ECOSYSTEM SERVICES PROVIDED BY MANGROVES AND CONTRIBUTIONS TO SUSTAINABLE LIVELIHOODS

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Abstract
A number of studies have documented the ecosystem provided by mangroves especially to sustenance of human welfare. Over 20 million people have also been reported to rely on mangroves all over the world for survival. Despite significance of mangroves, the rate of loss is unprecedented. The paper therefore discussed the ecosystem services provided by mangroves to livelihoods as well as the various human impacts. Mangroves provide a number of services, including the habitat and nursery ground for the production of fish, crustacean, and molluscs' species that are harvested locally. Local residents also use mangroves for firewood. Despite the significance of mangroves around the world, their loss is at an alarming rate. The loss is mainly due to anthropogenic activities. The process of petroleum exploration, especially where there are oil spills, is one of the major factors leading to mangroves destruction in Nigeria. In addition to this, burgeoning human population in the Niger delta region have led to the conversion of some mangrove areas to urban spaces. The need for appropriate institutional framework and legislation to protect total loss of mangroves at all levels has become important. Efforts should also be geared towards restoration of mangroves and prevention of further loss so as to provide necessary ecosystem services pertinent to sustaining livelihoods of people that depend on them.

Keywords: Mangroves, Oil exploration, Degradation, Livelihoods, Niger Delta
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Introduction

Globally, mangroves are found in 123 countries and territories and cover a total of 152,000km^2 (Spalding *et al.*, 2010). This makes mangrove a relatively rare forest type. Mangroves are mainly found in the tropics and a few warm temperate regions of the world, with their abundance and diversity along wetter coastlines and in deltaic and estuarine areas. The most extensive mangroves are found in river deltas**,** where rivers flow directly into the ocean and have created new expanses of land through the active deposition of new sediments. These are quickly colonized by mangroves and can form very broad communities. They include the vast expanse of the Sundarbans, Niger and Orinoco deltas; the more degraded mangrove areas of the Ayeyarwady and Mekong deltas; and the more complex deltaic coastlines of northern Brazil or southern Papua, where multiple rivers form a continuous deltaic fringe (Spalding *et al.*, 2010).

Nigeria is reported to have the largest mangroves in Africa and third largest in the world (Abere and Ekeke, 2011). Furthermore, over sixty percent of the mangrove stands in the country are found in the Niger Delta region (Human Rights Watch, 1999). Specifically, the southern region of the country has extensive mangrove ecosystem which spreads across Ondo, Edo, Delta, Bayelsa and Rivers States with over 7,300km^2 (Spalding *et al.*, 2010). Furthermore, the Niger Delta is the world's third largest delta, and most extensive freshwater swamp forest in West and Central Africa (Ikwegbu, 2007). The spatial boundary of the mangrove ecosystem in Nigeria is unique because it is shielded from sea water, this makes it different from other African countries where the mangroves are directly exposed to sea water (Niger Delta Environmental Survey, 1997).

Description and potential of mangroves

Normally, mangrove are trees or large shrubs which normally grow in or adjacent to the intertidal zone (Seanegar, 2003). The species of mangroves found in Nigeria are presented in Table 1. These species of mangroves are dominated by red mangroves (Rhizoporaceae) followed by white mangroves (Avicennia). *R. mangle* with *R. harrisonii* are found in intermediate areas, with *Avicennia germinas, Laguncularia racemosa* and *Conocarpus erectus* are less common, with the former typically in more saline environments near river mouth and on more sandy substrates. *Nypa fruticans* was introduce into the Calabar regions in 1906 and is now widespread and still increasing, particularly in the lower- salinity higher reaches of channels and estuaries (James *et al.*, 2007). The Niger Delta is of regional importance for many species, including a great diversity of fish (Hughes and Hughes,1992) and many water birds such as herons, ibis and pelicans, larger animal species include the west African manatee, hippopotamus, Sitatunga, otters, and Nile and dwarf crocodiles.

To survive in harsh ecological niche, several mangrove spices have developed convergent adaptations in morphology, physiology or reproductive strategies. The physical environment of mangrove is characterized with regular inundation of the soil and variable salinities. Some mangroves have slightly higher salt tolerance than terrestrial plants, but most also exclude salt in order to survive (Spalding *et al.*, 2010).

