Chapter 21
Cameroon Mangroves: Current Status, Uses, Challenges, and Management Perspectives

Gordon Nwutih Ajonina

Abstract Cameroon has mangrove cover of more than 220,000 ha contributing to 6% of African coverage, the sixth largest in Africa and the largest in Central Africa. They have great structural peculiarity with diverse flora and fauna being the most giant in Africa and among the biggest and tallest in the world reaching over 1 m in diameter and 60 m in height especially around the Wouri estuary. The mangrove forests encompass three ecosystem types: freshwater (from inland hydrology), brackish water, and marine water systems. Cameroon mangroves provide a wide range of vital ecosystem goods and services valued at 77,040,470,590 FCFA (US $154,080,941)/year, i.e., 8,347,128 FCFA (US$ 16,694)/ha/year. The tangible ecosystem services (provisioning services) or natural resources provide a means of subsistence for more than 30% of the population of the country living in coastal areas dependent on its resources, particularly wood and non-timber products including fishery products. The non-tangible services include: regulatory services ranging from stabilization of the coastal zone, carbon sequestration to improvement of the micro- and macro-climate; support services, supporting the food chain, spawning ground, and habitat for many other marine and aquatic animals; and cultural services as a venue for spiritual activities of most festivals with enormous potential for ecotourism and environmental education. Mangrove and associated coastal areas have been lost annually at more than 1% in Cameroon but this varies greatly within the regions increasing in Rio del Rey area by 9.4% per year, declining in the Cameroon Estuary by −1.1% per year with Douala-Bonaberi (country's economic capital and most populated city) area being the highest hotspot reaching −6.2% per year, and—2.1% per year in the Estuary of Ntem. The driving factors are coastal population growth, urbanization, fish processing, sand extraction, and uncoordinated policies and government economic coastal development programs including accentuated pollution from extractive and processing industries. Government and partners have contributed significant efforts currently putting over 92% of mangrove

G. N. Ajonina (✉)
Institute of Fisheries and Aquatic Studies, University of Douala, Yabassi, Cameroon

CWCS Douala-Edea Coastal Forests, Marine and Mangrove Programme, Mouanko, Littoral Region, Cameroon

S. C. Das et al. (eds.), *Mangroves: Biodiversity, Livelihoods and Conservation*,
https://doi.org/10.1007/978-981-19-0519-3_21

coverage under various conservation and sustainable management practices: conservation as national park (50.3%), Ramsar sites and under sustainable management (70.8%) as communal forest (35.2%), and community forest ownership (7.5%). Many awareness campaigns, sustainable utilization, and restoration and research initiatives have also been embarked upon. What really remains is the enhancement of management effectiveness of these mangroves through policy amelioration and coordinated efforts of the different stakeholders in the perspectives of sustainable management of Cameroon mangroves. Recommendations are made to attain this goal.

Keywords Mangroves · Livelihoods · Conservation · Sustainable use · Cameroon

21.1 Introduction

Cameroon's coast stretches over a distance estimated at 500 km and represents almost 1/5 of the whole coastline of the Congo Basin. The mangrove forests and associated coastal forests cover an important part are hugely important but a globally threatened ecosystem (Dahdouh-Guebas et al. 2020). These mangroves are mainly grouped in three areas (mangrove blocks) from north to south: Rio Del Rey estuary contiguous with the mangroves of the Niger Delta in Nigeria; the estuary of Cameroon; and the Ntem estuary comprising mouths of Rivers Nyong, Lekoundjé, and Ntem contiguous with the mangroves of the Equatorial Guinea Republic. In recent years, the mangroves of Cameroon have been subject to several types of studies including descriptive studies to show biological and socio-economic potential to highlight their ecological role in coastal protection, studies to show changes in these areas and policy oriented studies. Some mangrove sites have been or are the subject of resource conservation projects. All these interventions facilitated the acquisition of an advanced level of knowledge of these important ecosystem resources.

In this chapter, within the framework of exploring the biodiversity, livelihoods, and conservation concerns of mangroves, available relevant data are exploited to present the current extent and distribution of mangroves in Cameroon; status of mangrove biodiversity and ecosystem services; values and current uses of mangrove; threats, challenges, and drivers of mangrove biodiversity loss; conservation, sustainable utilization, participatory management, and research initiatives in place to addressing the threats and challenges; and recommendations with perspectives for sustainable mangrove management.

21.2 Extent and Distribution of Mangroves in Cameroon

21.2.1 Site Description of Cameroon Mangroves

Cameroon mangroves stretch from the Southwest, through the Littoral to the South regions. According to Letouzey (1968), they extend inland from the coast for up to 30 km and are largely riverine establishing along coasts and creeks. According to the latest comprehensive mapping of mangroves of Cameroon by MINEP-RCM (2017) exclusive mangrove areas in Cameroon cover over 221,162 ha (or 234, 293 ha including associated coastal forests) commonly grouped into three main blocks. In the North Rel Del Rey estuary mangroves cover 180,538 ha (45.5%) (or 131,497 ha including associated coastal forests) from the mouth of Rivers Akpa Yafe and Ndian from the border with Nigeria contiguous with the mangroves of the Niger Delta, Lokele, and Meme right up to the West of Mount Cameroon (Fig. 21.1). In the center Cameroon estuary mangroves, 93,549 ha (42.3%) (or 99,730 ha including associated coastal forests) stretching from the bay of River Bimbia, the islands formed by the tributaries of Rivers Mungo, Wouri, and Dibamba and around the cities of Limbe, Tiko, and Douala to River Sanaga estuary. In the south Ntem estuary mangroves, 2354 ha (1.1%) (or 3067 ha including associated coastal forests); occurring in patches from the south of River Sanaga, the Nyong estuary, Lokounje to Ntem River on the border with Equatorial Guinea (Fig. 21.1).

21.2.2 Panoramic Appraisal of Cameroon Mangrove Blocks

21.2.2.1 The Rio del Rey Estuary Block

This is situated in a landscape of the hottest biodiversity spots of Cameroon, downstream from Cross River, Korup and Takamanda forests, in the shadow of Mt. Cameroon and in the wettest corner of Africa with 4–10 m of annual rainfall, it is the biggest mangrove zone; parts of it are still very much intact, with a known quality of fisheries grounds. It is probably one of the best conserved mangrove ecosystems on the Western and Central Africa Coast. It lies in a presently remote and undeveloped area of the Cameroon coast with a number of oil palm plantations at its periphery, no important roads or other infrastructures cross this area and only a few small human settlements. Since the 1960s there has been some off-shore oil exploitation in the Gulf of Guinea at a distance of 100–200 km off the Rio del Rey coast. The area includes Bakassi Peninsula that was recently included in the Cameroonian territory. There is a large potential for more oil and gas exploitation in this important biodiversity hotspot. The area is sparsely populated with about 400,000 inhabitants; there are 115 mangrove villages with a total population of 250,000 people, about 70% of whom originate from Nigeria. The trend towards fragmentation and overexploitation are important especially with the nearby Nigerian town of

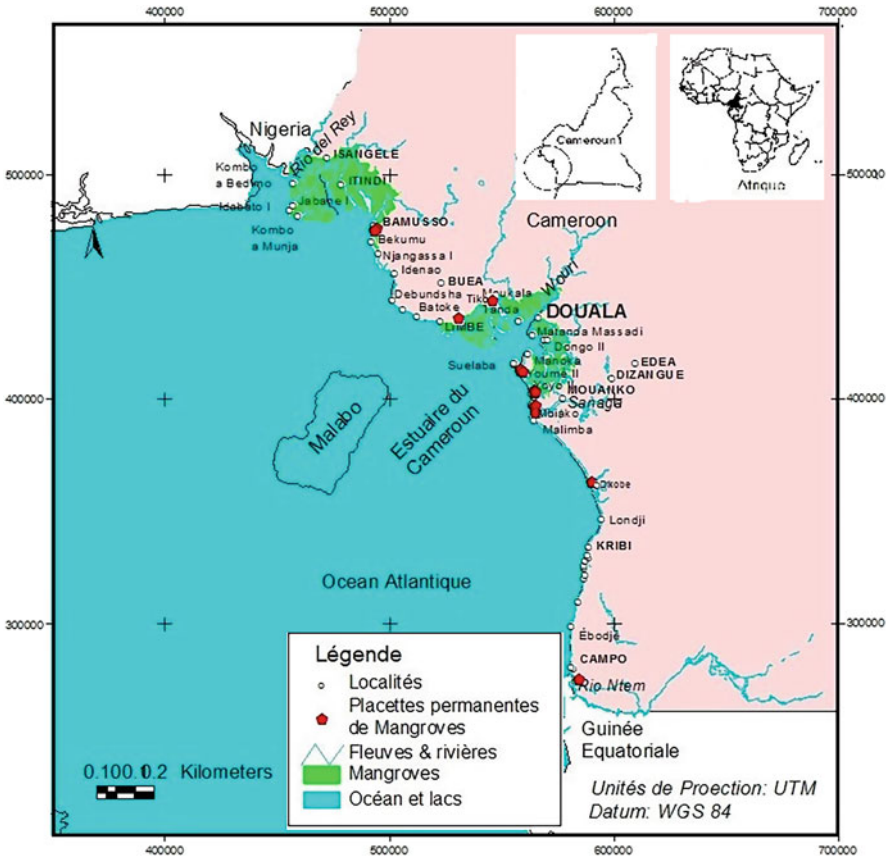

Fig. 21.1 Map showing the distribution of mangroves of Cameroon

Calabar with a population estimated at two million people. The main activities are fisheries, fish drying, and exploitation of mangrove poles for building and trading. The main markets being the Nigerian town of Calabar. This presents a trend towards fragmentation and overexploitation of its resources. The remoteness and insecurity of the area make it a real challenge to build up good relationships with local fisheries communities and develop a comprehensive conservation and development strategy. The area faces a big threat from fast advancing alien invasive palm *Nypa fruticans* introduced in near-by Nigeria in 1902 from SE Asia as is carried by the governing Beneguela Current and is dominating indigenous mangrove species. Conservation activities by the government, NGOs, private sector, and local communities have been focusing on baseline studies and projects geared towards the creation of the Ndongore national park covering over 121,590 ha including the marine and

mangrove zone (Cameroon's third marine park) with about 72,000 ha of mangroves. Part of the Rio Del Ray area has also been enlisted as Cameroon's fifth Ramsar Site from recent water bird and wetlands surveys undertaken by WWF with NGOs including the Cameroon Wildlife Conservation Society (CWCS).

21.2.2.2 Cameroon Mangrove Estuary

It is a confluence zone of the estuaries of five important Cameroon rivers: River Bimbia, Moungo, Wouri, Dibamba, and Sanaga. Sanaga the largest of the Cameroon rivers, at 918 km long arises from the Adamawa foothills and drains an area of 133,000 km^2, serves as a lifeline on which millions of Cameroonians depend. The main dam for hydro-electricity production at Edea some 30 km from Douala supplies electricity to more than half of the Cameroon population and the main aluminum company ALUCAM is also located at Edea. Although being the largest mangroves in Africa reaching 60 m in height and more than 1 m in diameter due to fluvial influences, they are the most threatened mangroves in Cameroon from development pressures, pollution, and natural resources extractive activities. They are heavily surrounded by many towns including the Cameroon economic capital and industrial city of Douala with over two million people, a very good road network links the various towns including Kribi, Yaounde (300 km away from Douala), Tiko, Buea, and Limbe and the Douala International Airport. It has a number of oil palm plantations at its periphery belonging to a number of national and multinational companies including CDC, SOCAPALM, FERME SUISSE, and SACAFAM. The area is also under petroleum exploration and exploration activities of PECTEN and PERENCO companies. The area is heavily populated with about 3.2 million inhabitants with some 62 mangrove villages with total population of 63,000 people in foreign dominated (about 70%) fishing camps. The main activities are fisheries, bivalve exploitation along the Sanaga mouth with annual tonnage of 8000 t, fish drying and exploitation of mangrove poles for building, and trading. The main markets are Douala, Yaounde, Bafoussam, Bamenda, etc. along a very good road network. Mangrove conservation activities are mainly undertaken by CWCS since 1997 within the Douala-Edea wildlife Reserve being raised in 2018 to the status of a national terrestrial and marine park (first marine park) covering about 263,000 ha with about 40,000 ha of mangroves. Lake Ossa and lower Sanaga sections of the park are being designated as Ramsar Sites.

21.2.2.3 Ntem Mangrove Estuary

These discontinuous patches of mangroves (around rivers Nyong, Lonkonjie, and Rio Ntem) with about 3200 people are intact though also close to the Chad-Cameroon Pipeline and Kribi Deep Sea Port project areas. The area also has a number of oil palm plantations belonging to SOCAPALM at its periphery with good roads or other infrastructures crossing the area. The main activities are

fisheries, trading, and especially beach tourism that attract thousands of nationals and international tourists with tourism infrastructures especially hotels in Kribi and environs. WWF is active in the area with its Kudu Zombo program within the Campo Ma'an landscape covering over 700,000 ha including Rio Ntem and parts of Kribi coast. Also prominent among actions are those of the Marine Turtle initiative of a local NGO, Association Nationale de Protection des Tortues Marines "KUD'A TUBE" at Ebodjie between Kribi and Campo whose actions have led to the Gazettement of the second marine park in Cameroon—the Manyange na Elombo-Campo Marine National Park covering 110,300 ha with 1500 ha of mangroves. The Rio Ntem mangrove section of Equatorial Guinea is a Ramsar Site and presents a good trans-border opportunity to the designated Cameroon section of the Ramsar site. The recent effort of the Cameroon government to classify the Lokoundjé Falls as a World Heritage site was highly contested by the local population. But the Kribi Deep Sea port project has been largely successful.

21.2.3 Status of Mangrove Biodiversity and Ecosystem Services

Generally, the biodiversity of mangroves in Cameroon is well known with studies carried out largely in the mangrove area of the Cameroon estuary than in other mangrove blocks (Rio Del Rey and Ntem blocks). Although this can pose a real problem of comparison between the blocks in terms of biodiversity, mangrove biodiversity is quite specific in flora and fauna and can be found the same everywhere.

