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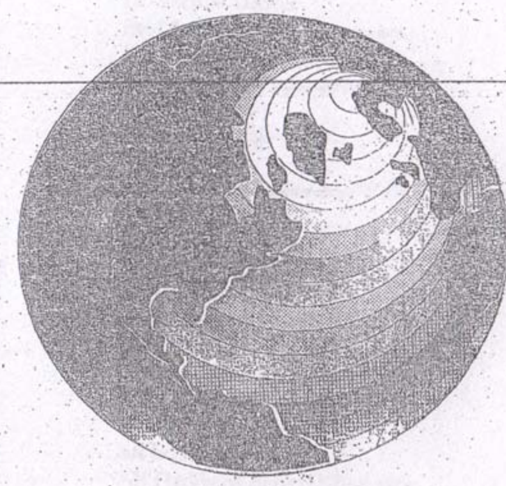

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ECOLOGICAL ECONOMICS OF MANGROVE FOREST IN NIGERIA

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LEAD PAPER: SUB-THEME 6

Introduction

The mangrove forest is a forest biome in the tropical and subtropical coastal intertidal zone predominated by a group of halophytic trees and shrubs commonly referred to as mangroves.

Mangroves are various large and extensive types of trees and shrubs of the genus Rhizophora, which grow in saline coastal sediment habitats in the tropics and subtropics. Mangroves which are also called halophytes are adapted to life in harsh coastal conditions. They contain a complex salt filtration system and complex root system to cope with salt water immersion and wave action. They are adapted to the low oxygen (anoxic) conditions of waterlogged mud (Wikipedia, 2016a).

Mangroves live life on the edge. With one foot on land and one in the sea, these botanical amphibians occupy a zone of desiccating heat, choking mud, and salt levels that would kill an ordinary plant within hours (National Geographic, 2007).

There are several species of mangrove trees found all over the world. Some prefer more salinity, while others like to be very close to a large fresh water source (such as a river). Some prefer areas that are sheltered from waves. Some species have their roots covered with sea water every day during high tide. Others are more sensitive to salinity, and grow closer to the shore. Other species grow on dry land, but are still part of the ecosystem.

As a group, mangroves can't be defined too closely, thus Wikipedia (Ibid) observed that about 110 species are considered "mangroves", in the sense of being a tree that grows in such a saline swamp, though only a few are from the mangrove plant genus, *Rhizophora*. National Geographic (2007) however identified 70 species of Mangroves from two dozen families comprising palm, hibiscus, holly, plumbago, acanthus, legumes, and myrtle. They range from prostrate shrubs to 200-foot-high (60 meters) timber trees, while NOAA (2014) identified 80 species of Mangroves.

The arguably controversial number of identified Mangroves notwithstanding, one thing the Mangroves share in common wherever they live, is that they are brilliant adapters. Each mangrove has an ultrafiltration system to keep much of the salt out and a complex root system that allows it to survive in the intertidal zone. Some have snorkel-like roots called pneumatophores that stick out of the mud to help them take in air; others use prop roots or buttresses to keep their trunks upright in the soft sediments at tide's edge. The plants' interlocking roots stop riverborne sediments from coursing out to sea, and their trunks and branches serve as a palisade that diminishes the erosive power of waves.

It is also worthy of note that a given mangrove swamp typically features only a small number of tree species. For example, It is not uncommon for a mangrove forest in a region (Niger Delta) to feature only three or four tree species. This is not to say however that mangrove forests lack diversity. Though the trees themselves are few in species, the ecosystem that these trees create provides a home (habitat) for a great variety of other organisms.

The mangrove biome, or mangal, is a distinct saline woodland or shrubland habitat characterized by depositional coastal environments, where fine sediments (often with high organic content) collect in areas protected from high-energy wave action. The saline conditions tolerated by various mangrove species range from brackish water, through pure seawater (30 to 40 ppt [parts per thousand]), to water concentrated by evaporation to over twice the salinity of ocean seawater (up to 90 ppt) (Wikipedia,Ibid.).

Mangrove forests are particularly found in tropical and subtropical regions within 30^0 of the equator. These tidal areas, such as estuaries and marine shorelines, are frequently inundated with salt water. Mangrove forests occupy about 15.2 million hectares of tropical coast worldwide: across Africa, Australia, Asia and America (Wetlands International, 2014).

