Chapter

The Impact of Landscape Reclamation on Mangrove Forest and Coastal Areas in the Niger Delta, Nigeria

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Abstract

Coastal area is in serious danger from land reclamation in the Niger Delta, Nigeria. This is because of land expansion activities such as urban development. Landscape reclamation is intended for urban city expansion, road construction, housing project, crude oil exploration and sand mining. Reclamation is carried out by both government and private developers. The government sometimes forcefully acquires coastal areas from the native community, remove the mangrove forest and sand fill the area in other to establish projects beneficial to the public. Private investors reclaim coastal areas to execute private business that would boost their economic fortunes. Oil companies clear coastal forest and set up oil wells and pipelines in swampy locations. Increasing population in small communities had also led to the reclamation of coastal areas to create room for the construction of houses to accommodate more people. However, many land reclamation activities are not development-centered, but business-centered. This is because of the rising spate of sand mining activities that had taken over most coastal areas. Sand mines are often abandoned after some years of operation. Reclamation is done without proper environmental impact assessment. This situation had led to the loss of many species.

Keywords: Niger Delta, urbanization, invasive species, hydrocarbon pollution, mangrove, exploration, seismic activities, oil spillages, pipelines

1. Introduction

Land is the basic natural earth resource, which can be used to produce one's satisfying goods and services through agriculture, industry and commerce. Land in the Niger Delta area is in large demand because of traditional and cultural beliefs attached to the possession of land [1]. Land is regarded in this area as the best form of asset investment because of the prestige attached to its ownership. The cost of land appreciates and has no depreciative value. But a land or coastal area that has been plundered and polluted may loss its economic value [2]. The aim of acquiring land varies, but is mainly for possession and or production of goods and services to satisfy socio-economic and socio-cultural needs. The following are natural resources found in land in Nigeria: columbite, dolomite, gold,

tin, iron ore, limestone, silver, uranium and crude oil. The crude oil resource is mainly present in the Niger Delta region of Nigeria, which is the centripetal force on which the nation's economy revolves [3]. Land is highly priced and many have died for its sake through fratricidal wars and communal clashes because of its scarcity. This situation had precipitated the uncontrolled reclamation of coastal lands [4]. People go as far as buying land in the bottom of the river for the purpose of future reclamation and development.

Land policy in Nigeria is influenced by government and culture. This is encapsulated in the Land Use Act promulgated in 1978, which states that all lands in Nigeria belong to the Federal Government, this include but not limited to underwater land that is 200 nautical miles from the shore. The Governors of each states of the federation hold the land in trust for the Federal Government, and are entitled to be the sole signatory of all certificate of occupancy (C of O) before a piece of land is legally owned by an individual or group of individuals. Therefore with the enormous power conferred on the governments in each state, they can easily acquire or seize land in the name of public good and repossess it as private property for their personal aggrandizement. Before coastal lands are to be acquired proper environmental impact assessment (EIA) studies need to be conducted to develop proper management plan aimed at forestalling loss and extinction of common and rare species. But in most cases no proper EIA or landscape assessment is carried out [5]. It is the responsibility of the Government to protect the land against illegal landscape reclamations. However, in many communities coastal lands are protected traditionally if they have cultural significance to the people [1]. Despite the negative consequences of coastal land reclamation to aquatic species, it can add some economic value if used for non-intrusive agricultural activities. Nevertheless, land utilization is influenced by nature and characteristics of soil, soil moisture and temperature, topography and land location, flora, fauna and climate. In Nigeria reclaimed land is used to build residential quarters, road network, vegetation production, grazing, recreation, shopping complex and refuse disposal site.

Land reclamation is also known as land fill, it is the process of creating new land from ocean, riverbeds or lake beds. It is the returning of lands to an improved state. It is also referred to as the process of improving lands to make them suitable for more intensive use. Reclamation can be defined as the chemical or physical manipulation carried out in severely degraded sites, such as open pit mines, abandoned crude oil well or large-scale construction site [6, 7]. Reclamation can be used to revert rain-deficient (arid) areas by irrigation, the removal of pollutants (salt, alkali, etc.) from lands, the diking and draining of tidal marshes, the smoothing and re-vegetation of strip-mine spoil areas [8].

Historically, reclamation meant irrigation projects that brought wetlands and deserts (considered useless wastelands) into agricultural production. The major purpose of land reclamation is to restore degraded land, but in the Niger Delta land reclamation is used to acquire land from coastal communities for the purpose of expanding land surface for construction of houses for human habitation. Land reclamation in the Niger Delta passes through five phases, which in all ramifications affect the environment. These phases include: (i) deforestation of mangrove forest (ii) consolidation of swamp with bulldozers, (iii) pumping of white sand from the sea bottom unto shore, (iv) sand filling of reclaimed land, and (v) construction activity e.g. roads, buildings, industries and parks.

Land can either be physical or economic. Physical land covers all the earth including land surface, sub-surface, under water and super surface (atmosphere). Economic land on the other hand, is part of physical land that can be used to produce economic commodities for man's satisfaction [2]. For instance, sand filling of a town named Buguma in the Niger Delta, Nigeria increased economic

land at the detriment of the mangrove forest and other coastal species. Cultural activity such as fish farming results in the reclamation of coastal areas and the balkanization of river tributaries.

2. Reasons for land reclamation in the Niger Delta

The Niger Delta is found in the southern part of Nigeria and borders the Atlantic Ocean (**Figure 1**). Mangrove vegetation is the dominant species found at the interface between the land and the sea. Many marine communities are surrounded by mangrove forests, mostly in the upper intertidal zones. Population increase has led to the migration of people towards the coastal locations. The causes of land reclamation in the Niger Delta are grouped into two: (1) direct and (2) indirect causes. The direct causes include: (i) land expansion, (ii) construction activities, (iii) land acquisition and (iv) succession (land-forming activities of mangroves). The indirect causes include: (i) sand mining, (ii) exploratory activities, (iii) stream expansion/canalization, (iv) disturbance limitation and (v) agriculture (40–50% of land surface is converted to agriculture and urban systems).