21.2.3.1 Floristic Diversity

In the current state of knowledge on taxonomy, six native and 1 introduced species form the woody floral background mangroves of Cameroon in particular and those of the entire Atlantic coast in the Gulf of Guinea in general. Native species are: *Rhizophora racemosa, Rhizophora harrisonii*, *Rhizophora mangle* (Rhizophoraceae), *Avicennia germinans* (Avicenniaceae), *Laguncularia racemosa*, *Conocarpus erecrus* (Combretaceae), and the introduced species, *Nypa fructicans* (Arecaceae). The characteristic zoning pattern around a mangrove formation can only be on a relative scale because in many places there is no clear zoning. The spatial distribution of vegetation is very irregular because different species tend to settle on different micro topographic configurations and different soil types (Mbog 1998). In most sites, *Rhizophora racemosa* occupies more than 90% of the areas covered by mangroves, followed by *Avicennia germinans* which takes about 5% (Ajonina 2008). *Rhizophora* therefore forms the most extensive stands of mangroves, with many almost monospecific areas. This monospecificity is generally

followed by a mixed zone where all Rhizophoraceae (*R. racemosa*, *R. harrisonii*, and *R. mangle*) can be found mixed, where the sediments are more consolidated but still flooded daily by the tides.

Above this level, where tidal flooding is reduced, there is usually an area with *Avicennia germinans* which can be monospecific, or mixed with *Laguncularia* or *Conocarpus*. A study carried out in the mangroves of Bakassi, Limbé, Douala, Tiko, and Kribi on the vitality of mangroves shows a preponderance of the species *Rizophora mangle* in a good number of sites (ONEQUIP 2009).

It should be noted that *Nypa fructicans*, which is a species native to Asia and introduced into these formations, occupies the ground considerably after *Rhizophora*. The other companion species covers a small area, *Avicennia germinans* which is recognizable by its pneumatophores and the presence of salt crystals on its leaves is easily distinguished in the landscape of *Rhizophora racemosa* to which it is often mixed by its lighter green leaves. This difference could be demonstrated even on false color infrared aerial photos, where *Rhizophora* appears a brighter red than *Avicennia* (Mbog 2002).

The six species of mangrove trees live most often, in association with more than 40 other species of plants considered as "companion species" or "accidental." Among these plants considered to be the most commonly observed are: *Drepanocarpus lunatus*, *Dalbergia ecastaphylum*, *Hibiscus tiliaceus*, *Phoenix reclinata*, *Acrostichum aureum*, *Pandanus candelabrum*, *Raphia palma-pinus*, *Sesuvium portulacastrum*, *Alchornea cordifolia*, *Annona glabais*, *Elogeliis guinensista*, *Athona glabais*, *Elogeliis guinensista Bambusa vulgaris*, *Cocos nucifera*, *Eremospatha wendlandiana*, and *Guiborutia demensei*.

21.2.3.2 Phytoplankton

More than 430 species of phytoplankton have been counted and can be grouped into three classes: Bacilliophyceae, Dinophyceae, and Cyanophyceae. These different species have different levels of affinities for pollution with the majority (39%) in the neutral class. Most of the species are comparable to those recorded by Folack (1989) and Mbeng et al. (2017) in the Kribi area in the south and in the Limbe region in the west, respectively.

21.2.3.3 Fauna Diversity

Mangroves are habitats that are home to an important, very varied and diverse fauna that colonizes each ecological niche. Important by both the number of species and the economic value of most of them. In general, a distinction is made between aquatic fauna, terrestrial fauna, and avian or aerial fauna.

Aquatic Fauna are the most important in terms of both the number of species and the economic value of most of them.

Zooplankton Some 205 species of zooplankton are found in the mangroves of the Cameroonian coast with different levels of affinity for pollution.

Aquatic Mammals These include manatees (*Trichechus senegalensis*). According to the NGO APEMC (Association for the Protection of Marine, Coastal and Wetlands Ecosystems), manatee populations were estimated at more than 2500 individuals around the 1980s across the country. Today, due to intensive poaching by fishing communities, this species no longer reaches 1000 individuals across the country. This species is in danger of total extinction in Cameroon if no action is taken because according to monitoring carried out by the NGO Cameroon Wildlife Conservation Society (CWCS 2000–2006), at least 30 individuals, caught in fishing nets are killed per year in the Douala-Edea National Park. Its flesh is appreciated by local riparian communities, and its oil highly prized in cosmetics. The Otter (*Aonyx capensis microdon*) is another species that lives in the mangroves of Cameroon. It is found in abundance in the mangroves of the Douala-Edea national park.

Regarding cetaceans in the nearby sea, eight species have been identified by Ayissi et al. (2014): Atlantic Humpbacked dolphin (*Sousa teuszii), Delphinus capensis,* Short-beaked common dolphin (*Delphinus delphis), Tursiops truncatus, Stenella attenuata,* or *S. frontalis, S. coeruleoalba,* Humpback whale (*Megaptera novaeangliae),* Sperm whale (*Physeter macrocephalus),* some have been observed by AMMCO (African Marine Mammal Organization) using local fishers surveys with a flexible mobile application software siren (https://ammco.org/telecharger_siren).

Reptiles For the purpose of feeding and nesting, five species frequent the mangrove area, namely the green turtle (*Chelovia vydas*) (Cholomïdae), olive turtle (*Lepido Chelys olivarea*) (Cholomidae), leatherback turtle (*Dermochelys coriacea*) (Dermochelidae), hawksbill (*Evert vuoduelys imbricaba*) (Cholomidaes), and loggerhead turtle (*Carrella Carrella*) (Cholomïdaes) (Ayissi et al. 2003).

Crustaceans Present in all mangrove waters, crustaceans are numerous in the mouths of estuaries. The most commonly observed in the country's mangroves are: *Nematopalemon hastatus* (crayfish or Njanga) heavily used in artisanal fisheries by local communities. *Penaeus kerathurus* or tiger shrimp, *Parapenaeopsis atlantica*, *Panaeus notialis*, and several species of crabs that inhabit the mangroves such as *Ginossis pelii, Cardiosoma armatum, Geryon maritae, Panopeus africanus*, etc. (Ngo-Massou et al. 2014).

Molluscs The most characteristic molluscs of Cameroonian mangroves are oysters or gastropods. They are found in all the mangroves of Cameroon where some 39 species have been recorded (Ngo-Massou et al. 2012; Kottè-Mapoko et al. 2017) with some re-descriptions of certain genera by Shahdadi et al. (2019, 2021). Among the molluscs that live in these mangroves we can cite: *Pugilina morio, Thais coronata, Corbula trigona, Crassostrea gasar, Littorina angulifera, Loripes aberrans, Nassa argentea, Neritima adansoniana, Tagelus angulanus, Pachymeliana fuscatus, Pachymeliana aurita Shut callifera,* and *Melampus liberanus*.

Fish In mangrove areas, we find pelagic fish species: Clupeidae, Scombroidae, Sphrynaedae, Cichlidae, Trichiuridae, Carangidae and demersals: Scianidae, Pomadasidae, Lutjanidae, Cynoglossidae, Dsyatidae, Ariidae., Polynemidae. Among these species, pelagic fish (*Sardinella maderensis* and *Etmalosa fimbriata*) are the most exploited, especially in the Bakassi area (ONEQUIP 2009). Nearly 40 species of fish are found in the mangrove area. The most commonly observed fish species are: *Caranx hippos*, *Caranx* spp., *Trachinotus teraia*, *Tilapia* spp., *Pellonula afzeliusi*, *Arius gigas*, *Arius heudeloti*, *Arius parkii*, *Ethmalosa fimbriata*, *Sardinella ceperensis*, *Plectorhynolithus*, *Pomadotasysus* spp., *Pomadotasysus* spp., *Dentex congoensis*, *Ilisha africana*, *Galeoides decadactylus*, *Polydactylus quadrifilis*, *Pomadasys jubelini*, etc.

Regarding sharks, three species have been identified: *Carchahinus leucas* and *Shpyrna* sp. (Hammerhead shark); *Squatina aculeata* (Saw-back shark) and *Squatina oculata* (smoothback shark) in the Bekumu area (Rio Del Rey).

Terrestrial Fauna Ecological studies on the terrestrial fauna of mangroves in Cameroon still remain very disparate, very specific, descriptive, and not very in-depth. However, they make it possible to distinguish between resident fauna and non-resident fauna. The resident fauna takes into account that located in the canopy of mangroves (mammals, reptiles, nesting birds, insects). Non-resident fauna is that which is not fixed in the intertidal zone or the zone of tidal waves. It includes migratory birds and euryhaline animals that spend part of their life cycle in mangrove ecosystems. Data on microfauna and mesofauna are rarer. Despite these reserves, the terrestrial fauna of mangroves is very diverse. It is made up of reptiles, mammals, birds, and insects.

The Mammals Included in this group are blue monkeys (Cercopithecidae), antelopes such as sitatunga (*Tragelaphus spekei*), aquatic buckskin (*Hyemoschus aquaticus*), bush pigs (*Potamochoerus porcus*), etc.

Reptiles Also include the dwarf crocodiles (*Osteolaemus tetraspis*), giant crocodiles (Crocodylia), monitor lizards Nile (*Varanus niloticus*), African pythons (*Pithon selae*), aquatic cobras (*Boulangerina annulata*), etc.

Avifauna Observations show that many birds (more than 125,000 individuals counted in January 2014 are found on the Cameroonian coast, CWCS 2014) live permanently in the mangroves which are roosts for several endemic species and places of temporary accommodation for many migratory species. Species such as *Ardea goliath* (Heron), *Bubulcus ibis* (Cattle keeper), *Butorides stratus* (Gray heron with green back), *Egratta alba* (Egret), *Numenius arquata* (Courbis), *Phala crocarax africanus* (Cormorant) and *Tringa* Sp., African Open Beak and Scissor Beak. Pelicans (*Pelicans refeseus*), black herons (*Egretta ardesiaca*), intermediate egrets (*Egretta garzetta*), sea swallows (*Sterna* spp), petrels (*Oceanites oceanicus*), knights (*Tringa* spp), African comorants (*Phalacrocorase africanus*), sandpipers (*Calidris* spp), riverbanks *(Limosa numernius arguata* and *N. phalopus*), plovers (Charadrius), gray parrots with red tail (*Psittacus erithacus*) hornbills, giant blue turacos (*Corythaeola cristata*), wild ducks, etc. are also encountered. There are over

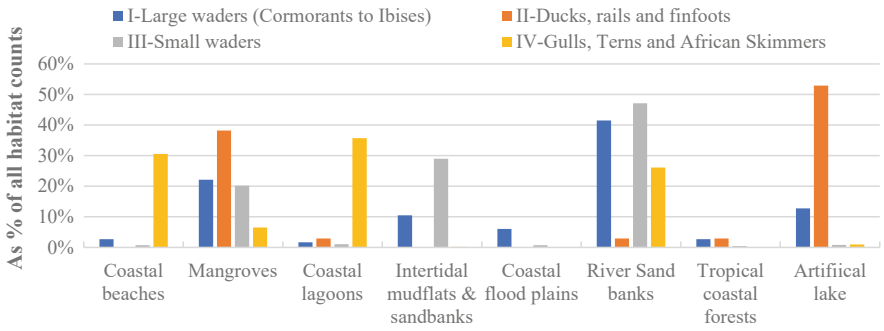

Fig. 21.2 Habitat distribution of bird groups (Ajonina et al. 2021)

70 species of water bird that annually visits mangroves and the coastal zone (Ajonina et al. 2003, 2009a, b, 2020, 2021) with up to 40% affinity to the mangrove habitats (Fig. 21.2).

21.3 Stand Structural Characteristics: Stand Densities, Volume, Biomass, and Carbon Stocks

Generally, there is a great structural peculiarity of mangrove stands in the Central African coast stretching from Cameroon to Angola in being the most giant in Africa and among the tallest in the World (Blasco et al. 1996) reaching over 1 m in diameter and 60 m in height (Akendengue et al. 2021) (see Figs. 21.3 and 21.4) especially around the Wouri estuary in Cameroon where mangrove trees of up to 131.7 cm were measured in Ngalaberi mangrove creeks (009°40′41″E, 3°49′19”N) (Ajonina 2008).

The average stand density in intact mangrove forests is 3255.6 trees/ha with 80% of the trees in the lower 10 cm diameter class, the standing volume of 427.5 m^3/ha corresponding to aboveground biomass of 305.7 Mg/ha (Ajonina et al. 2014a, b). Together with dead wood, the total biomass of vegetation reached a maximum of 825.0 Mg/ha. The total stock of carbon in the non-degraded mangrove ecosystem was estimated at 1520.22 ± 163.93 Mg/ha with 982.49 Mg/ha (65%) below ground (soil and roots) and 537.73 Mg/ha (35.0%) in the aboveground biomass (Ajonina et al. 2014a, b). Though the carbon sink potentials of mangrove are high (Ong 1993), the biomass is among the highest in the world and superior to adjacent Congo Basin Rainforest (Fig. 21.5).