Research has shown that mangrove has higher level of primary productivity than most other tropical and temperate forests. Biomass and carbon storage capacity in the soils within a mangrove stand can also be very high, even in low stature forests, as a result of high level of below-ground biomass. These potentials of mangrove may have an important role to play in global carbon budgets as well as mitigating the impacts of climate change (Spalding *et al.*, 2010).

Table 1: Species of mangroves found in Nigeria and their characteristics

Species	***Family***	***Characteristics***
Acrostichum aureun	Pteridacea	Ferm, 3m high, pinnae redish when young, leaflets with blunt tips
Avicennia germinans	Avicenniaceae	Tree, leaf leathery elliptic, fruit ellipsoid, flower white with yellow centre, pheumatophores
Conocarpus erectus	Combrataceae	Tree or shrub, bark fissured, dioecious
Laguncularia racemosa	Combrataceae	Tree or shrub, leaf leathery, obovate or elliptic, leaf stalk red with glands, flower whitish bell-shaped
Rhizophora mangle	Rhizophoraceae	Tree, florescence with few flowers, prop root
Rhizophora racemosa	Rhizophoraceae	Tree, florescence much branched with many flowers, prop roots
Rhizophora harrisonii	Rhizophoraceae	

Source: Spalding *et al.*, 2010

Ecosystem Services Provided by Mangroves

A number of studies have shown the contributions of mangroves to human welfare in terms of the goods and services they provide (i.e. direct use values), and the ecological functions which indirectly support economic activity (i.e. indirect use values) (Ronnback, 1999; Balmford and Bond, 2005; De Groot et al., 2006; James *et al.*, 2011). The direct use benefits derived from mangrove ecosystems include the extraction of fuelwood in the form of firewood and charcoal, as well as salt which are either used locally or sold to obtain income. Also, products such as wood are extracted for the construction of buildings, fish traps, and fish stack (a local material used to store and preserve fish). On the other hand, some of the indirect benefits derived from mangroves include breeding grounds for both onshore and offshore fisheries (Barbier, 2007) and protection of coastlines from storms and erosion. Federal Government of Nigeria (FGN, 2007) have reported that the highest proportion of people employed in the Niger Delta region (about 44.2%) are engaged in agriculture, forestry and fishing industries. The contributions of mangroves to livelihoods in the tropics are discussed below.

(A) Timber and Forest Products

Wood products: The dense timber of many mangroves species, couple with their resistance to rotting in saline waters as well as their resistance to termite and insect attack, are sought after for construction and other uses. The wood is widely used for boat building and for much traditional fishing gear such as traps (Corcoran *et al*, 2007).

Another less sustainable use of mangrove wood is in the production of woodchip and pulp, variously used for paper and chipboard production and, for conversion to rayon for the textiles industry.

Fuel wood: Fuelwood derived from mangroves are widely used as firewood and converted into charcoal. Rural people, especially in countries where there are few alternative energy sources and only few other forests remain, rely on fuelwood obtained from mangroves. Due to the dense nature of mangrove wood, the derived charcoal is considered to be of high quality and forms the basis for large commercial-scale production.

***Tannins*:** over the years, tannins obtained from the bark of several trees of *Rhizophora* and *Bruguiera* (found in Pacific) has played a critical role in the preparation of leather. The same properties of tannin are also used by fisheries to cure and extend the life of their nets and lines.

***Roofing*:** The leaves of *Nypa* palms are often woven together and widely used as a form of thatch for traditional housing throughout its range.

Food: The fruits of some mangroves species are consumed as food by some locals. Specifically, fruits of *Sonneratia, Avicennia, Bruuiera* and *Kandelia,* are consumed (Bandaranayake, 1998; Tan, 2001). However, before the fruits are consumed, there is need for some level of processing such as cooking or soaking to remove tannins or otherwise make the fruit palatable (Bandaranayake, 1998; Tan, 2001). Jayatissa *et al,* (2006) reported that the pulp obtained from *Sonneratia* has been used in Sri Lanka to make fruit drinks and ice cream. Leaves from a number of mangroves species are also used in making herbal teas. The flower stalk of *Nypa* palm is also cut to produce sweet sap which is directly consume or fermented into an alcoholic drink or vinegar. The jelly-like endosperm from within *nypa* fruits is also quite widely eaten and is even gathered on commercial scale (Ng and Sivasothi, 2001). Nectar from a number of mangrove species produces excellent honey and is widely utilized by beekeepers even commercially. Hunting and gathering of animals within the mangrove forest is also widespread.

