ENVIRONMENTAL CHALLENGES TO THE MANGROVES, WETLANDS IN NIGER DELTA AREA AND THEIR POSSIBLE SOLUTIONS

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Abstract
Wetlands, including mangroves perform several functions such as control and protection from erosion, floods, storms and tidal damage and generate goods and products such as fish and forest resources. These functions are of fundamental importance to the society. This paper reviews the challenges of mangrove wetlands which are climate change factors and anthrophogenic factors with their possible solutions such as policy implementation, non-destructive aquaculture practices, avoidance of dumping of degraded materials, flow sewage and industrial waste into ecosystem should be discouraged in other to manage mangrove and wetlands ecosystem on sustainable basis.

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Introduction

The Niger Delta region of Nigeria hosts the largest extent of mangrove in Africa and the fifth largest mangrove in the world (Spalding *et al*, 2010). The Niger Delta is the world's third largest Delta and West/Central Africa's most extensive freshwater swamp forest (Ikwegbu, 2007). The spatial boundary of the mangrove ecosystem in Nigeria is unique because it is shielded from sea water, a characteristic that differ from that of several other African countries where the mangrove are directly exposed to sea water (NDES, 1997). Over sixty percent of the mangrove stands in Nigeria are found in the Niger Delta region. The mangrove ecosystem is extensive and spreads across Ondo, Edo, Delta, Bayelsa and River state (WB, 1995).

Mangrove forests are coastal plant communities that are part of a larger coastal ecosystem that typically includes mud flats, sea grass meadows, tidal marshes, salt barrens and even coastal upland forests and freshwater wetlands (i.e. peat lands), freshwater streams and rivers (Ikwegbu, 2007) . In more tropical climates coral reefs may also be part of this ecosystem (Kumar, 2000). They are critical habitat for many species of fish and wildlife, serve as coastal fish and shellfish nursery habitat, and produce large quantities of leaf material that becomes the basis for a detritus food web (James *et al*., 2007; James, 2008). The important mangrove vegetation such as the sea grass beds is widely recognized. Despite their importance, mangrove vegetations are threatened all over the world by direct and indirect causes. Apart from the global climate change and its effects such as rise of temperature, sea level, atmospheric CO_2 etc. (their decline is mainly related to anthropogenic activities (Balmford and Bond, 2005; Saunders *et al*., 2006). 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 the inhabitants. (Amnesty International Australia, 2009).

The consequences of these have been enormous financial loss, extensive habitat degradation, and poverty leading to the continuous crises in the Niger Delta region, which have recently culminated into several communal conflicts, kidnapping of oil workers, and desrtuction of oil installations. This continued growth has resulted in environmental problems such as coastal wetland loss, habitat degradation, water pollution, gas flaring, and destruction of forest vegetation and host of other problems.

Mangrove forests are very important ecosystems that established along the intertidal zone in tropical and subtropical regions and these ecosystems are found in coastal rivers, estuaries and bays (Yim and Tam, 1999). These ecosystems have many benefits. They are a barrier against cyclones, protect coastal and provide good nursery ground for some of the important aquatic organisms (Raman *et al*., 2007). Biodiversity in these ecosystems is very high (Lugo and Snedaker, 1974; Boto *et al*., 1984) however unfortunately there are many threats in mangrove ecosystems. Mangrove ecosystems are near the coastal cities and industrial centres, so there are some threats such as metal contamination (Mackey *et al*., 1992; Lacerda *et al*., 1993; Rivail *et al*., 1996., Lacerda, 1998; Tam and Yao, 1998). Identification of these threats is important for mangroves management. The main goal of this study is identifying destructive threats on mangrove ecosystem in Gabrik International Wetland for sustainable management of them.

Ecosystem service values of mangrove wetlands area include the following:
Fish and shellfish habitat**,** wildlife habitat, pollution filtration, protection against wave damage, heavy metal removal, oxygen production, nutrient production and recycling, chemical pollution absorption, aquatic production, microclimate regulation, world climate regulation, flood control, erosion control, groundwater and recharge supply, energy source, livestock grazing, fishing, fertilizer industry, recreation and aesthetics, reservation of gene pool and scientific research.