Fig. 21.3 Atypically giant mangroves of central Africa (tree measured in a permanent sample plot at Campo (Ipono)-Ntem estuary, Cameroon)

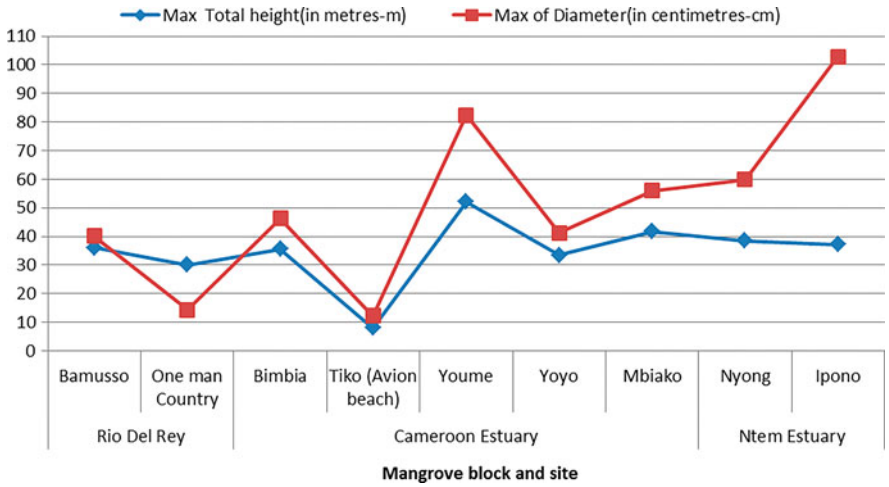

Fig. 21.4 Mangrove landscape profile in Cameroon: height and diameter from permanent sample plots (Ajonina and Chuyong 2017)

21.3.1 Mangrove Forest Dynamics and Carbon Sequestration

Regeneration data are obtained from the analysis of satellite images between 2000 and 2015 and those of population dynamics are derived from the analysis of data from permanent plots established along the Cameroonian coast between 2001 and

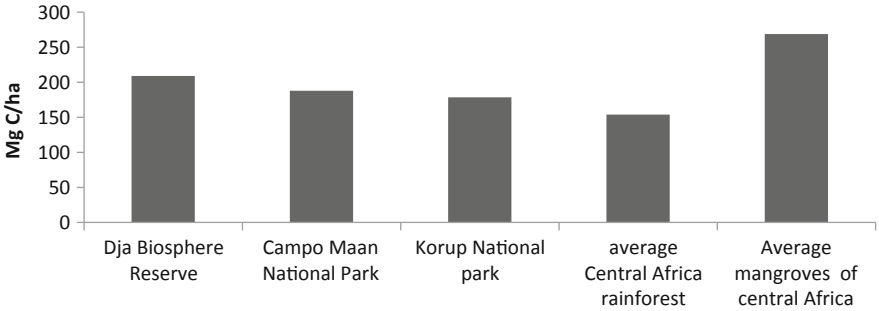

Fig. 21.5 Comparison of aboveground carbon stocks from selected terrestrial rainforests in the Congo basin and mangroves (Ajonina et al. 2014a, b)

2003 and remeasured once every 2 years by the CWCS (Ajonina 2008; Ajonina et al. 2014a, b; Ajonina and Chuyong 2017).

The annual regeneration rate varies from 0.0 to 2.0% in the Rio Del Rey estuary, 0.0 to 8.0% in the Cameroon Estuary, and 0.0 to 0.5% in the Ntem Estuary. The mortality rate in Cameroon mangrove forest is located between 0.0 and 14.0% per year (Ajonina and Chuyong 2017; Ndema et al. 2014; Ajonina and Chuyong 2017) (Fig. 21.6). The average mean annual increment in diameter (MAI) for primary and secondary stems under different management regimes was 0.15 cm/year.

This translates into annual increments of aboveground biomass above and below ground of 12.72 Mg/ha/year and 3.14 Mg/ha/year, respectively. Carbon sequestration rates vary by forest conditions, the aboveground parts (AGC) had proportionately higher sequestration rate (6.36 MgC/ha/year) compared to soil carbon pools (BGC). Undisturbed forests sequester on average of 16.52 MgC/ha/year against 0.39 Mg C/ha/year and 6.89MgC/ha/year by the highly and moderately degraded systems, respectively. The average rate of carbon sequestration for all forest conditions was 7.93 Mg C/ha/year, a figure comparable to similar studies elsewhere in Malaysia (Ong 1993), Thailand (Komiyama et al. 2005), and Kenya (Kairo et al. 2008).

21.4 Values and Current Uses of Mangrove

21.4.1 Mangrove Goods and Services

Mangroves provide many ecosystem goods and services that can be used directly or indirectly by local coastal communities (Ajonina and Eyango 2014) to guarantee their livelihood and ecological securities. Mangroves provide vital ecosystem services which include: tangible ecosystem services (provisioning services) or natural resources as a means of subsistence for 30% of the population of the country living in coastal areas dependent on its resources, particularly wood and non-timber

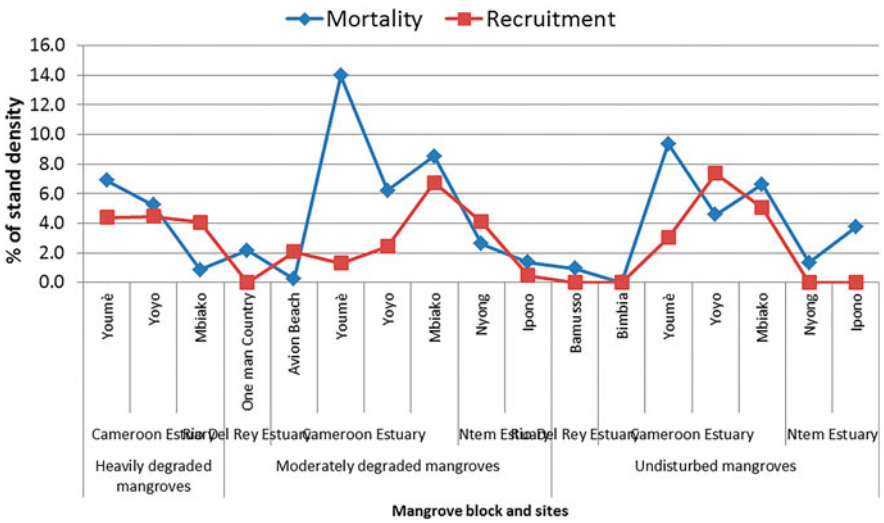

Fig. 21.6 Patterns of mortality and recruitment across Cameroon coast (Ajonina and Chuyong 2017)

products including fishery products; non-tangible services including: regulatory services ranging from stabilization of the coastal zone, carbon sequestration to improvement of the micro- and macro-climate; support services, supporting the food chain, spawning ground and habitat for many other marine and aquatic animals; and cultural services as a venue for spiritual activities of most festivals with enormous potential for ecotourism and environmental education (Dahdouh-Guebas et al. 2020).

21.4.2 Economic Valuation of Mangrove Ecosystem Services

According to a study in the Douala-Edea area (Noumeyi 2015), mangrove provisioning ecosystem services had an estimated monetary value of 2,027,761,495 FCFA (US$ 4,055,523)/year, i.e., 3,627,107 FCFA (US$ 7254)//ha/year. Regulating ecosystem services in turn had monetary value of 75,012,709,095 FCFA (US $ 150, 025, 418)//year, i.e., 4,720,021 FCFA (US $ 9, 440)/ha/year. Overall, the value of some goods and services of this ecosystem was 77,040,470,590 FCFA (154, 080, 941)/year, i.e., 8,347,128 FCFA (US $ 291, 467)/ha/year. In a similar study conducted in the Wouri area (Ajonina et al. 2015), the flow of people and goods across the Wouri River generates a turnover of 12,252,600 FCFA (24,505 USD)/canoe/year at Youpwé and 3,896,286 F CFA (7792 USD)/canoe/year in Akwa Nord.

21.4.3 Socio-Economic Elements and Main Uses of Natural Resources

The mangrove zone covers three regions (states/provinces) (the Southwest, the Littoral, and the South) spread over six Divisions (or departments), 24 districts, and 166 villages/districts in Cameroon. There are approximately 3,600,000 people in and around Cameroon's mangrove ecosystems, with 300,000 people (7.6%) residing in the mangrove formations (Ajonina 2010). The zonal distribution is very inequitable. In fact, about 70% of the population of the Rio Del Rey area live in mangroves, against 2.5% for the Cameroon estuary area and 21.3% for the Ntem estuary (Table 21.1).

The coastal zone of Cameroon is very populated with regional capitals such as Douala, the country's economic capital, and major cities (Kribi, Limbe, Tiko, etc.). There are also many villages and hamlets as well as fishing camps. The mangrove area has about 15 local communities including 5 urban communes and 10 peri-urban communes surrounded by companies of natural resource extraction industries (petroleum, agro-industries, etc.) and other industries.

Although the mangrove is a fragile ecosystem, its richness in natural resources ensures that it performs several important functions for the life and ecological security of five million Cameroonians (30%) living in the coastal zone. They represent an important economic source, used for thousands of years by the coastal populations who depend on them and contribute to the improvement of their living conditions (Mbog 1999).

21.4.4 Fishing Practices in Mangrove Areas

Fishing is the main economic activity in the mangrove areas of Cameroon. Industrial fishing is quite limited. Conversely, artisanal fishing is very widespread and is practiced by fishermen attached to mobile or fixed camps. This activity is the driving force behind a chain of other activities that fall into what can be called the fishing industry.

According to studies carried out by CWCS in three fisheries (Suelaba, Yoyo, and Mbiako) in Douala-Edéa National Park, 54 species of fish are exploited (CWCS 2000–2006; Nanji 2007). In the Sanaga estuary, bivalves (oysters) constitute a great source of income for the local populations in the recession season (November–June) when it is estimated that more than 800 tons are exploited with an income of more than 500 million CFA francs. The men harvest the oysters, while the women are interested in the pulpit where they make the "soy" steaks (Ajonina et al. 2005).

The players in the fishing industry represent the largest group of operators of mangrove natural resources. This group is dominated by young people and singles, especially in Rio Del Rey where fishermen live in temporary camps, far from their families. In this area in particular, several villages disappeared with the Bakassi

Table 21.1 Population in and around mangrove areas in Cameroon (After Ajonina 2010)

Mangrove zone	Name of the municipality	Number of mangrove villages	Total coastal population	Mangrove resident population	
				Total	As % total coastal
Rio Del Rey estuary	Ekondo Titi	35	75,000	5000	6.7
	Bamusso	20	10,000	10,000	100
	Bakassi	45	150,000	150,000	100
	Idenau	4	30,000	20,000	66.7
	Subtotal	114	265,000	185,000	69.8
Cameroon estuary	Limbe 3 (Bimbia)	5	60,000	20,000	33.3
	Tiko	6	40,000	25,000	62.5
	Yabassi (Nkam)	3	30,000	500	1.7
	Dibombari (Moungo)	3	20,000	500	2.5
	Douala I	3	450,000	2500	0.6
	Douala II	2	600,000	1000	0.2
	Douala III (Inclue Dibamba) 9 9	6	800,000	5000	0.6
	Douala IV	5	450,000	3500	0.8
	Douala V	3	800,000	3500	0.4
	Douala VI (Manoka)	22	45,000	15,000	33.3
	Ndonga (Dizangue)	3	5000	1000	25.0
	Mouanko	13	10,000	6000	60.0
	Subtotal	74	3,310,000	83,500	2.5
Ntem estuary	Kribi I/Lokonjie	4	10,000	1000	1 0.0
	Campo	6	5000	2200	44.0
	Subtotal	10	15,000	3200	21.3
Total		188	3,590,000	271,700	7.6

conflict and the military occupation. Conversely, an increase in the number of fishermen were noted in the villages and camps around Isangele, Baracks, Bamousso, Bekumu, etc. In the militarized zone temporary camps move regularly from place to place, with less and less sustained fishing effort.

Foreign fishermen are generally professionals in this industry. However, they are generally the poorest of the other economic players in the fishing industry and dream of defending their interests within professional associations. This organization can also help reduce the abuse of authority and harassment that could also come from a few crooked agents of the maritime brigade or the merchant navy. Finally, it can help organize (regulate) fishing and reduce conflicts between artisanal fishermen and industrial fishermen.

Opposite the group of fishermen, there is the group of fishmongers ("buyam-Sellam") and processors of fishery products. It is dominated by women who work full time sometimes following the fishermen and therefore moving from one fishing camp to another depending on the season (case of processors). In Rio Del Rey, the processors are often the wives of the fishermen and sometimes the fishermen themselves smoke their catches and then sell them on site to arriving traders or in periodic markets.

In the Wouri estuary area, the fishmongers of fresh fish, using motorized canoes, travel to the fishing grounds themselves to buy and collect the fishermen's catches. Overall, while fishermen are dominated by foreigners (Nigerians), fishmongers and processors are dominated by nationals.

The major problems facing fish wholesalers and processors relate to capital. The construction of smokehouses and other accessories is often expensive. Preserving fresh fish is even more complex and costly.

21.4.5 Sand Mining

Sand mining is one of the important activities in mangrove areas and especially those close to large cities (Douala, Tiko, Edéa, etc.). In Youpwè (Douala), artisanal sand extraction is estimated at more than 4 t per day (ONEQUIP 2009). The main quarries around Douala are located in sites such as Modeka Bay, Youpwè, Bonabéri, Akwa Nord at the level of the Wouri river mangrove. Like the mangrove poles exported to Nigeria, sand from the Cameroon estuary is currently exported in large quantities to Equatorial Guinea for construction.

21.4.6 Sectors of Industrial Development and Pollution

Among the other activities practiced in the mangrove areas, there is industrial agriculture led by companies such as SOCAPALM, HEVECAM, or CDC which cultivate oil palm, rubber, banana, or tea at an industrial scale. These companies are more located in the coastal strip of the Southwest region and are also around Kribi covering thousands of hectares. They use a lot of fertilizers, pesticides, and herbicides, the leaching of which affects the mangrove areas. These are products which generate nitrites, phosphates, chlorine and which are likely to cause eutrophication phenomena in the middle of mangroves. The result is a reduction in the natural productivity of these environments. The industrial plantations found in the area are home to important worker towns. This diversity bodes well for a wide variety of activities, including those in rural areas and those in industrial and tourist towns.

21.4.7 Urbanization and the Development of Human Settlements

In the Rio Del Rey estuary, the development of fishing camps has hardly any relation to the phenomenon of urbanization. The management of the border conflict between Cameroon and Nigeria has also helped to reduce fishing camps. However, it should be noted that the development of the Bakassi peninsula through the creation of an administrative unit can change this trend.

In the Cameroon estuary, the situation is presented in different terms. Indeed, the space of the estuarine system is considered by the Douala as a property bequeathed to them by their ancestors. However, it is one of the components of the public domain of the Cameroonian State because, according to the ordinance no ° 74/2 of July 6, 1974 fixing the state system, "the banks of the mouths of the rivers under the influence of the sea" form an integral part of the maritime public domain. Article 2 of the aforementioned ordinance prescribes that property in the public domain is not subject to private appropriation. We can therefore realize, faced with the reality on the ground, that the mangrove area of Douala is therefore the subject of illegal trade and we observe an advance of the city towards the mangroves which are gradually nibbled, destroyed, reclaimed for residential buildings.