2.1 Direct causes

2.1.1 Land expansion

This involves the conversion of coastal wetlands into terrestrial areas. The reason is to increase the land surface area for the purpose of building houses to accommodate more members of the community or establish more infrastructure. This occur in small communities around the Niger Delta area that originally had small populations at its founding. But due to increase in population size through births and emigrations the town no longer has enough space to accommodate the increasing population. This situation thus necessitated the reclamation of coastal areas to create more space for human habitation. An example is Buguma, an island town in the Niger Delta, which formerly had less than 100,000 people, but over the years rose to over 300,000 people. This situation made the local authority to cut down

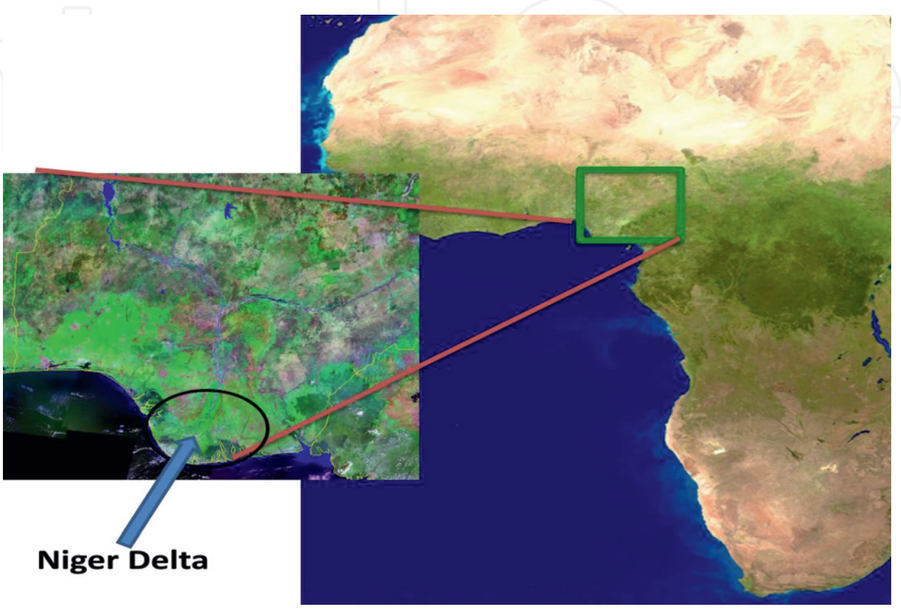

Figure 1.
Map of Niger Delta Nigeria (circled) bordering the Atlantic Ocean has the biggest mangrove forests in Africa.

and sand fill a mangrove forest measuring about 4.2 million m^2 in 1984 (**Figure 2**). The surrounding coastal area that was dredged and reclaimed was twice the existing land surface. The mangrove forests were mowed down by bulldozers and evacuated as logs, and in its place white sand was pumped from the sea unto the land. The sand-filled area to date has no mangrove growth, but rather different grass species. Presently buildings have been erected on the site, which are occupied by some people. The loss to the environment is permanent and enormous because for over 34 years no coastal species had grown in this area.

The second example is another site known as Borikiri in the outskirts of Port Harcourt, the capital city of Rivers State. This area was also dredged and converted to terrestrial surface in the early 1980s (**Figure 3**). So far in this location thousands of houses had been built, which houses over half a million persons. The implication of these landscape reclamations is that the destruction of mangrove forests lead to a colossal loss of ecosystem services to the environment. Anthropogenic activities around the coast is detrimental to its sustainability because of the addition of pollutants and contaminants [5].

2.1.2 Construction activities

This is the reclamation of a river for the purpose of constructing roads, residential quarters and industries [4]. These activities are common in areas where there are coastal vegetation e.g. mangrove wetlands. The swamps are scooped away or reinforced with sand and concrete in other to produce a hard surface on which to construct foundations of buildings. Swampy soils are also locally reinforced with hard soils known as "chikoko" and left for some years to solidify before houses are