Many mangrove forests can be recognized by their dense tangle of prop roots that make the trees appear to be standing on stilts above the water. This tangle of roots allows the trees to handle the daily rise and fall of tides, which means that most mangroves get flooded at least twice per day. The roots also slow the movement of tidal waters, causing sediments to settle out of the water and build up the muddy bottom.

Mangrove forests stabilize the coastline, reducing erosion from storm surges, currents, waves, and tides. The intricate root system of mangroves also makes these forests attractive to fish and other organisms seeking food and shelter from predators (NOAA, 2014).

At the intersection of land and sea, mangrove forests support a wealth of life, from starfish to people, and may be more important to the health of the planet than we ever realized (National Geographic, 2007).

The mangrove forests are among the most productive and biologically complex ecosystems on Earth. Birds roost in the canopy, shellfish attach themselves to the roots, and snakes and crocodiles come to hunt. Mangroves provide nursery grounds for fish; a food source for monkeys, deer, tree-climbing crabs, even kangaroos; and a nectar source for bats and honeybees.

Once established, mangrove roots provide an oyster habitat and slow water flow, thereby enhancing sediment deposition in areas where it is already occurring. The fine, anoxic sediments under mangroves act as sinks for a variety of heavy (trace) metals which colloidal particles in the sediments have scavenged from the water. Mangrove removal disturbs these underlying sediments, often creating problems of trace metal contamination of seawater and biota.

Mangrove swamps protect coastal areas from erosion, storm surge (especially during hurricanes), and tsunamis. The mangroves' massive root systems are efficient at dissipating wave energy. Likewise, they slow down tidal water enough so its sediment is deposited as the tide comes in, leaving all except fine particles when the tide ebbs. In this way, mangroves build their own environments. Because of the uniqueness of mangrove ecosystems and the protection against erosion they provide, they are often the object of conservation programs, including national biodiversity action plans.

The unique ecosystem found in the intricate mesh of mangrove roots offers a quiet marine region for young organisms. In areas where roots are permanently submerged, the organisms they host include algae, barnacles, oysters, sponges, and bryozoans, which all require a hard surface for anchoring while they filter feed. Shrimps and mud lobsters use the muddy bottoms as their home.https://en.wikipedia.org/wiki/Mangrove-cite_note-13. Mangrove crabs munch on the mangrove leaves, adding nutritients to the mangal muds for other bottom feeders. In at least some cases, export of carbon fixed in mangroves is important in coastal food webs.

The mangrove forest of Nigeria is the third largest in the world and the largest in Africa. The Mangrove forest extends from Badagry in the West to Calabar in the East covering a total area of 10,000km along the coast. Defined by regular saltwater inundation, the mangroves form a vegetation band of 15 to 45km wide paralled to the coast. The mangrove region is widest on the sides of the Niger Delta 35-45km and narrows towards the centre to a width of 15km except for the channel of the Brass River, which has extensive mangroves far upstream (Abere and Ekeke 2011). The two major mangrove species found in the coastal states are the Red mangrove (*Rhizophora racemosa*) and White mangrove (*Avicennia spp.*) (Bioresources Development and Conservation Programme, 2014). Over 60% of these mangroves or 6,000 square kilometers is found in the Niger-Delta. Mangrove forest grows along the coast and delta areas of Nigeria.

Mangroves are found in all coastal states of Nigeria namely: Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Lagos, Ogun, Ondo, and River States. The area is generally referred to as the Niger Delta and which is also the oil-producing area of Nigeria.

The most striking feature of the mangrove forests of Nigeria is the zonation of the dominant species more or less parallel with the shoreline, with each zone except the overlap, comprising one tree species. Zonation is related to the physiological characteristics of the different species, corresponding to the frequency and duration of tidal immersion, soil compaction, the extent of accumulation or erosion of soil and the salinity of the ground water.

The Nigerian mangrove forests which were earlier considered to be the least disturbed of the forest zones of Nigeria have now been exposed to fragmentation, deforestation and degradation as a result of efforts at developing the Niger Delta as well as oil exploration.

Despite their strategic importance, mangroves are under threat worldwide. They are sacrificed for salt pans, aquaculture ponds, housing developments, roads, port facilities, hotels, golf courses, and farms. And they die from a thousand indirect cuts: oil spills, chemical pollution, sediment overload, and disruption of their sensitive water and salinity balance. Where mangrove forests were intact, they served as natural breakwaters, dissipating the energy of the waves, mitigating property damage, perhaps saving lives.