Fishermen are no longer the only inhabitants of the mangrove area, which in some places is radically changing their activities. The canoe makers, outboard mechanics, pure farmers, the fisheries administration, and traditional authorities who presented themselves as facilitators of the fisheries sector are no longer the only players. The space is also occupied by commercial or industrial activities.

21.4.8 Logging and Forest Resource Management

According to Mbog and Ajonina (2007), the first systematic industrial exploitation of mangroves in sub-Saharan Africa began in the Gulf of Guinea in Cameroon, on the island of Manoka in 1919 when the Société Nationale de Bois du Cameroun obtained forest concessions to exploit mangrove wood and built a sawmill on this island. Considerable amounts of *Rhizophora racemosa* (red mangrove) timber have been removed. This wood extracted from mangroves was used for railroads (trans-Cameroonian), and for the manufacture of wooden barrels used for the conservation of palm oil and table wine in Europe.

Today there is large-scale commercial or industrial exploitation of mangrove timber in two aspects: fuelwood and timber. This is done using power saws by highly organized groups of non-fishermen from the surrounding villages and outlying neighborhoods. Two categories of mangrove logging are distinguished: Manual artisanal logging using rudimentary equipment carried out by fishing communities, especially women; and modern logging with sophisticated modern equipment carried out by groups of loggers who wholesale or retail their timber to all segments of

the population. These two types of exploitation have a significant impact on the mangrove ecosystem.

Logging activity which accompanies fishing is well established throughout the mangrove zone of Cameroon. Around all the fisheries, the search for wood (cutting and collecting) is daily. The wood is used for smoking fish, for the construction of smokehouses, for the construction or repair of houses, for the manufacture of canoes, for the production of latex which is used for coloring and preserving fishing nets, etc.

Mangrove wood is also cut and sold in towns for use as poles in urban constructions in Cameroon and Nigeria. Due to all these solicitations, the timber trade between the villages and all along the coast is flourishing. *Rhizophora* (red mangrove), one of the most abundant species in the Cameroonian mangrove, is also the most used. Trees 10 to 20 cm in diameter are cut into pieces of 1.5 to 2.5 meters maximum, to facilitate transport by canoe. In Cap Cameroon, these small farmers are even organized within an association, the "Firewood Cutters Union."

In the Rio Del Rey area, marked by large fishing camps and an absence of large towns, the production of wood for smoking fish represents the bulk of the cuts because housing construction is relatively limited. This trend may change with the development of the administrative center of the Bakassi Peninsula.

Conversely, in the southern part (Cameroon estuary, Manoka island, Souélaba peninsula), permanent habitation is more common and a lot of wood is consumed in the form of planks. In the areas surrounding the mangroves of Douala, the harvesters have the habit of penetrating the mangroves in order to make their choice on old trunks which, by falling, cause the fall of other trees and thus create large gaps in which rush the winds. This activity, which is accompanied by the use of chainsaws, is tending to become almost semi-industrial near Douala. Statistics on logging are difficult to collect for an activity recognized by its practitioners as illegal. Although this activity is done outside the law, the points of sale exist and are for some maintained by a game of corruption between the operators and the control services.

The extraction of *Rhizophora* bark for the exploitation of tannin has also been practiced in Cameroon following analyzes showed a generally high level of tannin (10–30% of the dry weight). Documents show an export in relation to the total wood removed (Mbog 1999). Today, the exploitation of mangrove wood is based in the Douala-Edea Fauna Reserve on the cutting of red mangroves, which are used for smoking and preserving fishery products, for cooking food in households, the construction of housing huts (lumber or poles), and the manufacture of fishing gear and handles of work tools.

Non-Timber Forest Products (NTFPs) have a great importance in the traditional life of the communities bordering the Mangroves. Mangroves indeed offer a wide range of Non-Timber Forest Products (NTFPs) which greatly contribute to the survival of poor local communities and create opportunities in the national and international market. Some of these products are consumed in the daily diet and some in cases of extreme famine. Picking edible species (leaves, roots, vegetable oils, wild fruits, mushrooms, saps, and others) is also a common practice. Initially intended for home consumption, some of these products are also marketed. Many

NTFPs are used in the cottage industry and in pharmacopeia for traditional medicine. Bark, leaves, roots, and fruits are used from mangroves.

The exploitation of the fruits (for consumption) and leaves (mat) of the Nipa palm (*Nypa fructicans*) depends on the presence of this species and concerns much more the mangroves of Rio Del Rey where it is abundant. Other NTFPs, notably rattan and palm trees found near or even within mangroves, are also subject to intensive exploitation and play an important role in the socio-economic life of the riparian populations.

The many species of lianas are used in the manufacture of furniture, or the making of roofs and hut structures. Today lianas and the leaf segments of *Nypa* and *Raffia* play an increasingly important role in the construction of huts, these lianas also represent a renewed interest in contemporary craftsmanship, in the manufacture of furniture and common objects of basketry.

Most of these products are found in large quantities in local markets and some for export, for example, the bark of *Rhzophora* spp. for tannin (farmers go through Nigeria for shipment), bunches of dried fruits of *Nypa fructicans* to decorate the interior, yohimbe peels.

21.4.9 Some Cultural Services

Mangroves have been of great immense cultural values as centers and sites for spiritual or ancestral worships including marking important cultural or traditional events. An example is the canoe races organized in the mangrove zone of Douala-Edea during the NGONDO festival a great traditional festival of the SAWA (Cameroonian tribe made up of clans: Bell, Bassa, Deido, Belle-Belle, Jebale, Akwa, Bojongo, and Moungo). They are organized during the first week of December or the last week of November. A race is estimated on average at 14,515,000 FCFA/year or a total of 7260 FCFA/ha/year of mangroves (Ajonina et al. 2013).

21.4.10 Ecotourism Potential

Though there is a scarcity of data on the recreation value of mangroves, available information indicate that mangroves are also potential tourism sites though not comparative to adjacent terrestrial ecosystems such as rainforests or other wildlife sanctuaries with bigger attractions. At the Ebojie Marine turtle site within the Ntem mangrove block, visitor records kept by the Association Nationale de Protection des Tortues Marines du Cameroun "Kud'A Tube" put an average number of visitors around ten visitors/month with a yearly total of 120 notwithstanding the COVID-19 crisis. Generally, tourism infrastructure in the mangroves is not yet fully developed and the potential has not yet been fully realized. Payments for Ecosystem Services

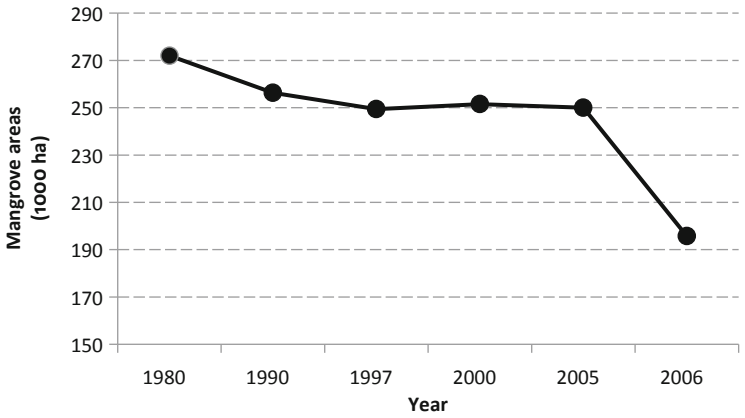

Fig. 21.7 Mangrove cover change in Cameroon (1980–2006) (UNEP-WCMC 2007)

(PES) schemes could explore improving ecotourism opportunities and income in the region.

21.5 Threats, Challenges, and Drivers of Mangrove Biodiversity Loss

21.5.1 Conversion and Degradation of Mangroves Ecosystems in Cameroon

According to the UNEP report (UNEP-WCMC 2007) of the mangrove cover study in West and Central Africa between 1980 and 2006, the mangrove cover in Cameroon in 2007 was about 200,000 ha having decreased by 28% between 1980 and 2006 in Cameroon (see Fig. 21.7).

21.5.2 Trends in Mangroves and Associated Coastal Forests Cover Changes

According to the analysis of satellite images between 2000 and 2015, mangrove land and associated coastal forests declined by −7.9% (−20,220 ha) in the period, i.e., −0.5% (−1348.0) per year. The rate of decline of intact mangroves is −0.8% (−501 ha) per year and increase in plantings and habitation of 3.7% (1492 ha) per year. Figure 21.8 shows intact mangrove swamps increase in the Rio del Rey area at 9.4% per year, decline in the Cameroon Estuary by −1.1% per year, and increase 2.1% per year in the Estuary of Ntem.

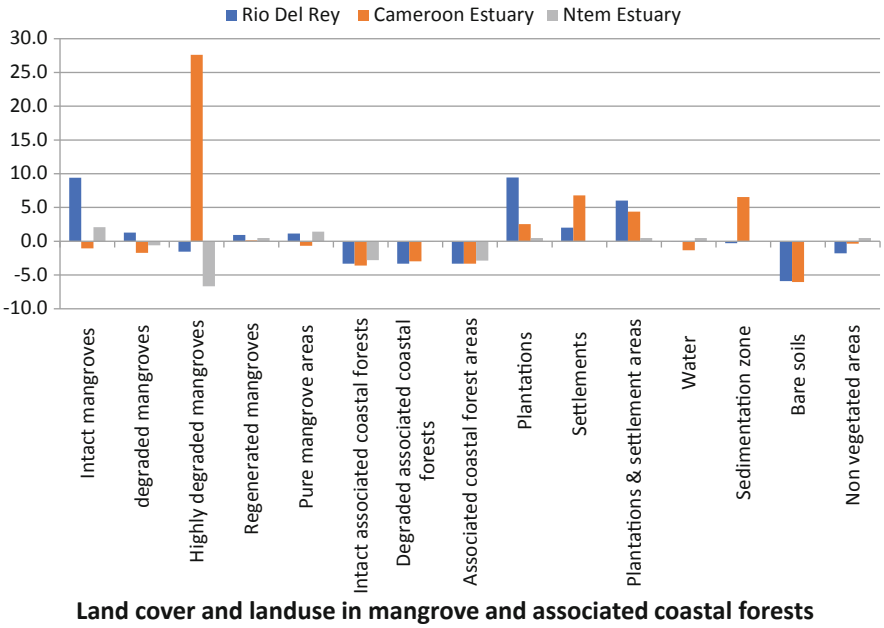

Fig. 21.8 Cover changes in mangrove and associated coastal forests in Cameroon

21.5.3 Causes and Consequences of Mangrove Conversion/Deforestation and Degradation in Cameroon

Population pressure on the unsustainable extraction of mangrove resources, the influences of invasive species, absence of a policy on mangroves, and climate change have been largely discussed as factors causing mangrove deforestation and degradation in Cameroon among others (Fig. 21.9).

21.5.3.1 Conversion or Deforestation of Mangrove Ecosystems in Cameroon

The direct causes being urban expansion and agricultural expansion especially the agro-industrial winter planting, palm groves, banana groves, etc. national companies: CDC and multinationals: SOCAPALM, FERME SUISSE, etc., and large-scale hydrocarbon exploration.

The main underlying factors are: demographic pressures, economic pressure, energy needs, and weak protection/legislation for mangrove areas—with large areas still unprotected except in the newly created Ndongoro National Park at the

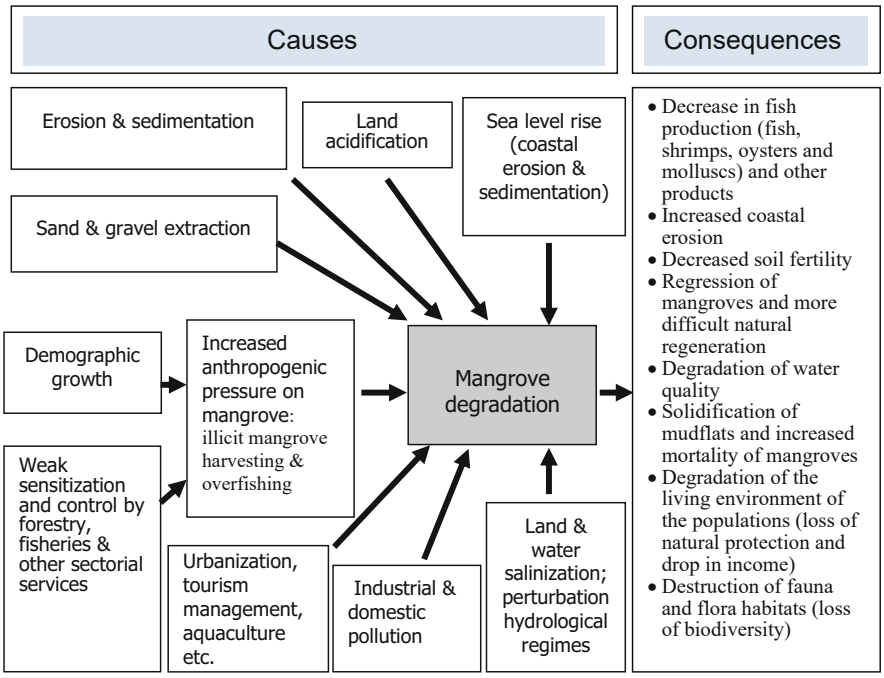

Fig. 21.9 Schematic diagram of mangrove degradation factors and consequences (Folock 2013 in MINEPDED 2014a, b, c)

border with Nigeria, Bois de Singe, Douala-Edéa National Park, and Campo Ma'an National Park on the border with Equatorial Guinea.

The majority of threats to mangroves from the main factors identified above include: urban infrastructure and agricultural development, eutrophication, and algal blooms—pesticides and fertilizers from large-scale plantations (rubber, palm oil, banana) in the coastal region of Cameroon. Invasive Species—The Nipa Palm is an introduced species, which has colonized several mangrove areas and competes with native mangroves, such as *Rhizophora*, water hyacinth (*Echorhina crassipes*) is also abundant. Most of the threats identified are well known, but not quantified and documented to better manage them.