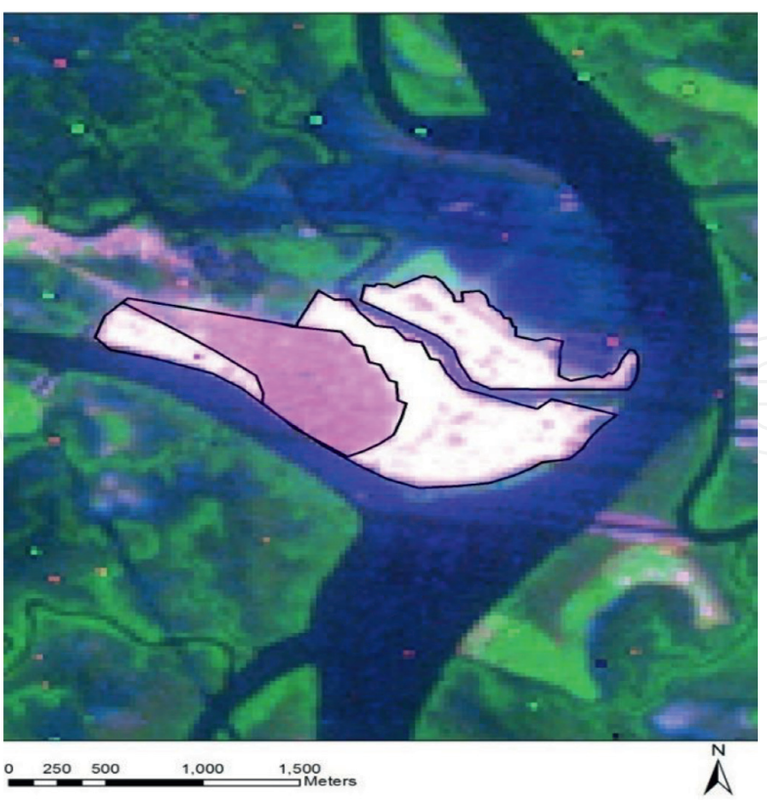

Figure 2.
Dredged and sand filled areas in Buguma, Niger Delta, Nigeria. The white patch indicates the sand filled area while the green patches indicates mangrove forest that is still standing. The white patches sum up to give a total of 4.2 million m^2 of mangroves removed in 1984. This estimate was made using Arc GIS [9].

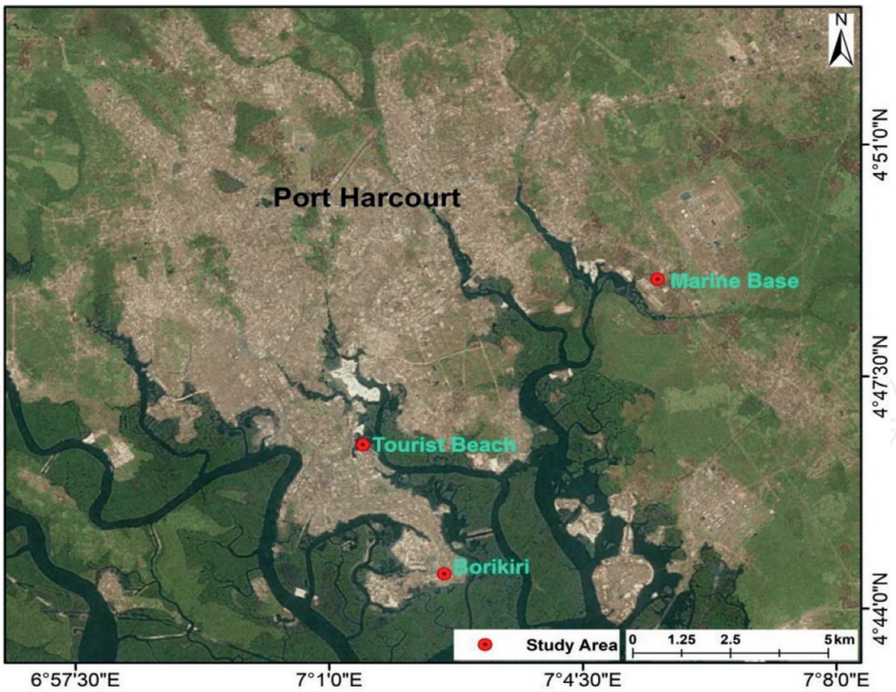

Figure 3.
Map of some areas around Port Harcourt that had been converted from coastal to terrestrial area.

built on it. Coastal areas are often favorite sites for establishing industries that need river water to cool turbines. Industries also flock around coastal areas because of the ease of transportation of goods and equipments.

Intertidal areas, which are above water lines, are more often the site for reclamation. These areas are naturally covered with water during high tides, but are filled with soil and consolidated to prevent tidal flooding during high tide. The solidified area is used as a platform for construction activities. Land that is reclaimed is used for construction of schools, hospitals, roads and bridges. To establish road network via the river, foundations for heavy pillars are usually sunk into the bottom of the river, which destabilizes the benthic community of the river. Areas close to the shore are also sand filled to connect bridges. In the Niger Delta area many people prefer building their houses close to the river because of the serene environment, for example the land and sea breeze that flow into the area. Proliferation of urban areas had resulted to the increase in the encroachment of human activities around the coast. Over population is a major factor that had led to the extension of cities beyond coastal limits. This action had further reduced the width of the coasts, leading to increased tidal flooding of terrestrial areas. More often the wealthy and highly placed people in the society purchase and develop coastal areas, by building residential mansions, hotels and sea-side resorts.

2.1.3 Land acquisition

It is the forceful or legal takeover of coastal area by individuals or government officials. Highly placed individuals prefer constructing their houses along coastal areas. Through the use of police power they acquire and take over mangrove forest they bulldoze the forest, dredge and sand fill the site, which they allow to lie fallow for some years or reinforce and develop immediately. Coastal sites are preferred by land speculators because they usually off-city limits and isolated from the rest of the population.

2.1.4 Succession as a primer for land reclamation

Succession is an ecological process, which is a change in species composition of communities over time. It is the result of abiotic (physical and chemical) and biotic agents of change. Mangroves are regarded as land forming organisms [10]. Thus mangroves are natural land reclaimers. This is because their adventitious root system traps sediments during tidal flow, and accumulate it over a long period of time. Presence of sediments leads to the gradual formation of terrestrial areas, which becomes the habitat for plants. Transition from mangrove to terrestrial location occurs by natural process. Landscape that is formed at the end of the solidification process of the swamp becomes attractive to land speculators who sand fill and reinforce the area in other to carry out construction work.

2.2 Indirect cause

2.2.1 Sand filling

Almost every coastal area in the Niger Delta has had one abandoned project or the other, one of which is sand dump. Sand mining activity is a lucrative business in the Niger Delta and is embarked upon by both private individuals and government officials. Local sand mining is done manually by the digging of sand from the bottom of the river during low tide and conveyed ashore in hand dug canoes. Sand mining is also done with more sophisticated machines, where pumps are used to convey sand from the bottom of the river unto land via long pipes. The continuous pumping and pouring of sand ashore after a while lead to the formation of sand mountains, which are more often abandoned at the end of the business (**Figure 4**). Deposited sand is usually evacuated by trucks to buyers. The environmental problem of this practice is that the sand dumped by the shore smothers plants and animals around the area and changes the coast from a marshy to a sandy area.