Economic and Ecological Importance of Mangroves

Mangrove ecosystems represent natural capital capable of producing a wide range of goods and services for coastal environments and communities and society as a whole. They are unique ecosystems occurring along the sheltered inter-tidal coastlines, mudflats, riverbanks in association with the brackish water margin between land and sea in tropical and subtropical areas. They sustain diverse flora and fauna species in large proportion and provide many ecosystem services such as coastal protection from storm, reduction of shoreline and riverbank erosion, stabilizing sediments and absorption of pollutants.

Some of these outputs, such as timber, are freely exchanged in formal markets while many of the services are non-market and thus cannot be freely exchanged in formal markets. Some of these goods and services of importance include:

Marine Fisheries

Mangrove forests are home to a large variety of fish, crab, shrimp, and mollusk species. These fisheries form an essential source of food for thousands of coastal communities around the world. The forests also serve as nurseries for many fish species, including coral reef fish. A study on the Mesoamerican reef, for example, showed that there are as many as 25 times more fish of some species on reefs close to mangrove areas than in areas where mangroves have been cut down. This makes mangrove forests vitally important to coral reef and commercial fisheries as well.

Wildlife Habitat

Mangrove systems support a range of wildlife species including crocodiles, birds, tigers, deer, monkeys and honey bees.[8] Many animals find shelter either in the roots or branches of mangroves. Mangroves serve as rookeries, or nesting areas, for coastal birds such as brown pelicans and roseatespoonbills. Many migratory species depend on mangroves for part of their seasonal migrations.

Timber and plant products

Mangrove wood is resistant to rot and insects, making it extremely valuable. Many coastal and indigenous communities rely on this wood for construction material as well as for fuel. These communities also collect medicinal plants from mangrove ecosystems and use mangrove leaves as animal fodder. Recently, the forests have also been commercially harvested for pulp, wood chip, and charcoal production.

Improving Coastal Water Quality

Mangroves maintain coastal water quality by abiotic and biotic retention, removal, and cycling of nutrients, pollutants, and particulate matter from land-based sources, filtering these materials from water before they reach seaward coral reef and seagrasshabitats.[10] Mangrove root systems slow water flow, facilitating the deposition of sediment. Toxins and nutrients can be bound to sediment particles or within the molecular lattice of clay particles and are removed during sediment deposition. Compared with the expense of constructing a wastewater treatment plant, mangroves are commonly selected as receiving areas of effluent. Increasingly the notion of specifically constructed mangrove wetlands is being adopted and used for treatment of aquaculture and sewage effluents.

Mangroves are functionally linked to neighbouring coastal ecosystems. For instance, terrigenous sediments and nutrients carried by freshwater runoff are first filtered by coastal forests, then by mangrove wetlands, and finally by seagrass beds before reaching coral reefs. The existence and health of coral reefs are dependent on the buffering capacity of these shoreward ecosystems, which support the oligotrophic conditions needed by coral reefs to limit overgrowth by algae.[13] Mangroves supply nutrients to adjacent coral reef and seagrass communities, sustaining these habitats' primary production and general health.

Protection against Natural Disasters

As a result of their intricately entangled above-ground root systems, mangrove communities protect shorelines during storm events by absorbing wave energy and reducing the velocity of water passing through the root barrier. In addition, mangroves protect intertidal sediment along coastlines from eroding away in harsh weather year round.

Wave energy may be reduced by 75 per cent in the wave's passage through 200 meters of mangrove forests. Mangrove covered shorelines are less likely to erode, or will erode significantly more slowly, than unvegetated shorelines during periods of high wave energy. Other factors mangroves have an influence on, include coastal profile, water depth and bottom configuration. Furthermore, Mangroves provide a number of essentials for many different ecosystems, including food and shelter for a diverse animal community, living both below and above sea level.

Maintaining a healthy mangrove forest sustains natural protection and is less expensive than seawalls and similar erosion control structures, which can increase erosion in front of the structure and at adjacent properties due to coastal currents. The tsunami has provided an opportunity to illustrate that healthy mangroves serve as a natural barrier against massive waves – protecting infrastructure developments and saving lives. The World Conservation Union (IUCN) compared the death toll from two villages in Sri Lanka that were hit by the devastating tsunami giant waves. Two people died in the settlement with dense mangrove and scrub forest, while up to 6,000 people died in the village without similar vegetation. This study proves that mangroves provide a natural wall, which is necessary in high impact natural disasters areas such as this one (Wikipedia 2016b).

