Logging activities in mangrove forests; A case study of Douala Cameroon. African journal of environmental Science and Technology 2(2) 022-030

FAO (2007). The Worlds Mangrove 1980-2005, FAO Forestry paper 153: Forest Resource Division, FAO, 77p

FAO (2009). The reverence of mangrove and coastal forest to African Fisheries and Water Resources. Nature and Faune 24(1). Pp 143.Http://www.fao.org/Africa/publications /nature –and-fauna-magazine

FAO (2011). State of the world's forest. Food and agriculture organization of the United Nations, Rome, Italy

Feka, N. Z. & Manzano, M. G. (2008). The implications of wood exploitation for fish smoking and mangrove ecosystem conservation in the South West Region, Cameroon: Journal of Tropical Conservation Science 1(3):222-241.To inform 9and educate the Cameroonians public on mangrove conservation issues Vol 1 No 1

Huff, A. and Tonui, C. (2017). Making mangroves together: Carbon, conservation and co-management in Gazi-Bay, Kenya; opendocs.ids.ac.uk

IUCN (2004). Biodiversity in sub-Saharan Africa and its island conservation, management and sustainable use. Occasional papers of the IUCN species survival commission No 6

Kathiresan, K. and Bingham, B.I. (2001). Biology of mangroves and, mangrove ecosystems. Adv . Mar.Biol.40.81-251

Kathiresan, K. (2012). Importance of mangrove ecosystem. International Journal of Marine Science, Vol.2, No. 10:70-89

Macnae, W. (1968). Fauna and Flora of mangrove swamps. Adv.Mar. Biol.6,73270.

MINEF, (1994). Forestry, wildlife and fisheries regulations. Law No 94/01/94. Ministry of Environment and Forestry, Yaoundé, Cameroon

MINEF, (1995). National Forestry Action Plan of Cameroon Ministry of Environment and Forestry; Forestry policy document; Yaoundé, Cameroon

Malik, A., Rasmus, F. Ole, M. (2015). Economic valuation of mangroves for comparison with commercial aquaculture in South Sulawesi, Indonesia Forest. Journal. DOI:10.3390/F6093028

Mapoko, E.F. (2017). Mollusc composition and destruction in the mangroves of the Cameroon Central coast DOI:10.20431/2349-0365

Nakamura, T., Sullivan, E., Bochove, V., Lauvieren, H. (2014). The importance of mangroves to people: A call to action. DEP/1813/CA.ISBN:978-92-807-3397-6. Affiliation: United Nations Environmental Programme- World Conservation Monitoring Center

Purvaja,R. and Ramesh, R. (2001). Natural and Anthropogenic effects on phytoplankton primary productivity in mangrove. Chemistry and Ecology ,17:41-58

Perez, M.O., Contanza, R., Martinez Sutton, P., Anderson, S., and Mulder, K. (2008). The value of coastal wetlands. Current opinion in environmental sustainability. Ambio 37;241-248

Polidoro, B.A., Kent, E.C., Lorna, C., Norman, C.D., Aaron, M.E., Joanna, C.E., Elizabeth, J.E., Edwino, S.F., Kandasamy, K., Nico, E.K., Suzanne, R.L., Toyohiko, M., Gregg, E.M., Vien, N.N. Jin, E.O., Jurgenne, H.P., Severino, G.S., Jonnell, C.S., Sukristijono, S., Yamin, W. and Jean, W.H. (2010). The Loss of species: Mangrove extinction risk and geographic areas of global concern. Plos ONW 5(4): e10095. Doi: 10.1371/journal.pone.0010095

Ramasurbranian, R. and Ravishankar, T. (2004). Mangrove forest restoration in Andhra Pradesh, India. M. S. Swaminathan Research Foundation Chennai, India. www.mssrf.org

Ravishankar, T. and Ramasubramanian, R. (2004). Manual on mangrove nursery techniques. M.S. Swaminathan Research Foundation, Chennai.

Salem, M. E. and Mercer, D. E. (2012). The economic value of mangroves: A Meta-Analysis. Sustainability 4:359-383

Simon, L.N. and Raffaelli, D. (2012). Assessing ecosystem effects of small scale cutting of Cameroon mangrove forests. Journal of Ecology and the Natural Environment 4(5), 126-134

Sow, M. (2012). Mangrove restoration as a defense against coastal erosion. In guide on adaption options in coastal areas for local decision makers: Guidance for decision making to cope with coastal changes in West Africa, UNESCO

Thomas, S.C. & Baltzer, J. L. (2005). Edaphic specialization in tropical trees: physiological correlation and responses to reciprocal transplantation. Ecology 86:3063-3077

Tomlinson, P.B., (1986). The botany of mangroves. Cambridge University Press, Cambridge

UNEP (2007). Mangrove of Western and Central Africa. UNEP-Regional seas program /UNEP-WCMC. http://www.unep- wcmc.org/resources/ publications/ UNEP-WCMC- bio- series/26.htm

Vincent, F.A. (2005). Project to alleviate poverty through self-employment and enterprise creation in Fako Division of Cameroon. Fako Local Economic Development Agency.

Vovides, A.G. Bashan, Y., Jorge, A.L. & Roger, G. (2011). Nitrogen fixation in preserved, reforested, naturally regenerated and impaired mangroves as an indicator of functional restoration in mangroves in the Arid Region of Mexico. Restoration Ecology 19(201): 236-244