2.2.2 Exploratory activities

Oil and gas exploration is the main exploratory activity that occurs in the Niger Delta region. It occurs at on-shore or off-shore locations [3]. Before exploration

Figure 4.
Former mangrove forest that was converted to sand fill in Buguma, Niger Delta, Nigeria.

the site is prepared through pilling, dredging, sand filling, grading and concreting. Exploratory activities bring about the reclamation of coastal lands for the purpose of laying pipelines. It also involves the establishment of well heads and booth camps. During exploration the coast is first dredged, cleared of vegetation and reclaimed in other to create a plat form for mounting pillars that carry oil pipelines and well heads. This occurs during off-shore drilling in mangrove swamps. Surrounding areas of the swamps are usually dredged and sand-filled to enable it to support the mounting of crude oil well head and the laying of pipelines (**Figure 5**). Concrete bases are constructed on this platform to carry the pipes from the drilling point, which may be at an off-shore or on-shore site to the refinery. These activities automatically put pressure on the coastal community when other infrastructural activities such as living quarters for staff, health facility, recreational ground and educational facilities are established for workers and their families. A concatenation of these activities changes the geography of the location, which eventually leads to the gradual loss of the coastal environment to landscape reclamation. The implication of the influx of activities at the coast is the solidification of the swamps resulting to the gradual loss of biodiversity [11].

2.2.3 Stream expansion and canalization

This is a situation where rivers near ports are expanded to accommodate large ocean going ships. Canalization is done to enable ships to berth at the wharf, without running aground. During canalization, earth moving dredgers are deployed to excavate the benthic soil. The scouring of the river bottom crushes and destroys a lot of organisms such as shell and non-shell fish community in that location. The dredged soil that is evacuated from the river bottom is dumped on land surface and smothers coastal vegetation such as mangroves. Accumulation of dredged spoil converts the swamp to terrestrial area and also changes the physico-chemistry of the coasts [3]. Expansion of creeks allow for navigational activities, commerce and construction. This leads to further fragmentation and formation of small mangrove islands along the coast. Changes in land form lead to changes in the biogeography of the area. Terrestrial land form eventually evolves from an aquatic environment after solidification.

Figure 5.
Crude oil pipeline and well head situated in reclaimed coastal area in the Niger Delta, Nigeria.

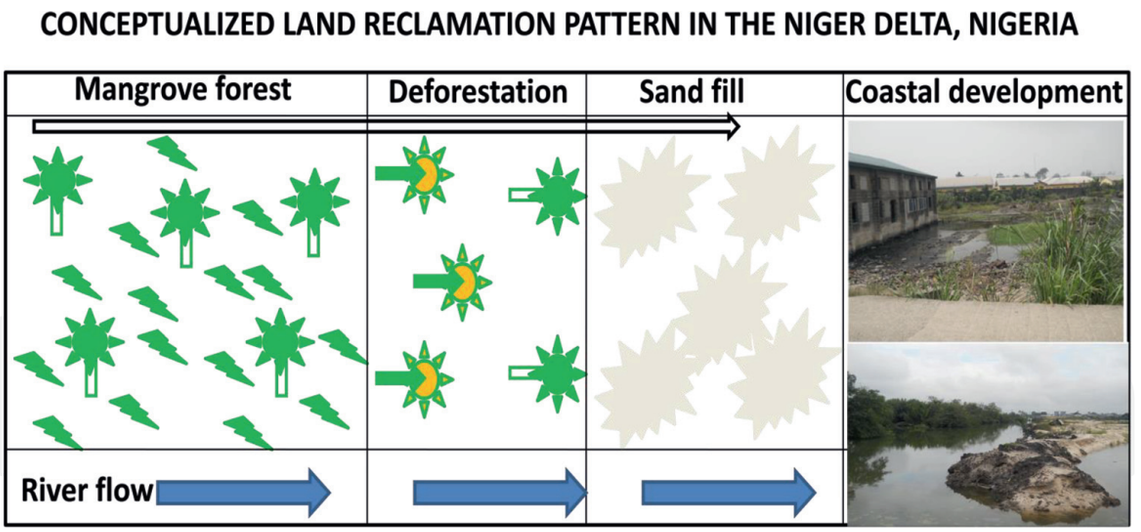

Figure 6.
A conceptualized reclamation pattern in coastal communities in the Niger Delta, Nigeria.

2.2.4 Disturbance

Invasion of foreign species in coastal areas is another precursor to land reclamation activity aimed at remediating the sites in the Niger Delta region. Nipa palm (*Nypa fruticans*) is the major invasive species [12, 13] in the Niger Delta area and has over taken many mangrove forest and coastal areas. The problem is that mangroves provide numerous ecosystem services to the local people while the palms provide no ecosystem service to the people. Because of the non-use of the palms they had been removed from several locations with the aid of swamp buggies as a means of mitigating their negative environmental effect. The entry of big machinery into the swamp had added more stress to the coast by destroying many soil-dwelling and benthic organisms. The problem of this action is that the nipa palm forest after being cleared is repossessed by the government for infrastructural developments, which rather than reduce the negative effect worsen the situation of the coast. An example of this pattern of landscape reclamation is found in a place called Eagle Island, Niger Delta where the mangrove forests were cut down and sand filled and later the area was used for developmental project (**Figure 6**).