21.5.3.2 Degradation of Mangrove Ecosystems in Cameroon

Mangroves are subject to degradation, the direct and underlying causes of which lie in two different (often linked) processes affecting mangroves: destruction or total degradation. In some cases, total destruction may be due to urbanization, large tourism or industrial enterprises, rice cultivation or their eradication to make way for shrimp farming. In other cases, partial deforestation is further aggravated by

degradation of the mangrove (where most trees remain), due to activities such as oil or mining; we notice:

- physical degradation of mangroves by excessive cutting of mangroves;
- an alarming overexploitation under the action of a significant demographic growth and in the particularly difficult ecological and socio-economic context: the new habitat needs around the large agglomeration which cause significant clearing and an increase in energy and in natural resources especially sand;
- increasing pressure on fishery resources to which is added a misguided and technically unsuitable exploitation of mangroves (cutting of mangrove roots to harvest oysters, for example);
- The two groups of mangrove degradation factors (natural and anthropogenic) are summarized in Fig. 21.12 with the resulting consequences.

Among the direct factors of degradation are the energy needs of the growing urban and rural populations. Despite the abundant use of timber and non-timber forest products from mangroves, adequate legislation does not yet exist. On the socio-economic level, although the fishermen are a large majority of the professionals of the sector, the activity is dominated by foreigners confronted with problems of organization of the sector and by poverty compared to the other economic actors of the sector, the fishing industry.

The logging that is done throughout the mangrove zone of Cameroon in relation to the development of fishing camps (construction wood) and the intensity of catches (smoke wood) is in worrying proportions for nearby cities which also require mangrove wood in the form of poles or planks for urban constructions. Statistics on logging are difficult to obtain for an activity recognized by its practitioners as being outside the law.

Data on sand exploitation is insufficient to understand the impact of this activity, which is taken in great proportions around large cities. There are also reports of the export of mangrove sand from Cameroon to Equatorial Guinea. However, we can point out the importance of sandy beaches in the reproduction of certain species such as sea turtles.

21.5.3.3 Degradation Through Pollution of Mangrove Ecosystems

Mangrove zones are highly polluted especially from the Cameroon estuary with waters with Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) rates of more than 250 mg/l (Fonocho 2008; CWCS 2010) (see Figs. 21.10 and 21.11). This is largely due to the heavy concentration of industries and human activities in Douala City but also from agro-industrial plantations (SOCAPALM, HEVECAM, CDC) around mangrove areas including petroleum and gas exploration and exploitation that pour their wastes and effluents (liquid and solid) directly into the mangrove areas and the use of chemical products in fishing.

The degradation of mangroves and the disappearance of biodiversity promote eutrophication of the waterways as well as the suffocation of frequently flooded and

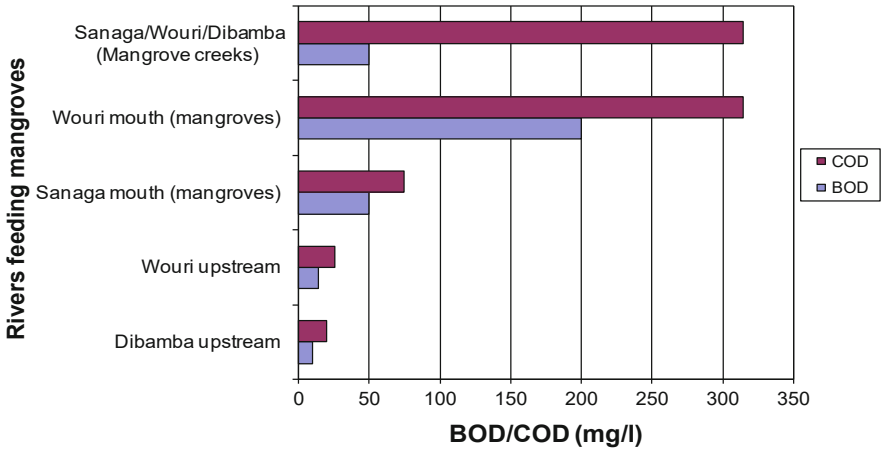

Fig. 21.10 State of pollution of the mangrove ecosystem of the Cameroon estuary [Sampling periods: August 2007 (mangrove areas) and August 2008 (upstream areas)], Fonocho 2008

Fig. 21.11 Pollution of mangrove ecosystems (Littoral Region: Photos NGUEKAM W.E in 2012)

non-oxygenated soils (Cam-Eco Study Report 2010). This is accelerated by invasive species such as water hyacinth and the Nypa palm (*Nypa fructicans*). The Indo-Asiatic mangrove palm *N. fruticans* introduced in Nigeria in 1906 has reduced native species diversity, with rapid invasion into Cameroon at the rate of 175 Nypa palm/ha/year (Moudingo et al. 2019).

The biochemical oxygen demand in the mouths and estuaries of the main rivers characterizing the hydrographic network of the mangrove zone exceeds the authorized limit value which is 250. The same is true for certain metals such as SS and coliforms whose concentration is well above the authorized limits.

Some pollutants result from the breakdown of chemicals used in industries. They fall within the range of molecules called persistent organic pollutants (POPs) which are harmful to the health of living beings in general and humans in particular. In the environment, they are deposited on vegetation, soils, and rivers and are absorbed by

animals and fish which are then used as human food. They are the precursors of cancer in living beings and increase the vulnerability of infected species. Their presence in liquid and solid effluents justifies the absence of industrial waste treatment units. The lack of national standards on industrial waste management and the costs incurred by the recommended measures seem exorbitant for companies.

21.5.3.4 Policy, Legal, and Institutional Challenges to Sustainable Mangrove Management

Despite the ecological, economic, social, and cultural importance of Cameroon's mangroves, they are still not managed on a sustainable basis. Table 21.2 brings together the elements showing the strengths, weaknesses, constraints, and opportunities on policy, legal, and institutional framework relative to sustainable mangrove management in Cameroon.

The assessment of the implementation of national legal instruments reveals many gaps and shortcomings which demonstrate the efforts that remain to be made to have a complete and effective legal framework. Stakeholders' analysis within the mangrove zone carried out by Forkam et al. (2020) show that there are two major categories of stakeholders involved in the management of mangrove with different levels of involvement and interventions in the management process (Fig. 21.12). These are: (a) direct (primary) stakeholders (indigenous and non-indigenous of the local population and characterized by fishermen, fish smokers, mangrove exploiters including harvesters, processors, and marketers) concerned with mangrove exploitation and (b) indirect stakeholders made up of (secondary) stakeholders ("Development Agents" including NGOs, Research and Academic institutions, and the Council; "Policy Makers" who are parliamentarians and senators; and "Policy Implementers" being the Ministry of Forestry and wildlife "MINFOF," Ministry of Environment Nature Protection and Sustainable Development "MINEPDED," Ministry of Fisheries, Livestock and Animal Husbandry "MINEPIA," Ministry of Agriculture and Rural Development "MINADER," and Ministry of Tourism "MINTOUR") not in direct contact with the resource but playing service control law and enforcement role; and (tertiary) stakeholders living at the proximity of the mangrove forest who do not equally exploit the mangrove directly but they enjoy the indirect ecological benefit (positive externalities or green house benefits). They are mostly petty traders living in the area such as shopkeepers and fishmongers "buyam-sellam" either of smoked fish or fresh fish preserved in ice boxes mainly ecological services beneficiaries.

Currently, MINFOF, MINEPDED, and MINEPIA are major government institutional actors involved directly in the management of mangrove ecosystems and the coastline in Cameroon; other ministries are also involved, but to lesser degrees. Local administrations are not equipped to face the multiple environmental, economic, and social challenges of mangroves and the coastal zone in Cameroon. The institutional problems thus identified are:

Table 21.2 SWOT analysis of the policy, legal, and institutional framework relative to sustainable mangrove management in Cameroon

Strengths	*Weaknesses /failures*
• Favorable international context with ratified conventions including those that protect mangroves • The major players in mangrove management are globally known • Consultation frameworks exist or are under development and operate on a legal basis (decisions noting the collaboration frameworks, drafts of management documents for these frameworks, etc.) • Several donors are interested in the sustainable management of Cameroon's mangroves (FAO, GEF, etc.) • Projects have been carried out on the mangrove swamp and have made it possible to draw up documents from which we can draw lessons to be valued and lessons to be learned • The framework law which imposes the carrying out of EIAs on industrial enterprise projects • Political will with regard to participatory planning • Physical setting of mangroves fairly well known • Ongoing creation of more mangrove Ramsar sites	• Weakness in the EIA prescription for major investment projects or environmental audits for companies already established or lack of monitoring of the implementation of environmental management plans • Lack of specific regulations in the middle of mangroves (legislative texts) • Low valuation of traditional/indigenous knowledge and lack of an appropriate management model • Policy gap and multisectoral strategy for sustainable mangrove management • Weak local organization of the population • Lack of development initiatives led by the population • Mangrove not sufficiently taken into the country's planning and developmental processes, e.g., marginalization of the mangrove problem in current programs like the Forest-environment sectoral Programme (PSFE) • Lack of cross-border strategy to properly channel the activities of other nationals in mangrove areas
Opportunities	*Constraints/obstacles*
• Multiplicity of coastal projects that include mangroves at least at environmental impact scoping stages • Availability of the main stakeholders involved in supporting project actions (public services, international organizations and national NGOs, etc.) • Stakeholders are involved in the construction of various platforms on mangrove management, some with strong technical and organizational potential • Ongoing policy reforms in forestry and fisheries to integrate mangroves issues • Existence of NGOs active in the mangroves • Creation of more marine protected areas that include mangroves as integral habitats	• Existence of jurisdictional conflicts • Proximity to polluting companies • Population unemployment • Insecurity linked to border conflicts • Informality of several main activities in mangrove areas • Absence of reliable data and information especially on fisheries stocks and exploitation dynamics

- the lack of coordination and consensual planning of the initiatives undertaken by the actors who operate in the sustainable management of mangroves in Cameroon;
- conflicts of jurisdiction between the different administrations;

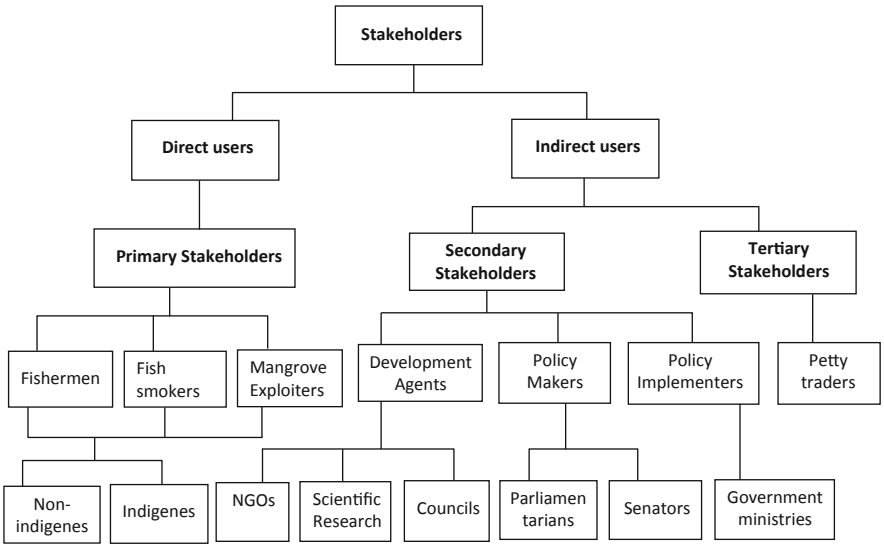

Fig. 21.12 Stakeholders involved in mangrove exploitation and management (after Forkam et al. 2020)

- a weakness in the prescription of Environmental Impact Studies and continuous/permanent monitoring of environmental, sanitation, and public health indices;
- the inadequacy of national environmental and forest policies to the management of humid and fragile ecosystems in general, and particularly those of mangroves;
- A legal vacuum in terms of land: paradox of the location of mangroves in the maritime domain of the State and its exploitation or occupation;
- insufficient staff in certain sectoral services;
- the lack of adequate equipment for monitoring coastal areas including mangroves;
- the non-involvement and little consideration of the concerns and traditional knowledge of decentralized communities and local communities in the protection and management of mangrove ecosystems;
- the weak technical, organizational, financial, and managerial capacity of the riparian communities to enable them to fully participate in the protection and sustainable management of mangrove ecosystems.

21.6 Addressing the Threats and Challenges

The uncontrolled loss and degradation of mangroves have been met with efforts through projects that were mostly isolated and a lack of intersectoral coordination and a lack of access and dissemination of lessons learned from innovations and conservation initiatives, restoration, and sustainable use. The current management

regime is discussed in the context of projects initiatives in these areas: conservation; awareness creation and environmental education tool for mangroves; restoration practices through mangrove reforestation; technology practices of sustainable use of mangrove resources; participatory management; and research and monitoring. These initiatives are to be strengthened and capitalized with a better coordination and integration of stakeholders in mangrove related projects.

21.6.1 Conservation

21.6.1.1 Creation of Mangrove Protected Areas

Some encouraging commitments have been made by the Cameroonian government with the support of civil society, especially international and national NGOs, for the conservation of mangroves through the creation of mangrove protected areas or their inclusion in the system of coastal protected areas. The Ndongore protected area project, or the Kribi Marine Park project with WWF support is considered and the inclusion of mangroves in the system of coastal protected areas of the Douala-Edea National Park as together they capture over 50.30% of the country's mangroves currently in marine protected area systems (Table 21.3). Also noting the full protection of certain species associated with the mangrove, for example: manatee, sea turtle, etc. In this regard, we should point out that there is a center in Ebodjé created by the ECOFAC program for the conservation of marine turtles, which has acquired many achievements, in particular in raising the awareness of populations and other tourists around certain hotels in Kribi. The awareness-raising tools developed encourage stakeholders to promote the release of young turtles accidentally caught in the sea. Donations of fishing gear such as nets have made it possible to consolidate this awareness-raising action. It is also a form of Payment for the Environmental Service (PSE). These initiatives should be strengthened and capitalized with better consultation and integration of stakeholders through mangrove projects and programs.

21.6.1.2 Ramsar Site Creation Initiatives

The government and partner have committed to designate Cameroonian territory under the Ramsar site regime, two sites have already been created and four are being created in the coastal zone to include more than 70.88% mangrove areas (Table 21.4).