***Medicines*:** Majority, if not all, of the communities in tropical coastal areas has used mangroves leaves, bark, fruits or other products for traditional medicine (Bandaranayake, 1998; 2002). These are used in treatment of various diseases and sicknesses both internally and externally. Some of the reported diseases and sicknesses range from stomach ulcers to asthma and as a contraceptive (Bandaranyake, 1998; 2002).

***Fodder*:** Mangroves are also used as a dietary supplement for and in feeding animals.

(B) Fisheries

Mangroves are among the most intertidal habitats for marine and coastal fisheries. According to Ronnback (1999), mangroves related species have been estimated to

support 30 percent of fish catch and almost 100 percent of shrimp catch in south-east countries. In Queensland, Australia, mangroves have been reported to support 75 per cent of commercial fisheries species (Manson *et al.,* 2005). Other invertebrate that are of particular value and found in mangroves include molluscs such as oysters, cockles and mussels, crabs and shrimps. These are gathered by locals either for domestic consumption or for commercial markets. Mangrove also sustain offshore fisheries by providing nursery area for younger fish, which are observed to migrate offshore into deeper water or adjacent habitats as they mature (Sato *et al.*, 2005). This contributes to production of fish at local and national levels.

(C) Recreation

Tourism in mangrove ecosystem is fast developing. Boat tours are perhaps the most popular means of access; but board walks have also been built through many mangrove forests, offering mud-free, tide-independent access to many areas. Recreational fishing and bird watching are among more specialist uses. In some areas, tourists are taking part in tours to see wild animals such as monkeys among others.

(D) Coastal Protection

Mangroves play an important role in wave attenuation, while their complex root systems help in binding and consolidating sediments. In this way they reduce rates of erosion and provide a critical buffer during more extreme storm events. Of course, mangroves are not immune from erosion; but their presence can nevertheless make the difference between a stable or prograding coastline versus an eroding coastlines. Major storm can have considerable impact in coastal communities and natural ecosystems. High winds and waves associated with major tropical storms are often exacerbated by storms surges, which can raise sea levels by 5m or more above normal high tides.

(E) Biofiltration

The complex structure of mangroves enables them to constrain water movements and to trap sediments, while their high productivity also enables them to extract nutrients from surrounding waters. This has enabled mangroves to perform a valuable service by removing excess nutrients and other pollutants, notably from sewage and aquaculture affluent. This function has been actively evaluated in a number of studies (Tam, 2006).

(F) Reducing Carbon Emission

Arguments are growing in support of actions toward reducing emission from deforestation and forest degradation (REDD) (Martin, 2008). However, the role of mangrove in global carbon cycle has been somewhat overlooked in this regard, perhaps because of their relatively small total area and often lower physical stature than many adjacent tropical moist forests. Due to their larger proportion of below ground biomass, mangroves are very high in biomass compare to higher canopy terrestrial forest. They can

therefore play a greater role in sequestration of new carbon dioxide from the atmosphere than other forests due to higher rates long-term carbon deposition in soils and those potentially offshore. Avoided deforestation of mangroves may not only prevent CO_2 release, but play a more significant role in additional CO_2 sequestration than would be achieved by other forest types.

Human Impact on Mangroves

Some 20 million people rely on mangroves for survival (Spalding, *et al.*, 2010). This reliance is causing overexploitation of mangrove resources. Apart from the global climate change and its effects such as rise in temperature, sea level, atmospheric carbon dioxide among others, the decline in area of mangroves is mainly related to anthropogenic activities (Balmford and Bond, 2005; Saunders et al., 2006), while some human uses have been sustainable for centuries, recent pressures are intense. Large areas of mangrove in the western lagoons have been lost to urban and agricultural expansion. There are also considerable problems within the urban and industrial pollution, while overfishing has had significant impacts upon the fisheries (Hughes and Hughes, 1992). In terms of degradation, major oil spills have occurred that have devastated rivers, killed mangroves and coastal life and affected the health and livelihoods of millions of inhabitants. The local people adjacent to mangroves have lost their farmland and their incomes from oil spills and breathe air that reeks of oil, gas and other pollutants (Amnesty International Australia, 2009). The under listed are some of the factors leading to loss of mangroves in the tropics.