2.2.5 Agriculture

Agricultural activities such as rice paddies and aquaculture are embarked upon in swampy coastal locations [14]. These activities are economically beneficial to farmers, but inimical to the environment. This is because such activities lead to the clearing of the mangrove forest and other coastal vegetation. It also changes the coastal structure and lead to flooding of upland areas. The soil chemistry is also affected by the manures and fertilizers that come from the farm and the waste from fish ponds. A combination of these activities leads to the acidification of the river causing fish deaths and physiological and reproductive problems of numerous marine organisms.

3. Impact of land reclamation on mangrove and coastal environment

Land reclamation impact the coastal environment in several ways (**Table 1**).

Potential impact	Site preparation		Dredging	Sand mining	Sand filling	Construction
	Deforestation	Clearing				
Air emissions	☆	☆	☆	☆	☆	☆
Noise & vibration	☆	☆	☆	☆	☆	☆
Impacts on mangroves	☆	☆	☆	☆	☆	☆
Reclamation	☆	☆	☆	☆	☆	☆
Impacts on wildlife & coastal life	☆	☆	☆	☆	☆	☆
Geology & hydrogeology	☆	☆	☆	☆	☆	☆
Impacts on soil & water	☆	☆	☆	☆	☆	☆
Health impacts	☆	☆	☆	☆		

Table 1.
Potential environmental impact of land reclamation in the Niger Delta, Nigeria.

3.1 Environment

3.1.1 Site vegetation clearing

Before reclamation the site is cleared, which leads to the destruction of native plant species within the reclaimed area [3]. This could lead to permanent loss of mangroves or other plant species of economic/medicinal importance and habitat for marine organisms and wildlife and their emigration to unaffected areas, thereby upsetting the ecological balance. During clearing heavy machinery fell trees. This further denigrates the soil structure and converts the aquatic environment to marshy environment. The swampy environment is a mixture of mud and water, after a long period of perturbation the swampy soil gets solidified and changes to a terrestrial environment.

3.1.2 Increased erosion of the cleared areas/river banks

Once the bulldozer rolls in to mow down the mangroves, it creates depressions for tidal pressure to wash in ashore. This is because the adventitious roots of the mangrove forest serve as tidal breaks. The presence of mangroves along the coast stabilizes and reinforces the soil against erosion. Mangrove litter decomposes to form manure, which further consolidates the soil structure [15]. Thus the removal of vegetation loosens the soil and makes it susceptible to the force of erosion. In the same vein the wheel of the bulldozers fragments the soil particles and makes it porous and prone to leaching or wind erosion.

3.1.3 Increase access for hunting and logging

Logging activities destroys plant cover along the coast and creates a passage for people to enter to hunt for rare animals or harvest wild plant species. Similarly,

reckless and indiscriminate hunting in opened forest reduces population and thus reduces species diversity, which may lead to extinction of some species.

3.1.4 Changes in topography of sand filled area/river bed and dredged areas

This could lead to the death of soil dwelling organisms. Changes in river channel via canalization or dredging changes the river system by increasing the length and breadth of the river which affects the flow dynamics and hydrology of the river [3]. This situation affects the fish survival and population. Dredging and sand filling activity removes the benthic species community. It also deepens the sea bed, which affects the water level. Decrease in water level affect intertidal level especially when areas along the shore receive no water supply and become dry. This leads to the death or migration of amphibious species along the coast. The dehydration of the intertidal areas cuts off dissolved oxygen and food supply to aquatic species.

3.1.5 Increased turbidity

This could lead to the reduction in species composition and diversity of aquatic resources. It could also lead to fish kills and smothering of aquatic organisms. Increased turbidity leads to the blockage of light beyond water surface, thus hampering photosynthetic activities below the water surface such as the benthic region.

3.1.6 Disturbance of aquatic life

This includes zooplankton, phytoplankton, benthic organisms and fisheries. It also affects soil-dwelling organisms from adverse impact on water and soil quality. The felling of trees and the uprooting of their stumps leads to soil fragmentation. Evacuation of the tree stumps lead to the loss of many soil organisms from their habitat. Sand filling of the coasts lead to the burial of millions of species. Loss of trees leads to increased soil erosion and increased sedimentation of river.

3.1.7 Ground water/soil quality could be impaired by leachates from generated dredged soil

The dumping of dredged soil on mangrove vegetation smothers the plants and increases the heavy metal concentration of the soil [3]. This affects the survival of soil-dwelling organisms by increasing the acidity and alkalinity of the soil. Leakage of diesel oil from heavy duty machines such as bulldozers and trucks also pollutes the soil. Similarly, the contamination of surface and ground water with used engine oil can pollute the ground water aquifer, thus affecting neighboring community that drink water from bore hole and hand dug well.

3.1.8 Impairment of environmental quality

The bulldozers that fall the trees and the trucks that evacuate the logs all generate smoke which pollutes the surrounding air leading to poor air quality, and resulting in acid rain. This leads to the impairment of the health of aquatic and terrestrial organisms around the reclaimed area.

3.1.9 Improper disposal of solid waste

This could lead to the contamination of soil surface and ground water, disruption of fishing activities and decrease in aesthetic value of the environment.

4. Impact of landscape reclamation on marine ecosystem

The marine coastal ecosystem is made up of different zones. The uppermost layer or photic zone is 10 m of water and absorbs 80% of solar energy, which carries out primary productivity. The warm shallow waters of the continental shelves are most biologically productive and support the greatest species diversity. Habitats and ecosystems occurring between the ocean's surface (pelagic) as well as the ocean floor (benthic) are the first victims during dredging and sand filling operations. This is because the organisms that reside in these areas are wiped out during the first phase of reclamation.