Challenges facing Mangroves and Wetlands from Climate change

- **Sea-level rise**

Global sea-level rise is one of the more certain outcomes of global warming, it is already likely taking place (12-22 cm occurred during the 20th century). The range of projections for global sea-level rose from 1980 to 1999 to the end of the 21st century (2090-2099) is 0.18-0.59 m (Solomon *et al*., 2007). Recent findings on global acceleration in sea-level rise indicate that upper projections are likely to occur (Church and White, 2006). ‘Relative sea-level change’, the change in sea-level relative to the local land as measured at a tide gauge, is a combination of the change in eustatic (globally averaged) sea-level and regional and local factors. The former is the change in sea level relative to a fixed Earth coordinate system, which, over human time scales, is due primarily to thermal expansion of seawater and the transfer of ice from glaciers, ice sheets and ice caps to water in the oceans (Church *et al.*, 2001). The latter is the result of vertical motion of the land from tectonic movement, the glacio- or hydro-isostatic response of the Earth's crust to changes in the weight of overlying ice or water, coastal subsidence such as due to extraction of subsurface groundwater or oil, geographical variation in thermal expan- 238 E.L. Gilman *et al*. / Aquatic Botany 89 (2008) 237-250 sion, and for shorter time scales over years and shorter, meteorological and oceanographic factors (Church *et al*., 2001). The rate of change of relative sea-level as measured at a tide gauge may differ substantially from the relative sea-level rate of change occurring in coastal wetlands due to changing elevation of the wetland sediment surface. Additional variability might be caused by differences in local tectonic processes, coastal subsidence, sediment budgets, and meteorological and oceanographic factors between the section of coastline where the coastal wetland is situated and a tide gauge, especially when the tide gauge is distant from the wetland.

- **Extreme high water events**

The frequency of extreme high water events of a given height relative to fixed benchmarks is projected to increase over coming decades as a result of the same atmospheric and oceanic factors that are causing global sea-level to rise, and possibly also as a result of other influences on extremes such as variations in regional climate, like phases of the El Nino Southern Oscillation and North Atlantic Oscillation, through change in storminess and resulting storm surges (Woodworth and Blackman, 2004; Church *et al.*, 2001, 2004b). For example, an analysis of 99th percentiles of hourly sea-level at 141 globally distributed stations for recent decades showed that there has been an increase in extreme high sea-level worldwide since 1975 (Woodworth and Blackman, 2004). In many cases, the secular changes in extremes were found to be similar to those in mean sea-level. Increased frequency and levels of extreme high water events could affect the position and health of coastal ecosystems and pose a hazard to coastal development and human safety. Increased levels and frequency of extreme high water events may affect the position and health of mangroves in some of the same ways that storms have been observed to effect mangroves, including through altered sediment elevation and sulfide soil toxicity, however, the state of knowledge of ecosystem effects from changes in extreme waters is poor.

- **Storms**

During the 21st century the Intergovernmental Panel on Climate Change projects that there is likely to be an increase in tropical cyclone peak wind intensities and increase in tropical cyclone mean and peak precipitation intensities in some areas as a result of global climate change (Houghton *et al*., 2001; Solomon *et al*., 2007). Storm surge heights are also predicted to increase if the frequency of strong winds and low pressures increase. This may occur if storms become more frequent or severe as a result of climate change (Church *et al*., 2001; Houghton *et al.*, 2001; Solomon *et al*., 2007). The increased intensity and frequency of storms has the potential to increase damage to mangroves through defoliation and tree mortality. In addition to causing tree mortality, stress, and sulfide soil toxicity, storms can alter mangrove sediment elevation through soil erosion, soil deposition, peat collapse, and soil compression (Smith *et al.*, 1994; Woodroffe and Grime, 1999; Baldwin *et al*., 2001; Sherman *et al*., 2001; Woodroffe, 2002; Cahoon *et al.*, 2003, 2006; Cahoon and Hensel, 2006; Piou *et al.*, 2006). Areas suffering mass tree mortality with little survival of saplings and seedlings might experience permanent ecosystem conversion, as recovery through seedling recruitment might not occur due to the change in sediment elevation and concomitant change in hydrology (Cahoon *et al*., 2003). Other natural hazards, such as tsunami, which will not be affected by climate change, can also cause severe damage to mangroves and other coastal ecosystem as illustrated in the 26th December 2004 Indian Ocean tsunami.