Table 21.3 National parks, mangrove cover, and interventions in the coastal zone of Cameroon

Mangrove block	Name of National Park	Year of creation	Surface area (ha)	Mangrove (ha)	Sea (ha)	Mangrove (%)	As % National mangroves	Main intervening partners
Rio Del Rey estuary	Ndongore	Ongoing (Public Notice issued on April 2020)	121631.2	71,921	49670.2	27.35	32.52	CWCS/ MINEPDED
Cameroon estuary	Douala-Edea	Decree Oct 2018	262,935	39,202	97137.6	14.91	17.73	CWCS/ MINFOF
Ntem estuary	Manyange na Elombo-Campo	Decree July 2021	110,300	121	110,179	0.11	0.05	WWF/ MINFOF
Total			494,866	111,244	256,987	22.48	50.30	

Table 21.4 Ramsar sites, mangrove cover, and interventions in the coastal zone of Cameroon

Mangrove block	Name of Ramsar site	Year of creation	Surface area (ha)	Mangrove (ha)	Sea (ha)	Mangrove (%)	As % National mangroves	Intervening partners
Rio Del Rey estuary	Rio Del Rey estuary	2010	165,000	115,330	49,670	69.90	52.15	WWF/CWCS/MINEPDED
	Batouke	Ongoing	3900	100	780	2.56	0.05	AMMCO, MINEPED
	Subtotal		168,900	115,430	50,450	68.34	52.19	
Cameroon estuary	Nkam—Wouri	Ongoing	584,490	30,878	100	5.28	13.96	Université de Douala (ISH)/CWCS/WTG, MINEPDED
	Lower Sanaga Delta	Ongoing	120,000	10,331	20,000	8.61	4.67	CWCS/MINEPDED
	Subtotal		704,490	41,209	20,100	5.85	18.63	
Ntem estuary	Ntem River	2012	39,848	121	500	0.30	0.05	MINEPED
Total			913,238	156,760	71,050	17.17	70.88	

21.6.2 Development of Environmental Awareness and Education Tools for Mangroves

NGOs have launched several awareness campaigns on the importance of mangroves and the need to conserve and manage them sustainably. The broad sensitization undertaken by the Cameroonian Network for the Conservation of the Mangrove Ecosystem (RCM) through the biannual meetings of the executive committee, the organization of coastal forums, and rotatory exchange visits in the mangrove areas of Cameroon constitutes a major advance.

The NGO "Cameroon Environmental Watch" (CEW) based in Yaoundé and also a member of RCM has developed awareness-raising tools on mangroves as part of its awareness-raising project entitled "Plein Feux sur les Mangroves du Cameroun," a project carried out in all the coastal university towns of Cameroon (Buea and Douala) and in Yaoundé between 2007 and 2008. These tools were presented during the African regional meeting of RAMSAR in November 2007 in an exhibition stand visited by the Prime Minister and during the National Forest Forum in Cameroon in March 2010. These tools could be used to promote environmental education in conjunction with this NGO.

21.6.3 Mangrove Restoration Practices Through Reforestation

Participatory mangrove reforestation activities were carried out by Cameroon Wildlife Conservation Society (CWCS) in degraded mangrove areas of the Douala-Edea National Park (Moudingo et al. 2016) especially around the villages of Mbiako, Yoyo, Youmé, and Bolondo. These actions received initial support of the French NGO "Planète Urgence"/IUCN in 2005, UNDP between 2007 and 2009, WWF in 2009, MINEPDED, 2016–2019, thereafter Planète Urgence and INBAR within the framework of The Restorative Initiative (TRI) with IUCN partners recently. In total, more than 50 ha of degraded mangroves have been reforested with the techniques of nursery, direct planting with wildlings and propagules of *Rhizophora* and *Avicennia* with a success rate of over 80%. Lessons learned from these reforestation trials are documented in project reports and other publications (Moudingo 2010; Ajonina et al. 2016).

It should be noted the very remarkable efforts since 2010 of reforestation of more than 30 ha of degraded mangrove plots in the urban environment of Douala by the GIC-PPC under the cover of the RCM and technical assistance of the CWCS from which the private sector intervened, members of parliament, students of the Institute of Fisheries Sciences (ISH) of the University of Douala in Yabassi (planting over 25 ha of degraded mangroves).

In addition, pilot *Rhizophora* nurseries and mangrove plantation trials have been established with various successes by MINEPDED, CWCS, WWF, and the people

of Campo Beach, in Kribi area by OPED in Rio Del Rey areas by CAMECO and other NGOs.

There is the need to consolidate these different isolated initiatives in order to appraise and document the level of success, best practices, and lessons learned to maximize their impact addressing restoration of degraded mangrove habitats.

21.6.4 Practices for Sustainable Use Technologies of Mangrove Resources

The mangrove wood use efficiency within the Douala-Edea area (Ajonina and Eyabi 2002; Feka et al. 2009; Feka and Ajonina 2011) for fish processing is the result of a technology introduced in 2000 by "Mangrove Action Project" (MAP) based in Los Angeles after its introductory experiences in Asia. The technology was therefore adapted in collaboration with the IRAD Oceanographic Research Center in Limbe with an expert on the subject and popularized in the Douala-Edea area. The principle is to close the opening around traditional smokehouses that source the smoke and thus prevent the leakage of thermal energy and to concentrate it more for smoking fish by reducing the effective smoking time. This technology reduces over 40% of the amount of wood used, thus limiting mangrove deforestation and combating climate change. It also has a positive impact on health as it lowers the rate of lung disease and reduces fires.

The material used to improve the smokehouse consists of mud bricks or planks closed on two sides with a sand hole to limit the leakage of thermal energy by conduction. The cost is estimated at 400,000 CFA francs (c200 US $) for smoking rooms using boards and one million (c500 US $) for those using bricks transported from the city. In terms of efficiency, they lead to a 30–40% reduction in wood used. In addition, the smoking time reduces from 21 h to 6–8 h. This had been the pivot for validation but has yet to be implemented by CDM which selected 400 smokehouses in nine villages of the reserve (Mbiako, Moloungo, Yoyo I, Yoyo II, Youmé, Bolondo, Nyangado, Sandjé and Sessioo) with potential generation of over 7800 tC/year. Similar efforts have been undertaken by the Women smoking fish around the mangroves in Kribi by OPED that earned them the prestigious 2016 Equador Prize.

The main problem with improved smokehouses is their acceptability and adoption by a large foreign and migrant population within the coastal areas.

21.6.5 Participatory Management

21.6.5.1 Through Mangrove, Marine, and Coastal Platforms

Backed by the 1990 law of Association in Cameroon, the process of institutionalization of the participatory management of mangrove ecosystems received an

impetus with the establishment of various platforms at the local, regional, and national levels. At the local level, is the case of the Douala-Edea mangrove management committee (COPCVAM) led by the CWCS. This committee has three bodies, including the general assembly, the technical implementing body, and the village reforestation committee. The latter is made up of village chiefs, fishermen, fish smokers, and wood cutters. One of the key actions of this organization is the simple management plan which deals, among other things, with zoning and management rules according to an action plan drawn up during the general assembly held twice a year. The real challenge for COPCVAM with a multiplicity of actors (foreign fishermen, fish smokers, mangrove wood cutters) is to respect established management rules with appropriate organizational capacity.

At the regional level concerning the Cameroon three mangrove blocks, the platforms are created with the facilitation of CAMECO in a legalization process bringing together municipalities, public services, and the private sector. The Cameroonian Network for the Conservation of Mangrove and Wetland Ecosystems (RCM) with over 40 NGOs, community-based organizations, researchers, etc. remains the only national platform active in the conservation of mangrove ecosystems.

21.6.5.2 Through the Regime of Communal and Community Forests

The Law 94/01 of January 14, 1994 on Forests, Wildlife, and Fisheries provides for the creation for the benefit of local populations under a given council (municipality) a communal forest to an undefined extent and communities of community forests of up to 5000 ha for legal entities (NGO, CBO, etc.) within a community. Community-based mangrove management initiatives have been undertaken by certain riparian populations including Manoka in the sixth district of Douala; Canton Bakoko in the third district of Douala; Bamusso Ekondo Titi and Tiko-Limbe III in Southwest Region. Over 42.75% of mangrove forests are currently under this form of management with over 35% under communal forestry and 7.5% under community forestry regime (Table 21.5).

21.6.6 Research and Monitoring

Research is being undertaken in the expanse of Cameroonian mangroves by the joint efforts from universities, NGOs, and research institutes under different projects, especially those that have defined monitoring aspects to address conservation, sustainable utilization, and restoration of mangrove forests (Blasco et al. 2000; Longonje 2008; Ajonina et al. 2009a, b; CAMECO 2010; Nfotabong et al. 2011; Priso et al. 2011; Munji et al. 2013, 2014; Tening et al. 2014; Din et al. 2016). The Cameroon estuary block has benefited from many studies (Din 1991; Din et al. 1997, 2001, 2002, 2006, 2008; Ajonina and Usongo 2001; Asaah et al. 2006; Ajonina

Table 21.5 Mangrove communal and Community forests in Cameroon

Mangrove block	Ownership	Year of creation	Surface area (ha)	Mangrove (ha)	Sea (ha)	Mangrove (%)	As % National mangroves	Intervening partners
Communal (council) forests								
Rio Del Rey estuary	Idabato council	Ongoing	17,840	15,840	2000	88.79	7.16	GEF/MINEPDED partners
	Kombo Itindi	Ongoing	6265	6011	254	95.95	2.72	GEF/MINEPDED partners
	Ekondo Titi/Bamousso	2014	43,512	35,829	7683	82.34	16.20	GEF/MINEPDED partners
	Subtotal		67,617	57,680	9937	85.30	26.08	
Cameroon estuary	Tiko-Limbe III	Ongoing	34,561	20,170	3736	58.36	9.12	CWCS/PNDP/ MINEDEP
Ntem estuary			–	–	–	0	0	
Total under communal ownership			102,178	77,850	13,673	76.19	35.20	
Community forests								
Rio Del Rey estuary	Isangele	Ongoing	1698	1430	268	84.22	0.65	GEF/MINEPDED partners
	Kombo Abedimo and Idabato	Ongoing	3344	3250	94	97.18	1.47	GEF/MINEPDED partners
	Kombo Itindi (1)	Ongoing	3508	3400	108	96.92	1.54	GEF/MINEPDED partners
	Kombo Itindi (2)	Ongoing	3654	3560	94	97.43	1.61	GEF/MINEPDED partners
	Subtotal		12,204	11,640	564	95.38	5.26	
Cameroon estuary	Bimbia/Bonadikombo	2000	1921	52	14	2.71	0.02	BBNRMC/MINEF
	Manoka	2017	3195	2700	495	84.51	1.22	CAMECO/ MINFOF

	Dibamba	Ongoing	2530	2300	230	90.91	1.04	CAMECO/ MINFOF
	Subtotal		7646	5052	739	66.07	2.28	
Ntem estuary			–	–	–	0	0	
Total under community ownership			19,850	16,692	1303	84.09	7.55	
Grand total under participatory management			122,028	94,542	14,976	77.48	4.75	

2008; Din and Baltzer 2008; CAMECO 2010; Priso et al. 2011, 2012; Nfotabong et al. 2013; Tening et al. 2013; Ngo-Massou et al. 2014; Tchakonté et al. 2014; Fonge et al. 2015; Fusi et al. 2016; Tchinda et al. 2019; Besack et al. 2021; Kottè-Mapoko et al. 2021); although very few in the Ntem estuary block (Dika 2010; Nfotabong et al. 2011; Angoni et al. 2015; Moudingo et al. 2020; Mama et al. 2021).

Research addressing mangrove and wetlands management issues has also been done through the dissertations of students in universities, as various knowledge products including technical reports and scientific publications though with little communication to influence policy outcomes to protect mangrove forests and integration with indigenous knowledge systems. Moreover, research endeavors in mangrove and wetlands still suffer from weak technical, material, and operational capacities of most institutions coupled with addressing the question of sustainability of data collection activities where communities are involved in data collection efforts.

21.7 Perspectives for Sustainable Mangrove Management

21.7.1 Conclusions

Cameroon features among the countries in Africa with mangrove cover having a great structural peculiarity with diverse flora and fauna being the most giant in Africa and among the biggest and tallest in the world reaching over 1 m in diameter and 60 m in height especially around the Wouri estuary. The mangrove forests provide a wide range of vital ecosystem services which include: tangible ecosystem services (provisioning services) or natural resources as a means of subsistence for more than 30% of the population of the country living in coastal areas dependent on its resources, particularly wood and non-timber products including fishery products; non-tangible services including: regulatory services ranging from stabilization of the coastal zone, carbon sequestration to improvement of the micro- and macro-climate; support services, supporting the food chain, spawning ground and habitat for many other marine and aquatic animals; and cultural services as a venue for spiritual activities of festivals with enormous potential for ecotourism and environmental education. Mangrove and associated coastal areas have been lost annually at more than 1% in Cameroon though varying between regions. The driving factors are coastal population growth, urbanization, fish processing, sand extraction, and uncoordinated policies and government economic coastal development programs including accentuated pollution from extractive and processing industries. Government and partners contributed significant efforts through conservation (national parks and Ramsar sites) and sustainable management practices (communal and community forest regimes). Many awareness campaigns, sustainable utilization and restoration, and research initiatives have also been embarked upon. What really remains is the enhancement of management effectiveness of Cameroon mangroves

through policy amelioration and coordinated efforts of the different stakeholders in the perspectives of sustainable management. Recommendations are therefore made to attain this goal.

21.7.2 Recommendations

Recommendations are made towards better conservation, sustainable use, and restoration of mangrove ecosystems and associated coastal forests through a win–win approach using whatever method/technique used (conservation, sustainable use, and restoration). There are five management approaches: holistic approach (multidisciplinary) involving different areas in the analysis of problems; ecosystem approach (man considered a component or link in the nature of chain); integrated approach (incorporating all relevant human activities: fishing, farming, hunting, farming, etc.); landscape approach (encourage connectivity of different ecosystems in the landscape); and participatory approach (development of partnerships with stakeholders, institutions, etc. involved).