Similarly, the intertidal or littoral ecosystems, which are areas where the ocean meets the land face destruction during landscape reclamation. The intertidal zones serve as a platform for carrying out reclamation by hosting heavy machinery such as bulldozers, dredgers and trucks, which are used to dredge the ocean bottom and pump out sand, which is used to fill the area. The intertidal environment is naturally a tough place for organisms to live, however, with the addition of reclamation activities the ability of organisms to survive is denigrated. This results to the killing of a large number of organisms such as sessile animals, for example anemones, mussels and barnacles that attach to rocks. There are also some burrowing organisms that dig into shore sand. Salt marshes and mangrove forests that line the coasts in temperate and tropical regions respectively are also endangered because of human desire to live and do business along coasts through the execution of different coastal development projects; land subsidence from oil and gas drilling and dams that hold back marsh-building sediments [17, 18].

Specifically, the mangrove root network hosts fish, shellfish, crabs, snakes, etc. In the same vein, birds feed and nest in the dense foliage. Mangroves provide various ecosystem services such as food, medicine, tools and construction materials. Globally, half of the world mangroves have been destroyed [16] as people have reclaimed those areas as a result of coastal development. Shrimp farming in particular has resulted to the conversion of large areas of mangroves. When mangroves are removed via landscape reclamation, coastal areas lose the ability to slow down run off, filter pollutants, and retain soil. As a result, offshore systems such as coral reefs and eel grass beds are readily degraded. Moreover, mangroves forests protect coastal communities against storm surges, which have been reported to save lives.

5. The role of human ecology in land reclamation

People participation is very important in landscape reclamation because it would provide a consensus view on land use to the host community [19]. Five ways human ecology influence reclamation of coastal environment include:

1. *Concentration*: is a process whereby a given area becomes concentrated by human population due to the fertility of the land. Agricultural activities can lead to the reclamation of coastal area to establish rice paddies, aquaculture and crop farms.

2. *Centralization*: these are lands that are regarded as focal points as a result of their economic value. These areas dominate the hinter land and are often reclaimed and sand filled to expand their economic potential. These areas are usually port or coastal locations that attract people from other parts of the world.

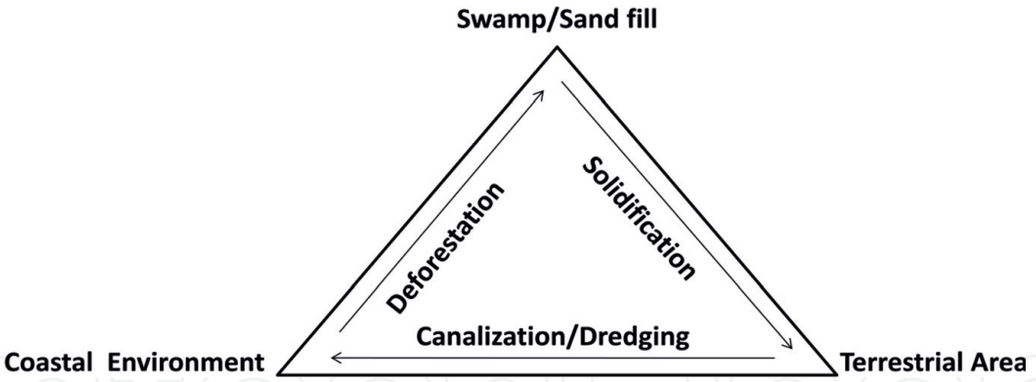

Figure 7.
Conversion of coastal environment to terrestrial area through deforestation and solidification to terrestrial environment in the Niger Delta, Nigeria.

3. *Segregation*: this is when units or communities cluster together based on homogeneity of ideals or goals. Homogeneous ideals such as customs, educational goals, and occupational goals all make up segregation. For instance, establishment of refinery in a locality leads to the reclamation of more coastal lands to harbor the cluster of people who come to seek for jobs.

4. *Invasion*: this is as a result of the migration of people into coastal communities in search of new technologies that provide job opportunities. An example is the establishment of the liquefied natural gas (LNG) plant in Bonny Island in the Niger Delta region of Nigeria. This facility is situated at a coastal community that is land-locked. Thus in other to expand the land area to accommodate the industrial complex, surrounding creeks were mowed down; sand filled and solidifies to build offices and apartments for workers.

5. *Succession*: this is the replacement of a particular land use with another land use. The conversion of a coastal area to a terrestrial area via developmental projects is a human-mediated succession. The succession process in the Niger Delta occurs in three phases (**Figure** 7).

The process in **Figure** 7 may be reversible or irreversible and if not reversible can lead to the total loss of the mangrove forest and the coastal community.

6. Restoration and management methods

Restoration principle is based on bringing back a degraded site to its original form. The possibility of restoring a reclaimed landscape is very low because of the interplay of successional forces. The conversion of a coastal environment to a terrestrial environment is absolute and cannot be reversed. Therefore, the best option is to remediate it so that it will carry out its ecological functions even if it results to another landform. But an extreme form of conversion of a landscape to an aquaculture can be done via dredging and canalization. This means areas that had been cleared and sand filled could be opened up again to be interconnected with the river, so that it will gradually become alive and revert to its original form [11]. This will however, take 10—20 years to stabilize. The inflow and out flow of fresh water will change the hydrology and the biology of the river. The area can be strictly protected against further anthropogenic activities to allow for evolutionary forces to change the restored environment. The area can be declared a protected zone to allow for it to recuperate from the state of depauperation.