- **Precipitation**

Globally, rainfall is predicted to increase by about 25% by 2050 in response to climate change. However, the regional distribution of rainfall will be uneven (Houghton *et al*., 2001). E.L. Gilman et al./Aquatic Botany 89 (2008) 237-250 241 Increased precipitation is very likely in high-latitudes, and decreased precipitation is likely in most subtropical regions, especially at the pole ward margins of the subtropics (Solomon *et al*., 2007). In the most recent assessment, the Intergovernmental Panel on Climate Change reported significant increases in precipitation in eastern parts of North and South America, northern Europe and northern and central Asia, with drying in the Sahel, the Mediterranean, southern Africa and parts of southern Asia (Solomon *et al*., 2007). Long-term trends had not been observed for other regions. Changes in precipitation patterns are expected to affect mangrove growth and spatial distribution (Field, 1995; Ellison, 2000). Based primarily on links observed between mangrove habitat condition and rainfall trends (Field, 1995; Duke *et al.*, 1998), decreased rainfall and increased evaporation will increase salinity, decreasing net primary productivity, growth and seedling survival, altering competition between mangrove species, decreasing the diversity of mangrove zones, causing a notable reduction in mangrove area due to the conversion of upper tidal zones to hypersaline flats. Areas with decreased precipitation will have a smaller water input to groundwater and less freshwater surface water input to mangroves, increasing salinity. As soil salinity increases, mangrove trees will have increased tissue salt levels and concomitant decreased water availability, which reduces productivity (Field, 1995). Increased salinity will increase the availability of sulfate in seawater, which would increase anaerobic decomposition of peat, increasing the mangrove's vulnerability to any rise in relative sea-level (Snedaker, 1993, 1995). Reduced precipitation can result in mangrove encroachment into salt marsh and freshwater wetlands (Saintilan and Wilton, 2001; Rogers *et al*., 2005a). Increased rainfall will result in increased growth rates and biodiversity, increased diversity of mangrove zones, and an increase in mangrove area, with the colonization of previously un-vegetated areas of the landward fringe within the tidal wetland zone (Field, 1995;). For instance, mangroves tend to be taller and more diverse on high rainfall shorelines relative to low rainfall shorelines, as observed in most global locations, including Australi. Areas with higher rainfall have higher mangrove diversity and productivity probably due to higher supply of fluvial sediment and nutrients, as well as reduced exposure to sulfate and reduced salinity (McKee, 1993; Field, 1995; Ellison, 2000). Mangroves will likely increase peat production with increased freshwater inputs and concomitant reduced salinity due to decreased sulfate exposure (Snedaker, 1993, 1995).

- **Temperature**

Between 1906 and 2005, the global average surface temperature has increased by 0.74 8C (Solomon *et al*., 2007). The linear warming trend of the last fifty years (0.13 8C per decade) is nearly twice that for the last 100 years. This rise in globally averaged temperatures since the mid-20th century is considered to be very likely due to the observed increase in anthropogenic greenhouse gas atmospheric concentrations (Solomon *et al.*, 2007). The range in projections for the rise in global averaged surface temperatures from 1980 to 1999 to the end of the 21st century (2090-2099) is 1.1-6.4 (Solomon *et al*., 2007). Increased surface temperature is expected to affect mangroves by changing species composition, changing phenological patterns (e.g., timing of flowering and fruiting) and increasing mangrove productivity where temperature does not exceed an upper threshold (Field, 1995; Ellison, 2000).

Mangroves reach a latitudinal limit at the 16^0C isotherm for air temperature of the coldest month, and the margins of incidence of ground frost, where water temperatures do not exceed 24 8C (Ellison, 2000). The optimum mangrove leaf temperature for photosynthesis is believed to be between 28^0 and 32^0C, while photosynthesis ceases when leaf temperatures reach 38-40^0C (Clough *et al*., 1982; Andrews *et al*., 1984). The frequency, duration and intensity of extreme cold events have been hypothesized to explain the current latitudinal limits of mangrove distribution (Woodroffe and Grindrod, 1991; Snedaker, 1995). However, the incidence of extreme cold events is not likely to be a factor limiting mangrove expansion to higher latitudes in response to increased surface temperature. The Intergovernmental Panel on Climate Change projects reduced extreme cold events (Solomon *et al*., 2007), in correlation with projected changes in average surface temperatures.

- **Atmospheric CO_2 concentration**

The atmospheric concentration of CO_2 has increased by 35% from a pre-industrial value, from 280 parts per million by volume (ppmv) in 1880 to 379 ppmv in 2005 (Solomon *et* *al*., 2007). In recent decades, CO_2 emissions have continued to increase. A direct effect of elevated atmospheric CO2 levels may be increased productivity of some mangrove species (Field, 1995; Ball *et al.*, 1997; Komiyama *et al*., 2008).