(i) Conversion to Other Land Uses: The most substantial changes to the world's mangrove cover have arisen from direct conversion of mangrove areas to urban and industrial spaces, to aquaculture and to agriculture. This challenge is often exacerbated as mangrove sediments shrink or settle following drainage and clearance, lowering the overall elevation. The loss of mangrove habitats has been associated with several impacts on local and often poor communities, who had relied on mangrove, remain. Fisheries productivity is often greatly reduced either because of pollution or by overfishing.

(ii) Built Environment: Planners have often viewed mangrove as low-value available space for direct conversion to industrial land, the building of ports or marinas, or the expansion of housing. It is only in a few places around the world that mangroves are being protected with examples in Naha (Japan), Sydney (Australia) and Pasir Ris (Singapore). At these places, small mangrove patches are maintained for their amenity value. Elsewhere, the various roles of mangroves in supporting fisheries, protecting coastlines or even reducing pollution have all been cited in favor of maintaining urban and peri urban mangrove (Spalding *et al.*, 2010).

(iii) Agriculture: Wide areas of mangroves have been converted to arable or even grazing land. Cash crops production are major drivers in many areas. In some places, former mangrove areas have been seen as ideal for rice cultivation because of the very level nature of the terrain. There are, of course, risks associated with the conversion of mangroves areas to agriculture. Over wide areas of West Africa, if mangroves soils dry out they become highly acidic and impossible to cultivate. Also, removal of mangroves can result to flooding and stalinization making the land to loose productivity or the complete abandonment of the land.

(iv) Aquaculture: This is one of the strongest drivers of mangrove conversion in recent decades, particularly shrimp aquaculture. Extensive shrimps aquaculture techniques built in intertidal areas are responsible for the most widespread losses of mangroves. In such systems, tidal movements are used to facilitate water exchange and flush waste waters through ponds that can be several hectares in extent. Typically these systems rely on natural stocking by shrimp larvae from incoming tides or are stocked from wild-caught larvae. Many aquaculture ponds are abandoned when concentration of disease or pollutants in the pond sediments is high. Unfortunately, such area cannot be recolonised by mangrove unless they are actively restored with the leveling of pond boundaries and restoration of water flows. In many aquaculture areas, remaining mangroves are considered important for their role in water purification, erosion prevention and for the provision of new shrimps larvae. The harvesting of wild larvae is an important source of employment in some locations, but even this can have negative impacts.

(v) Overharvesting: Mangroves are harvested without any restoration or framework of management. Depletion of stock can lead to social and economic cost as yield diminish over longer time frame. It can also leads to ecological cost, particularly with lower productivity and sometimes with issue of species replacement as key species are selectively removed.

(vi) Overfishing: Overfishing is a problem in the tropics, but locally within mangroves, but also in some offshore fisheries that depend on mangroves (Alongi, 2009). One local fishing method involves submerging branches into areas of open water to act as fish attracting devices (Isober, 2003). The importance of mangrove for fishing is immense and forms core arguments in many areas for the maintenance of mangrove cover (Manson, et al., 2005). Although, it is rare that overfishing can affect the forest itself, but heavy trampling by fishers can damage roots and prevent regeneration. In another sense, overfishing can affect existence of mangroves when fish stocks are reduced and subsequently loss of income or employment. Under such circumstances, the mangrove forest themselves will have lower perceived values to adjacent communities and are less likely to be defended from other human impacts.

(vii) Pollution: Oil pollution has caused degradation and destruction of vast area of mangrove ecosystem. Other forms of liquid and solid wastes discharged into mangroves are major causes of the death of both flora and fauna diversity in the ecosystem (Tam, 2003)

Anthropogenic Activities on Mangroves in Nigeria

With over 178 million people, Nigeria remains the largest population in Africa. The petroleum industry in Nigeria is the largest on the African continent. As of 2014, Nigeria's petroleum industry contributes about 14% to the economy. The Niger delta region of Nigeria is considered as one of the most severely petroleum-affected ecosystems in the world (Federal Ministry of Environment, 2006). The process of petroleum exploration, especially where there are oil spills, is a one of the major factors leading to mangroves destruction in Nigeria (Amnesty International Australia, 2009). In addition to this, burgeoning human population in the Niger delta region have led to the conversion of some mangrove areas to urban spaces; but the oil and gas industries itself has had much more far-reaching impacts. Both exploration and extraction lead to clearance of platforms, pipelines and communication, and for seismic surveys. It is estimated that the regeneration of cleared mangrove takes 30 to 40 years even where suitable and clean intertidal sediments remain (Spalding *et al*., 2010).