6.1 Case study: seedling recruitment experiment

Areas that have mangrove vegetation before can be restored through the exportation of mangrove soil and mangrove propagules and allowed for 20—30 years to develop into a mature mangrove forest. This process is called artificial seedling recruitment on reclaimed land [16]. In a natural seedling recruitment, after a disturbance event the first set of species that settle and colonize an area are the pioneer species. They gradually occupy the area through seedling recruitment process. In a classical case of land recuperation after landscape reclamation at Eagle Island in the Niger Delta, recruitment occurred through natural process within a space of 1–3 years. In 2014, an area measuring 100 m × 50 m was dredged and sand filled. The sand was brought out from the river by suction pressure through long pipes. The sand filled area became the dumping ground for sand, where trucks evacuated the sand to buyers. The side of the sand filled area was piled up to form balkanization against the inflow of river water. The sand mining activity was abandoned after 2 years of operation. In the course of this period a small outlet was created by the side of the sand filled area, which allowed the entry of river water into the sand filled area during high tide. Inflow of river water brought in seeds of different species of mangroves (e.g. red, white and black mangroves) and seeds of nipa palm and *Heritiera littoralis*. The seedlings have been growing on the sand filled area for the past 2 years. The plants growing on the sand fill area are between 0.5 m and 1.0 m tall. A field observation made indicates that seeds at the end of the sand filled area had better growth than seeds at the mouth of the entrance of the balkanized sand. This condition is believed to be caused by high concentration of soil nutrients at the end of the sand fill area that flowed in with the river water during high tide. Growth may also be facilitated by the absorption of soil nutrients embedded in the first layer of soil brought in by tides. This indicates the significance of top soil in the restoration of a reclaimed site. This is a natural ecological restoration. It is a regular progress or change by plant and animal due to natural or anthropogenic disturbances. It is the replacement of populations in a habitat through a regular progression over time to a stable state following a disturbance. In a preliminary study conducted in the sand dredged area, soil samples were collected for physico-chemical analysis at three sites (T1, T2 and T3) from the back of the sand filled area to the entrance of the sand fill area (**Figure 8**). Furthermore, census of species found in the area was made at the three study sites. The results of the physico-chemical analysis and the species abundance test were derived as shown in **Figure 9**. The result indicates that Potassium and magnesium had the highest concentration. Although they were not significantly different from each site ($F_{2,\ 12} = 0.19$, $P = 0.83$). However, there was significant difference in species abundance in the study site T1 (130 species), T2 (116 species) and T3 (60 species). The most dominant species found was white mangroves (*Laguncularia racemosa*) (108) followed by red mangroves (*Rhizophora racemosa*) (104), black mangroves (*Avicennia germinans*) (77) and nipa palm (*Nypa fruticans*) (17). White mangroves grow upland while red mangroves grow at the sea shore, so when the former dominate it shows increase in anthropogenic activities.

The next kind of management is human management [19]. It involves human beings because they are the ones that cause problems for biodiversity. It is a system where plants and animals have advantage in reserved area. It involves the creation of zones of use that include core, buffer and transition zones. The aim is to prevent the destruction of the ecosystem by human activities such as sand mining, exploration, hunting and fishing.

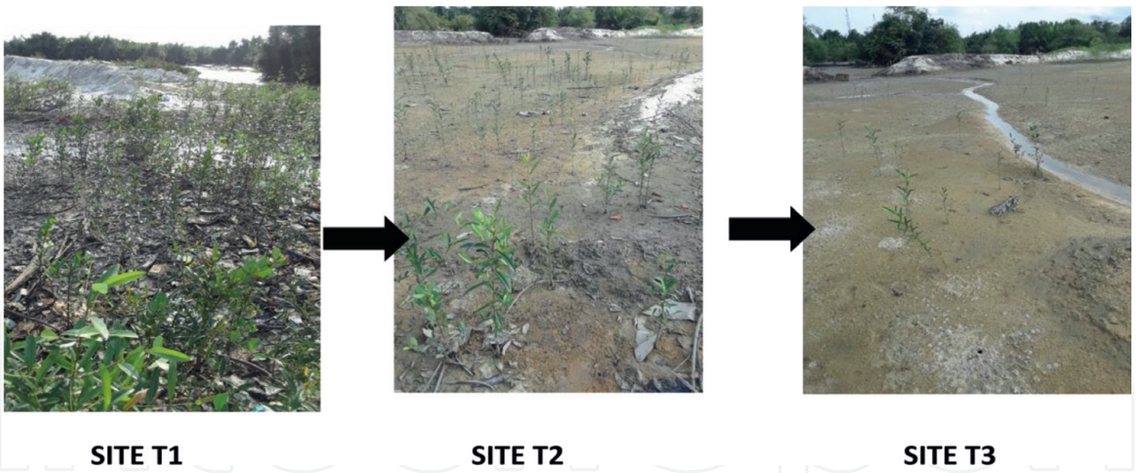

Figure 8.
Experimental design of recruitment experiment in a sand dredged mangrove forest at Eagle Island in the Niger Delta, Nigeria. Sites T1, T2 and T3 are the end, middle and mouth of the sand fill area.