Ball *et al*. (1997) showed that doubled CO_2 had little effect on mangrove growth rates in hyper saline areas, and this may combine with reduced rainfall to create some stress. The greatest effect may be under low salinity conditions. Elevated CO_2 conditions may enhance the growth of mangroves when carbon gain is limited by evaporative demand at the leaves but not when it is limited by salinity at the roots. There is no evidence that elevated CO_2 will increase the range of salinities in which mangrove species can grow. The conclusion is that whatever growth enhancement may occur at salinities near the limits of tolerance of a species, it is unlikely to have a significant effect on ecological patterns (Ball *et al*., 1997). However, not all species may respond similarly, and other environmental factors, including temperature, salinity, nutrient levels and the hydrologic regime, may influence how a mangrove wetland responds to increased atmospheric CO_2 levels (Field, 1995). The effect of enhanced CO_2 on mangroves is poorly understood and there is a paucity of research in this area.

- **Adjacent ecosystem responses**

Coral reefs, sea grass beds, estuaries, beaches, and coastal upland ecosystems may experience reduced area and health from climate change outcomes, including increased temperature, timing of seasonal temperature changes, and ocean acidification (Harvell *et al*., 2002;). Mangroves are functionally linked to neighbouring coastal ecosystems, including sea grass beds, coral reefs, and upland habitat, although the functional links are not fully understood (Mumby *et al*., 2004). Degradation of adjacent coastal ecosystems from climate change and other sources of stress may reduce mangrove health. For instance, mangroves of low islands and atolls, which receive a proportion of sediment supply from productive coral reefs, may suffer lower sedimentation rates and increased susceptibility to relative sea-level rise if coral reefs become less productive due to relative sea-level rise or other climate change outcomes.

Anthropogenic factors

- Conversion of Wetlands for Housing Development
- Rapid conversion of wetlands and agricultural lands for housing development and excessive urban sprawl and its associated problems of inefficient use of land. Annual Flooding of houses and destruction of life and property.
- Urban Space and development of Shanty Towns/ Slums
- Low-income populations building on marginal and wetlands with its associated public health risks – such as diarrhoea, cholera, guinea worm and hook worm malaria. (e.g. Sodom and Gomorrah).
- Mining, Land and Soil Degradation

- When wetland soils are exposed due to mining or the destruction of their vegetation, sulphides in the original soils are converted into sulphuric acid leading to acidification . Deforestation resulting in increased surface run--off and sediment load of water that flow into wetlands.
- Sanitation and Water Pollution
- The dumping of refuse, discharge of industrial and domestic sewerage, as well as agricultural run--off into wetlands increases the organic loading of the wetlands waters. This increases the biochemical oxygen demand (BOD) of the water body, leading to inadequate oxygen supply to support plant and animal life supply life. The discharge of the various forms of wastes into the water bodies create two major environmental health problems. First, they create a fertile environment for microbiological and biological agents to flourish and allow the spread of disease pathogens. Secondly, the chemical constituents in the waste create various health problems for humans and aquatic organisms.

Likely Solutions to the Challenges

- Coastal structure in the proximity of mangrove areas should be designed in such a manner as to avoid excess sedimentation or erosion.
- Avoidance of dumping dredged material, sewage and industrial wastes into the ecosystem.
- Proper inventory should be taken of the resources in the mangroves and wetlands area.
- Non-destructive aquaculture practices should be encouraged such as small sea level or above sea level ponds for agri-aquaculture.
- The jetties and small residential houses should be constructed on stilts without damaging the forest.
- Extraction processes for timber and other products should not be damaging the ecosystem
- Policy implementation should be encouraged in the mangroves and wetlands area
- Replanting of plant species should be done wherever on the sites the natural regrowth is insufficient.
- Ecotourism can be promoted to provide job opportunities for local people without disturbing the ecosystem.

Conclusion

Wetlands ecosystems are complex but valuable assets in every nation. To be able to manage them effectively and efficiently requires the understanding of the dynamics of human and environmental parameters at play. The success of any wetlands management programmes will depend on the involvement of communities whose life styles are interlinked with the wetlands and whose activities directly affect the wetland ecosystem.

Protection of wetlands should therefore be for the people and not against them, "for" "against" in other to maintain it on a sustainable basis.

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