In the delta region of Nigeria, mangroves provide a number of ecological services, including the habitat and nursery ground for a productive range of fish, crustacean, and mollusk species that are harvested locally and in off-shore fisheries (UNDP, 2006). Local residents also use mangroves for firewood and for dying their fishing nets. In addition, they collect a number of non-timber forest products from the understory. As mangroves are cut for firewood, or to permit the construction of navigational canals, villages, and oil company operations, they are gradually being replaced by *Nypa* palms (*Nypa fruticans*). The dredging of channels, and the digging of new canals, has led to changes in water flows and salinities, including erosions or heavily siltation. The dumping of dredges spoils on mangrove margins has smothered roots and destroyed many mangroves areas. Overtime, such areas are replaced by freshwater forest or grassland (Nwilo and Badejo, 2006; Corcoran *et al*, 2007).

Direct pollution is widespread in the delta, (Federal Ministry of Environment, 2006). Pollution can lead to direct mangrove losses (Chindah *et al.*, 2007) as well as loss of fisheries production and impact on human health. Such environmental impacts are major drivers of political tensions and social unrest throughout the delta. Many ethnic groups consider themselves excluded from the wealth generated from the oil industry, while suffering declining fisheries, poor air quality and polluted drinking water (Nwilo and Badejo, 2006).

As reported by James *et al.,* (2007), total mangrove area in the Niger delta declined by over 200 square kilometers between 1986 and 2003 as consequences of the many impacts already mentioned. It is sad to mention that formal conservation efforts for mangroves have remained minimal (if any). There is some legal framework intended to reduce accidental oil spills. There are also increasing efforts to prevent sabotage, while certain oil companies are trying to engage with local communities and invest in local projects, as well as to reduce environmental damage. Remarkably, there are no significantly protected areas with mangroves, although forest reserves include a few small mangrove areas and may offer very limited legal protection.

Managing Mangroves for Sustainable Livelihoods

Mangroves are interesting and unique ecosystem; they also play important roles in human society. Meanwhile, adjacent human activities, on land and sea, have also greatly affected mangroves ecosystems. The greatest drivers for mangrove forest loss are direct conversion to agriculture, aquaculture and urban land uses. Coastal zones are typically densely populated and pressure for land is often intense. Even where mangroves remain, they have been degraded through various anthropogenic activities. More recently, the likelihood of new threats to mangrove is caused by climate change, most notably through raising of sea levels. Although, mangrove may withstand slight rises in sea level through the accumulation of sediments and organic matters in their soils; however, this may be insufficient in many areas. Sea level rise may also lead to inland movement of mangrove; however such migration will be hindered by adjacent human land uses.

In many places around the world, mangroves have now been actively planted, or have been encouraged to grow through activities such as site clearance and the removal of waste (Kumar, 2000; Jayatissa *et al.*, 2006; Walton, 2006). Generally the term "***restoration***" is used where mangroves are returned to areas in which they previously existed; but where there is no evidence of prior existence, the term "***afforestation***" is more appropriate. Early projects of mangrove plantation were generally undertaken in order to provide a source of timber and fuel wood (Walton *et al,* 2006), with *Nypa* planted in some areas for its sugar and alcohol, and as a source of roofing materials. Other early plantation in the Philippines was undertaken to provide protection from typhoons (Primavera, and Esteban, 2008).

Since 1980s a broader array has been cited for mangrove plantation. These include protection of inland resources and human life during storm surges erosion reduction; biodiversity conversation; fisheries enhancement; as a form of mitigation for mangrove removal in other areas, typically led by coastal developers (Field, 1996; Walton *et al.,* 2006); for aesthetic appeal in the middle east (Saenger, 2003); and even as a source of livestock fodder (Sato *et al,* 2005).

Conclusion

Going by the roles play especially in human society, there is urgent need for awareness creation and public sensitization on the value of mangroves and the consequences of their loss. The need for appropriate institutional framework and legislation to protect total loss of mangroves at all levels is also important. This is pertinent in facilitating development of necessary conservation strategy by concerned authorities. Investing in restoration of degraded mangroves should also be encouraged.

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