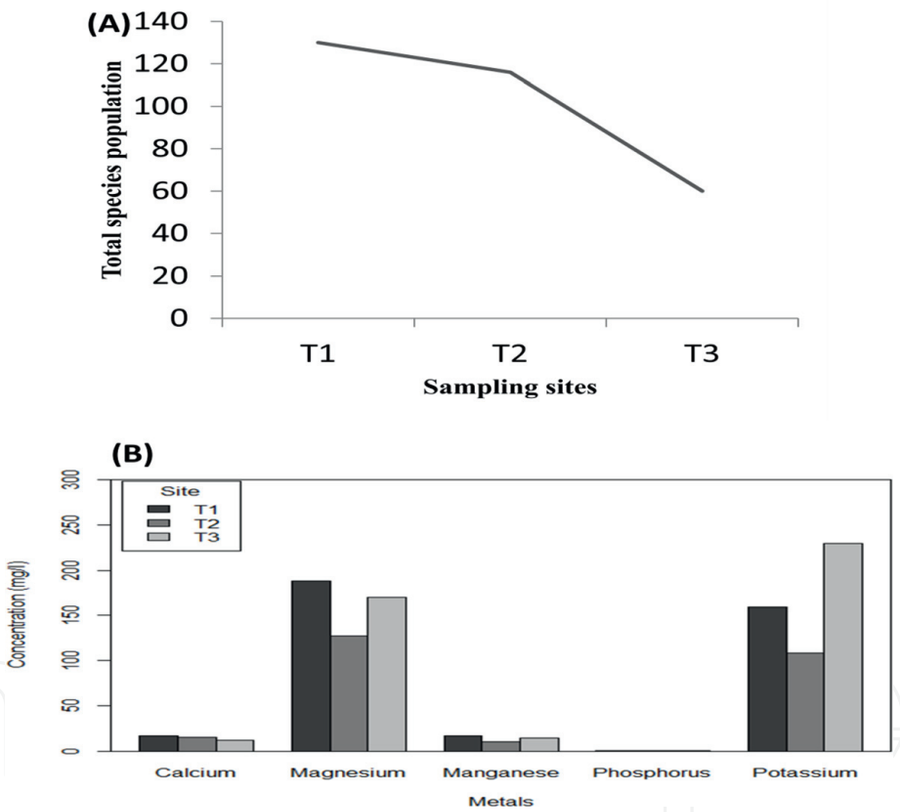

Figure 9.
(A) Graph of species population along sampling points (T1, T2 and T3) indicates a decrease in number of species from point T1 (high nutrient content) to point T3 (low nutrient content); and (B) graph of concentration of physico-chemicals along within sites T1, T2 and T3.

7. Ecosystem management

Together the system of management is called ecosystem management, which is a way of managing reserve to benefit biodiversity and people. It is a strategy for protecting or restoring the function, structure and species composition of an ecosystem while providing for its sustainable socioeconomic use. The method is a natural recovery and a passive method of accomplishing restoration. However, there are other ways of actively restoring reclaimed landscape. They include:

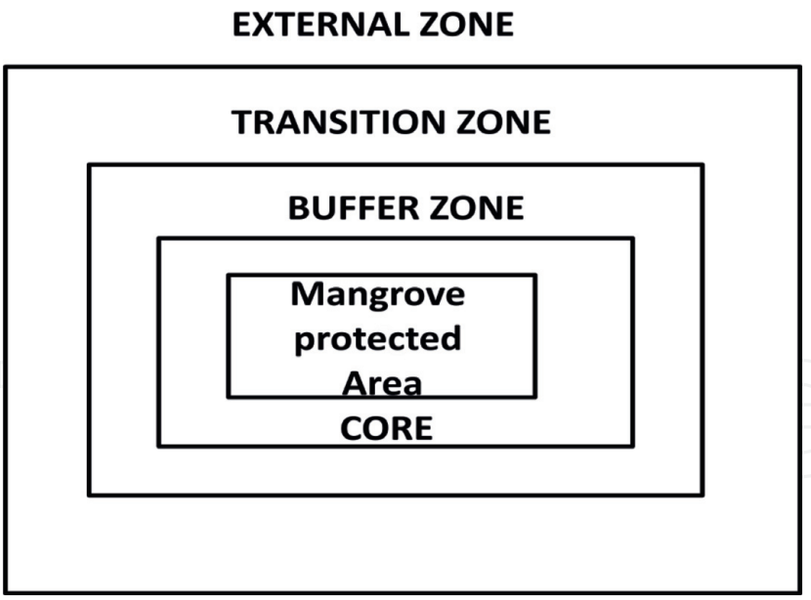

Figure 10.
A proposed mangrove protect ted area design where no exploration, exploitation or reclamation activity will occur in the Niger Delta, Nigeria.

1. *Replacement*: instead of going back to the original, which is impossible, it involves taking it to a different direction to create a replacement. We basically try to establish new habitat type because we cannot establish historic ecosystem. For instance, oil field that is established in mangrove swamp. Degraded coastal landscape would be remediated by taking away excavated polluted soil and replacing it with swamp soil. The water channel has to be set up to facilitate interconnectivity. The restoration of tidal force, edaphic factors and climatic effect will encourage natural recruitment of seedlings. The colonization of pioneer species will accelerate the establishment of other successional stages (e.g. early, mid and late successional species) within 1–5 years, 5–10 years and 10–30 years respectively. Another example is the replacement of invasive nipa palm forest with native mangrove forests.

2. *Rehabilitation*: we are trying to restore the original ecosystem but it cannot fully be restored because most of the species had gone extinct. An example is a construction project such as the installation of infrastructure on reclaimed coastal areas e.g. sea-side resort, roads, houses, light poles and shopping malls.

3. *Restoration*: it is the attempt to fully restore the original ecosystem. An example is a nipa palm invaded area. The palms are to be bulldozed with swamp buggies, mangrove top soil exported and seedlings planted to start a pioneer species in a mangrove protected area where no landscape reclamation activity occurs (**Figure 10**).

8. Conclusion

Landscape reclamation is used to remediate polluted and devastated area in many parts of the world such as abandoned coal mine, crude oil exploration site and abandoned aquaculture. But in the Niger Delta landscape reclamation is used to convert coastal areas to terrestrial areas. Two major activities that devastate coastal areas are sand mining and off-shore dredging. Sand mining is a thriving business in this area, which is done without proper environmental impact assessment or

feasibility study. Continuous mining leads to the deformation of the coast lines and the destruction of aquatic organisms, which results in extinction of species. Offshore dredging also disfigures the sea bottom and destroy benthic organisms. Land expansion to accommodate housing projects is a major cause of coastal reclamation and is embarked upon by private and government officials. The suggested solution to revert an already devastated area is by applying natural and human mediated ecological principles to facilitate land and coastal recovery [20].

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