The roles of different actors including government, NGOs, private sector, local communities and universities and research institute in implementing recommendations are equally discussed.

21.7.2.1 General Recommendations

Awareness Raising More awareness raising at all levels on mangrove ecosystems, its values and risks of its loss to trigger its integration and mainstreaming in all developmental planning processes at local, sub-national, and national levels.

Conservation Proper articulation of mangrove objectives and action plans in coastal and marine protected area systems including Ramsar sites.

Organizational and Functional Framework for Mangrove Stakeholders At the level of producers (fishermen and performers of related trades, woodcutters, sand farmers, etc.), co-management actions should aim at the organization of producers, coordination, harmonization of interventions, contribution to the rehabilitation of degraded areas, sharing of common benefits, etc. This development can build on institutions that are already functioning while working as needed on the creation of new institutions.

More Control and Monitoring of Mangrove Activities This includes mangrove timber cutting and marketing sector, in particular on local markets or in fishing camps; backed by proper regulations on the main activities undertaken in sensitive areas of mangroves.

Promotion of Good Management Practices Drawn from traditional know-how, including at the level of the promotion of achievements linked to local organizations of the populations.

Community-Based Mangrove Exploitation and Restoration Plans There is a need to promote and encourage the development and implementation of participatory plans for the exploitation and restoration of mangrove resources aimed at sustainable use within the municipalities with all the actors concerned.

Support Research Support research on all aspects that will lead to conservation, sustainable utilization, and restoration of mangrove ecosystems. Setting up a comprehensive database system on mangroves based on simple and accessible ecological, socio-economic, and institutional indicators to facilitate monitoring and reporting on mangrove utilization (wood, sand, fisheries, other natural resources) and ecosystems recovery/restoration dynamics and invasive alien species.

Funding Mechanism Exploration of funding mechanisms at different levels including adhesion to global initiatives especially carbon financing, 30 by 30, etc. to support conservation, sustainable utilization, and restoration initiatives within the mangrove ecosystems.

21.7.2.2 Recommendations on Legal Aspects

Legal Reforms Support the process of revising the 1994 forests, wildlife, and fisheries legislation as well as the 1996 framework law on the environment and their implementation texts to integrate, among others, considerations relating to the protection and sustainable management of the mangrove ecosystem in Cameroon. Mangrove be accorded a priority articulation of objectives, directives, and orientations for conservation, sustainable utilization, and restoration of mangrove ecosystems.

Appropriate Implementation of International Instruments Ensure the concrete and appropriate implementation of international instruments relating to elements of the marine and coastal environment to which Cameroon is a party.

EIA Legislation Strengthen the application of the framework law with regard to the realization of environmental impact studies for any project or important structure likely to affect the ecological balance of the mangrove area and help MINEPDED to mobilize resources for impact studies or other forms of studies carried out in mangroves relating to activities such as sand exploitation, logging, etc., reserved for the poor section of the population, in order to channel action operators instead of being confronted (by wanting to respect the precautionary principle) with a prohibition that is difficult to ensure. Need to set up and support the operation of a body responsible for ensuring the conduct of environmental impact studies and the implementation of mitigation or mitigation measures for the negative impacts identified.

21.7.2.3 Recommendations on Institutional Aspects

Proper Communications Strategies Within Existing Platforms Set up within collaboration platforms, communication strategies to avoid conflicts of competence/jurisdiction between different administrations. Building the intervention capacities of public services and other organizations involved in mangrove management.

Develop a Cross-Border Strategy Adapted to Mangroves This should aim, among other things, to channel the activities of other nationals in mangrove areas. Concerning issues relating to consultations (consultation frameworks and concerted actions), develop co-management initiatives and cross-border initiatives with Nigeria for the Rio Del Rey area and with Equatorial Guinea for the Rio Ntem area.

Coordination of Consultation Frameworks in Mangrove Ecosystems Several initiatives have been proposed (National Mangrove Committee, National Ecosystem Safeguarding Council, Sectorial mangrove management program, Cameroonian mangrove network, Various platforms, etc.). The Cameroon Mangrove network appears to be the most appropriate framework for collaboration for NGOs and grassroots organizations across all of Cameroon's mangroves. Target the intervention of administrations and other consultation bodies on specific actions in specific areas.

Participatory Monitoring Need to set up, with the participation of local populations, local mangrove harvesting monitoring committees in order to help resolve the problem of the inadequacy of public officials in charge of control and monitoring of management.

Private Sector Participation Encourage private sector participation in the mangrove management process as a potential sustainable funder of environmental actions and damage through payment for ecosystems schemes by enhancing the existing cooperative social and environmental policies already formulated by certain enterprises.

21.7.2.4 Roles of Stakeholders in Implementing Recommendations

Government Given the important cross-cutting role of mangroves in livelihood and ecological securities of coastal populations, the government through the various sectoral ministries (Agriculture, Forests, Wildlife, Fisheries, Livestock, Environment, etc.) should play a major regulatory role for the different sectors in a way that is compatible with the specificities of the mangrove ecosystem. This through the participatory process of developing and implementing good policies and practices leading to better conservation, sustainable use, and restoration of the mangrove ecosystem.

Non-governmental Organizations NGOs (local, national, and international) are already playing an important role in the proximity of mangrove communities; carrying out awareness-raising activities, environmental education, capacity building; and the implementation of development projects. Despite constraints and difficulties in accessing funding, it is necessary to continue to play this role.

Private Sector The private sector is very important not only as drivers of change, conversion, and degradation of mangroves through their activities, but also as a potential source of funding for improving impacts and the establishment of development projects to support local communities. The private sector can see themselves as small, medium, and multinational corporations (extractive industries: agro-industries, etc.).

Communities Riparian communities in the form of villages, decentralized local communities (local and urban councils) are always the recipients of negative or positive impacts from other actors. They must be the guarantors of mangrove ecosystems to which policies and good practices should benefit them.

Universities and Research Institutes In terms of formal training universities and research institutes play an important role in science and technology aimed at improving techniques for the conservation, sustainable use, and restoration of mangrove ecosystems by determining the potential (distribution map of species, stock, biodiversity, etc.), limits and techniques for the sustainable exploitation of mangrove resources.

Acknowledgements This chapter is a fruit of work done by experts and key stakeholders' consultations and interactions at all levels (government services, NGOs, private sector, and local communities including elected representatives, traditional authorities, and opinion leaders) including mangrove villages. The author is heartily thankful to all colleagues from these institutions too numerous to mention by name.

References

Ajonina GN (2008) Inventory and modelling mangrove forest stand dynamics following different levels of wood exploitation pressures in the Douala-Edea Atlantic coast of Cameroon, Central Africa. Mitteilungen der Abteilungen für Forstliche Biometrie, Albert-Ludwigs-Universität Freiburg, 2008-2

Ajonina GN (2010) Rapport final de réalisation du mandat. Consultation Project GEF PPG

Ajonina GN, Chuyong GB (2017) Permanent sample plots for monitoring mangrove ecosystems: an inventory and performance monitoring tool. In: The 9th regional PRCM coastal and marine forum: side event: coastal landscape resilience to climate change in West Africa, Conakry, Guinea, 23–27th October, 2017

Ajonina GN, Eyabi GD (2002) Saving Cameroon's Mangroves through improved fish smokehouses: CWCS community-based approach in Douala-Edea Mangroves. Mangrove Action Project Los Angeles. http://www.mangroveactionproject.org

Ajonina GN, Eyango MT (2014) Aquaforests and aquaforestry: Africa. In: Encyclopedia of natural resources: land. Taylor and Francis, New York, pp 16–38

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

Ajonina G, Ganzevles W, Trolliet B (2003) Rapport national du Cameroun. In: Dodman T, Diaguna CH (eds) African waterbird census/les dénombrements d'oiseaux d'eau en Afrique 1999, 2000 et 2001. Wetlands International Global Series No 16 Wageningen

Ajonina PU, Ajonina GN, Jin E, Mekongo F, Ayissi I, Usongo L (2005) Gender roles and economics of exploitation, processing and marketing of bivalves and impacts on forest resources in the Douala-Edaa Wildlife Reserve, Cameroon. Int J Sust Dev World 12:161–172

Ajonina G, Tchikangwa B, Chuyong G, Tchamba M (2009a) The challenges and prospects of developing a community based generalizable method to assess mangrove ecosystems vulnerability and adaptation to climate change impacts: experience from Cameroon. FAO Nat Faune 24(1):16–25

Ajonina GN, Amougou JA, Ayissi I, Ajonina PU, Dongmo MM, Ntabe EN (2009b) Waterbirds as bio-indicators of seasonal - climatic changes in river basin properties from eight years monthly monitoring in lower Sanaga, Cameroon. 2009. IOP Conf Ser: Earth Environ Sci 6:292021. http://m.iopscience.iop.org/1755-1315/6/29/292021

Ajonina GN, Kemajou JS, Bitchick A, Wambe EN (2013) Rapport technique sur l'évaluation chiffrée de la dégradation d'une partie de la mangrove du littoral. Organisation pour l'Environnement et le Développement Durable (OPED)- Ministère de l'Environnement, de la Protection de la Nature et du Développement Durable (MINEPDED)

Ajonina G, Kairo J G, Grimsditch G, Sembres T, Chuyong G, Mibog DE, Nyambane A, FitzGerald C (2014a) Assessment of carbon pools and multiple benefits of mangroves in Central Africa for REDD+ UNEP

Ajonina GN, Kairo J, Grimsditch G, Sembres T, Chuyong G, Diyouke E (2014b) Assessment of mangrove carbon stocks in Cameroon, Gabon, the Republic of Congo (RoC) and the Democratic Republic of Congo (DRC) including their potential for reducing emissions from deforestation and forest degradation (REDD+). In: Diop S, Barusseau J-P, Descamps C (eds) The land/ocean interactions in the coastal zone of west and central Africa estuaries of the world, pp 177–189. http://link.springer.com/chapter/10.1007/978-3-319-06388-1_15

Ajonina GN, Dibong SD, Seth RE, Gah-Muti Y, Ddinga NE, Nkomba A (2015) Revenus économiques et pollution écosystémique liés au transport des personnes et des biens traversant les mangroves de l'estuaire du Wouri (Douala, Cameroun). Int J Biol Chem Sci 9(4):1851–1862

Ajonina GN, Aya FA, Diame AK, Armah AK, Camara S, Amegankpoe C, Zabbey N, Kaya P (2016) Overview of experience of mangrove reforestation in West and Central Africa. Proceedings of the 38th Annual Conference of Forestry Association of Nigeria, Port Harcourt, Rivers States, 7th–11th March, 2016, pp 12–21

Ajonina G, Timba M, Njie F (2020) National Waterbird Census Report, Cameroon January 2020. In: van Roomen M, Agblonon G, Langendoen T, Citegetse G, Diallo AY, Gueye K, van Winden E, Luerssen G (eds) Simultaneous January 2020 waterbird and wetland census along the East Atlantic Flyway: National Reports. Wadden Sea Flyway Initiative p/a Common Wadden Sea Secretariat, Wilhelmshaven, Germany, Wetlands International, Wageningen, The Netherlands, BirdLife International, Cambridge, pp 96–99

Ajonina G, Timba M, Njie F, Mzoyem NJ (2021) Report January 2021 international waterbird census (IWC), in Central coastal Cameroon

Akendengue AI, Okanga-Guay M, Ondo Assoumou E, Ajonina GN, Mombo J-B (2021) Local allometric equations for estimating above-ground biomass (AGB) of mangroves (Rhizophora spp. and *Avicennia germinans*) from the Komo, Mondah and Rio Mouni estuaries in Gabon. Europ Scient J 17(34):172. https://doi.org/10.19044/esj.2021.v17n34p172

Angoni H, Tatchim AP, Nkonmeneck BA, Nguekam E (2015) Utilisation du bois dans les pêcheries côtières du Cameroun. Revue D'ethnoécologie 07. https://doi.org/10.4000/ethnoecologie.2166

Asaah HA, Ambimbola AF, Suh CE (2006) Heavy metal concentration in surface soils of the Bassa Industrial Zone I, Douala Cameroon. Arabian J Sci Eng 31:147–158

Ayissi I, Ajonina GN, Usongo L (2003) Etude Préliminaire sur les Tortues Marines dans la Reserve de Faune de Douala-Edea pour une stratégie de conservation. In: Proceeding of 2nd international congress on Chelovian, Saly-Senegal

Ayissi I, Ajonina GN, Angoni H (2014) Status of large marine flagship faunal diversity within Cameroon estuaries of Central African coast. In: Diop S, Barusseau J-P, Descamps C (eds) The land/ocean interactions in the coastal zone of West and Central Africa estuaries of the world, pp 97–107.http://link.springer.com/chapter/10.1007/978-3-319-06388-1_9

Besack F, Ebonji RS, Ajonina GN, Dieudonné ER, Willy SE, Brice N, Junior ME, Michel-Remi HT, Raphael O, Minette TE (2021) Spatial and temporal variation of the hydrological parameters in the Wouri-Nkam section of the Cameroon estuary, central African Atlantic coast. Open J Marine Sci 11:129–156. https://doi.org/10.4236/ojms.2021.114009

Blasco F, Saenger P, Janodet E (1996) Mangroves as indicators of coastal change. Catena 27:167–178

Blasco F, Carayon JL, Din N (2000) Les mangroves et le niveau de la mer In: Le changement climatique et les espaces côtiers. "L'élévation du niveau de la mer: risques et réponses". Actes du colloque d'Arles, pp 25–27

CAMECO (2010) Schema Directeur des mangroves des bassins versants de Douala-Edea. Cameroun Ecologie

CameEco (2010) Schéma Directeur d'Aménagement Participatif des Ecosystèmes de Mangroves et des Bassins Versants de la Zone Côtière de la Réserve de Faune de Douala/Edéa, Cameroun. Cameroun Ecologie

CWCS (2000–2006) CWCS Douala-Edea Forest Project-Activity Report 1999–2000, 2001, 2001, 2003, 2004, 2005 and 2006. Cameroon Wildlife Conservation Society, 132pp

CWCS (2010) Activity report 2009/Rapport d'activites 2009. Cameroon Wildlife Conservation Society, 43pp

CWCS (2014) CWCS Douala-Edea activity report 2013. Cameroon Wildlife Conservation Society, 51pp

Dahdouh-Guebas F, Ajonina GN, Amir AA, Andradi-Brown DA, Aziz I, Balke T, Barbier EB, Cannicci S, Cragg SM, Cunha-Lignon M, Curnick DJ, Duarte CM, Duke NC, Endsor C, Fratini S, Feller IC, Fromard F, Hugé J, Huxham M, Kairo JG, Kajita T, Kathiresan K, Koedam N, Lee SY, Lin H-J, Mackenzie JR, Mangora MM, Marchand C, Meziane T, Minchinton TE, Pettorelli N, Polanía J, Polgar G, Poti M, Primavera J, Quarto A, Rog SM, Satyanarayana B, Schaeffer-Novelli Y, Spalding M, Van der Stocken T, Wodehouse D, Yong JWH, Zimmer M, Friess DA (2020) Public perceptions of mangrove forests matter for their conservation. Front Mar Sci 7:603651

Dika E (2010) Essai de boisement et reboisement des mangroves de Ntem: Evolution sylvicole en pépinières communautaires et l'influence tidale. Mémoire d'Ingénieur des Eaux, Forets et de Chasse, Université de Dschang (En vue)

Din D (1991) Contribution à l'étude botanique et écologique des mangroves de l'estuaire du Cameroun. Unpubl. Thesis, 1991, Université de Yaoundé, Yaoundé

Din N, Baltzer F (2008) Richesse Floristique et Evolution des mangroves de l'Estuaire du Cameroun. African Geosci Rev 2:119–130

Din N, Blasco F, Amougou A, Fabre A (1997) Etude quantitative d'une station de la mangrove de l'estuaire du Wouri (Douala Cameroun): Premiers re'sultats. Sci Technol Develop 5(1):17–24

Din N, Priso RJ, Dibong SD, Amougou A (2001) Identification des principales causes de degradation des mangroves dans l'Estuaire du Cameroun. Sci Technol Develop 8(1):1–7

Din N, Priso RJ, Kenne M, Ngollo DE, Blasco F (2002) Early growth stages and natural regeneration of *Avicennia germinans* (L.) Stearn in the Wouri estuarine mangroves (Douala-Cameroon). Wetl Ecol Manag 10(6):461–472

Din N, Puig H, Blasco F (2006) Exploitation du bois dans les mangroves de Douala (Cameroun). Ann Fac Sci Univ Ydé I, série Sc Nat Vie 36(3):89–103

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

Din N, Ngo-Massou VM, Essomè-Koum GL, Kottè-Mapoko E, Emane JM, Akongnwi AD, Richelieu Tchoffo R (2016) Local perception of climate change and adaptation in mangrove areas of the Cameroon coast. J Water Resour Protect 8:608–618

Feka NZ, Ajonina GN (2011) Drivers causing decline of mangrove in West-Central Africa: a review. Int J Biodiver Sci Ecosyst Serv Manag 7:217–230

Feka NZ, Chuyong GB, Ajonina GN (2009) Sustainable utilization of mangroves using improved fish smoking systems: a management perspective from the Douala-Edea Wildlife Reserve, Cameroon. Trop Conserv Sci 4:450–468

Folack J (1989) Etude préliminaire du phytoplancton d'une zone côtière d'exploitation crevetticole (Kribi-Cameroun, Golfe de Guinée, Atlantique Centre Est). Cameroon J Biol Biochem Sci 2(1): 51–65

Folock J (2013) Documents préparés pour MINEPDED Plan Directeur de Recherche et de Suivi des Mangroves et des Ecosystèmes Côtiers du Cameroun. Ministère de l'Environnement, de la Protection de la Nature et du Développement Durable

Fonge AB, Tabot PT, Mumbang C, Mange CA (2015) Water quality and phytoplankton community structure in mangrove streams under different logging regimes in Cameroon. Afr J Ecol 54:39–48

Fonocho C (2008) Pollution levels of the mangrove ecosystems of Douala-Edea Wildlife Reserve. MSc thesis, University of Yaounde 1

Forkam DC, Ajonina GN, Ajonina PU, Tchamba MN (2020) Framework for assessing the level of stakeholders' involvement and governance in mangrove management: case of selected local communities in the south west coastal Atlantic Region, Cameroon. J Ecol Nat Environ 12(4): 150–164

Fusi M, Beone GM, Suciu NA, Sacchi A, Trevisan M, Capri E, Daffonchio D, Din N, Dahdouh-Guebas F, Cannicci S (2016) Ecological status and sources of anthropogenic contaminants in mangroves of the Wouri River Estuary (Cameroon). Mar Pollut Bull 109:723–733

Kairo JG, Lang'at JKS, Dahdouh-Guebas F, Bosire JO, Karachi M (2008) Structural development and productivity of replanted mangrove plantations in Kenya. For Ecol Manag 255:2670–2677

Komiyama A, Poungparn S, Kato S (2005) Common allometric equations for estimating the tree weight of mangroves. J Trop Ecol 21:471–477

Kottè-Mapoko E, Ngo-Massou VM, Essomè-Koum GL, Emane JM, Moussian LN, Tchoffo R, Din N (2017) Molluscs' composition and distribution in mangroves of the Cameroon Central coast. Intern J Res Stud Biosci 5(5):4–13

Kottè-Mapoko E, Ngo-Massou V, Essomè-Koum G, Nyamsi-Moussian L, Konango-Samè A, Boubakary, Din N (2021) Dynamic of mangrove associated molluscs in anthropized areas of the Cameroon coastline. Open J Ecol 11:565–579. https://doi.org/10.4236/oje.2021.118036

Letouzey R (1968) Etude phytogeographique du Cameroun. Edition Paul Chevalier, Paris

Longonje S (2008) Distribution, diversity and abundance of crabs in Cameroon Mangroves. PhD Thesis, University of York, York

Mama AC, Bodo WKA, Ghepdeu GFY, Ajonina GN, Ndam JRN (2021) Understanding seasonal and spatial variation of water quality parameters in mangrove estuary of the Nyong River using multivariate analysis (Cameroon Southern Atlantic Coast). Open J Marine Sci 11:103–128. https://doi.org/10.4236/ojms.2021.113008

Mbeng O, Folefac ZS, Ebonji RS, Togue KF, Ajonina GN, Mboglen D (2017) Evaluation of solid wastes, physico-chemical parameters and tidal variations in the mangrove ecosystem of Wouri estuary: the case of "village" and "Bois des Singes". Intern J Trend Res Develop 4(2) http://www.ijtrd.com/papers/IJTRD7742.pdf

Mbog DM (1998) Rapport d'étude Projet LME/GOG/UNIDO/NOAA, Evaluation des Ecosystèmes de mangroves du Cameroun, 42 p

Mbog DM (1999) Rapport d'étude sur les mangroves de l'estuaire du Cameroun. Identification des principales causes de dégradation des mangroves du Wouri, et mise en place d'un plan de gestion de la Biodiversité. Projet WWF/CARPE/BSP

Mbog DM (2002) Ecosystème mangrove du Cameroun. Présenté au ITTO International Mangrove Workshop 19–21 February, 2002 at Catargena, Colombie

Mbog D, Ajonina G (2007) Analyse du potentiel des mangroves et définition des besoins d'informations pour l'élaboration du projet OIBT. Cameroon Ecology Edea

MINEPDED (2014a) Plan Directeur de Recherche et de Suivi des Mangroves et des Ecosystèmes Côtiers du Cameroun. Ministère de l'Environnement, de la Protection de la Nature et du Développement Durable

MINEPDED (2014b) Protocole d'Evaluation Environnementale et Sociale dans les Mangroves et les Ecosystèmes Côtiers au Cameroun. Ministère de l'Environnement, de la Protection de la Nature et du Développement Durable

MINEPDED (2014c) Stratégie Nationale de Gestion Durable des Mangroves et des Ecosystèmes Côtiers au Cameroun. Ministère de l'Environnement, de la Protection de la Nature et du Développement Durable

MINEP-RCM (2017) Etats des lieux et Atlas sur les mangroves du Cameroun. Ministère de l'Environnement et Protection de la Nature (MINEPDED) et Réseaux Camerounais de Mangroves (RCM)

Moudingo EJH (2010) Assessment of community participation in mangrove ecosystem restoration in three selected villages of the Douala -Edea Wildlife Reserve, Cameroon. Post graduate Diploma (DESS) Project. University of Yaoundé I, Cameroon

Moudingo EJE, Ajonina GN, Mbarga BA, Tchikangwa BN (2016) Bumpy road to improved mangrove resilience in the Douala estuary,Cameroon. J Ecol Nat Environ 8(5):70–89

Moudingo JH, Ajonina G, Dibong D, Tomedi M (2019) Introduction, distribution and drivers of non-native mangrove palm *Nypa fruticans* Van Wurmb (Arecaceae) in Cameroon, Gulf of Guinea. In: Advances in ecological and environmental research, pp 1–13

Moudingo JH, Ajonina G, Kemajou J, Wassouni A, Bitom M, Assengze A, Tomedi M (2020) Sylvo-socioeconomic study of urban mangrove patches and challenges: case of Kribi, Cameroon. In: Patra JK, Mishra RR, Thatoi H (eds) Biotechnological utilization of mangrove resources. Academic Press, pp 79–115

Munji CA, Bele MY, Nkwatoh AF, Idinoba ME, Somorin OA, Sonwa DJ (2013) Vulnerability to coastal flooding and response strategies: the case of settlements in Cameroon mangrove forests. Environ Develop 5:54–72

Munji CA, Bele MY, Idinoba ME, Denis J, Sonwa DJ (2014) Floods and mangrove forests, friends or foes? Perceptions of relationships and risk s in Cameroon coastal mangroves. Estuar Coast Shelf Sci 140:67–75

Nanji RO (2007) Assessment of the fisheries resources of fishermen living around the Sanaga estuary (Douala-Edea Wildlife Reserve). DESS dissertation

Ndema NE, Enone ECJ, Ajonina G, Etame J, Gah-Muti SY, Ndongo D (2014) Growth dynamic and mortality rate of *Rhizophora* spp. within the mangrove forest of the Rio Ntem Estuary: case study – Campo (South Cameroon). Res J Agric Environ Manag 3:577–586

Nfotabong AA, Din N, Léopold G, Essomè Koum LG, Satyanarayana B, Nico Koedam N, Farid Dahdouh-Guebas F (2011) Assessing forest products usage and local residents' perception of environmental changes in peri-urban and rural mangroves of Cameroon, Central Africa. J Ethnobiol Ethnomed 7:41

Nfotabong AA, Din N, Dahdouh-Guebas F (2013) Qualitative and quantitative characterization of mangrove vegetation structure and dynamics in a peri-urban setting of Douala (Cameroon): an approach using air-borne imagery. Estuar Coasts 36:1181–1192

Ngo-Massou VM, Essomè-Koum GL, Ngollo-Dina E, Din N (2012) Composition of macrobenthos in the Wouri River estuary mangrove, Douala, Cameroon. Afr J Mar Sci 34(3):349–360

Ngo-Massou VM, Essomè-Koum GL, Kottè-Mapoko EK, Din N (2014) Biology and distribution of mangrove crabs in the Wouri river estuary, Douala, Cameroon. J Water Resour Protect 6: 236–248

Noumeyi SMJ (2015) Evaluation économique des biens et services écosystémiques: Cas de la mangrove et forêts associées du paysage côtier Douala-Edéa au Cameroun. Diplôme Master. Université Senghor, Egypt, 93pp

ONEQUIP (2009) Contrat N° 01090031 relatif à l'élaboration d'un programme de suivi de la vitalité des mangroves camerounaises. Projet CAPECE-CPSP/SNH. Rapport final

Ong J (1993) Mangroves - a carbon source and sink. Chemosphere 27:1097–1107

Priso RJ, Nnanga JF, Etame J, Din N, Amougou A (2011) Les produits forestiers non ligneux d'origine végétale: valeur et importance dans quelques marchés de la région du Littoral - Cameroun. J Appl Biosci 40:2715–2726

Priso RJ, Oum GO, Din N (2012) Utilisation des macrophytes comme descripteurs de la qualité des eaux de la rivière Kondi dans la ville de Douala (Cameroun-Afrique Centrale). J Appl Biosci 53: 3797–3811

Shahdadi A, Mvogo Ndongo PA, Suess T, Schubart CD (2019) Reappraisal and redescription of the three species of the recently defined genus *Guinearma* Shahdadi & Schubart,2017, with a key to the West African Sesarmidae (*Decapoda, brachyura*). Crustaceana 92(3):307–334

Shahdadi A, Mvogo Ndongo PA, Schubart CD (2021) Mito-nuclear discordance in West African mangrove crab species (Decapoda: Brachyura: Sesarmidae) suggests uni-directional mitochondrial introgression, despite prolonged evolutionary independence. Marine Biol Res. https://doi.org/10.1080/17451000.2021.1990959

Tchakonté S, Ajeagah G, Diomandé D, Camara AI, Konan KM, Ngassam P (2014) Impact of anthropogenic activities on water quality and freshwater shrimps diversity and distribution in five rivers in Douala, Cameroon. J Bio Env Sci 2014:183–194

Tchinda FLN, Ajonina GN, Nguinguiri JC (2019) Gender in community management of mangrove ecosystems in Cameroon: some lessons to ensure that no one is left behind. Nat Faune J 32(2): 84–88

Tening AS, Chuyong GB, Asongwe GA, Fonge BA, Lifongo LL, Mvondo-Ze AD, Che VB, Suh EC (2013) Contribution of some water bodies and the role of soils in the physicochemical enrichment of the Douala-Edea mangrove ecosystem. Afr J Environ Sci Technol 7(5):336–349

Tening AS, Asongwe GA, Chuyong GB, Fonge BA, Mvondo-Ze AD (2014) Heavy metal status in the Rio del Rey mangroves of Cameroon. Int J Curr Microbiol App Sci 3(12):701–717

UNEP-WCMC (2007) Mangroves of Western and Central Africa. UNEP – Regional Seas Programme/UNEP–WCMC