Biodiversity
Mangroves represent a rich and high diverse natural resource. Mangroves are home to many uniquely adapted biodiversity. The mangrove ecosystem plays a key role by providing the link between marine and terrestrial ecosystems. This link will provide and maintain the stability, not only to the mangrove habitats itself, but also to the other related coastal ecosystems, such as sea grass beds, coral reefs. This ecosystem plays a significant role in replenishing various fish populations for the coastal and lagoon fish industry. The nutrients given to the lagoon as a detritus from the mangrove ecosystem is carried in to the coastal waters by the tidal currents.

They become food for marine micro-organisms, which is the first step of the marine food chain. The shallow inter-tidal reaches that characterize the mangrove wetlands offer refuge and nursery grounds for juvenile fish, crabs, shrimps, and mollusks. Mangroves are also prime nesting and migratory sites for hundreds of bird species. Additionally, manatees, monkeys, fishing cats, monitor lizards, sea turtles, and mud-skipper fish use the mangrove wetlands as their habitat

Poverty Alleviation
Rural poverty persists in coastal areas and the majority of the coastal communities depend on fishing and agriculture for their livelihoods. Many mangrove resources are harvested for subsistence purposes. These include fuel-wood, aquatic products for food, shellfish species and fish species, medicinal herbs, vegetables, poles for fences, and posts. Most people are engaged in commercial activities like fishing, shrimp farming, collecting timber, vines for handicrafts and bark for tannin (traditionally in curing fishnets) (IUCN, 2006).

Siltation
The physical properties of plants in mangrove forests help in the siltation process. Siltation is closely related to the removal of toxins and water nutrients, because these materials are often bound to the sludge particles. The mangrove forest improves sea water quality through siltation.

Nutrient enhancer
The physical properties of mangrove forests tend to slow the water flow and sedimentation. Along with this deposition process occurs nutrients derived from various sources, including leaching from agricultural areas.

Fastening poison
Many toxins that enter the aquatic ecosystem are in a state bound to the surface of the mud or are in between the lattice of water molecules and soil particles. Some specific species in the mangrove forests and even help the process of actively toxic belay

Provision of In-situ and Ex-Situ Natural resources
Natural in-situ resources include all fauna and the results of mining or mineral that can be used directly in the mangrove region. While ex-situ natural resources include natural products in the mangrove forest, transported/transferred to other areas which is then used by communities in the area and a source of food for other organisms.

Transportation
In some mangrove forests, transport through water is the most efficient and most suitable to the environment.

Source of germplasm
Mangrove because of its biodiversity is a good store of Germplasm of wild life which is very beneficial both for the improvement of commercial species of animals and wildlife populations.

Recreation and tourism
Mangrove forests have aesthetic value, both from natural factors and of life in it. The mangrove forests provide different attractions with other natural attractions.

Characteristics of forests that are in transition between land and sea is unique in several respects. The tourists also get lessons on the environment directly from nature.

This tourist activities in addition to providing direct income to the manager through the sale of entrance tickets and parking, are also able to grow the economy in the surrounding community by providing employment and business opportunities, such as open food stalls, rent a boat.

Educational and research

The Mangrove is an outstanding field laboratory for research and educational activities to promote development of science and technology.

Maintain ecological processes and natural systems

Mangroves play very important roles in supporting ecological and geomorphological processes.

Carbon sequestration

The process of photosynthesis changes inorganic carbon (CO_2) into organic carbon in the form of vegetation. In most ecosystems, these materials decompose and release carbon back into the atmosphere as (CO_2). However, mangrove forests contain a large amount of organic material that does not rot. Storage of carbon in mangroves takes place through accumulation in living biomass and through burial in sediment deposits. With living biomass typically ranging between 100-400 tonnes/ha, and significant quantities of organic matter being stored in the sediments, mangroves rival the sequestration potential of rainforests. Therefore, more mangrove forests serve as carbon sink than a source of carbon.

Economic Valuation of Mangrove Forests' Goods and Services

The standard framework for understanding the economic costs and benefits or the economic value of ecosystems is called the Total Economic Value (TEV). The TEV highlights the multidimensional nature of economic value of any ecosystem, which ranges far beyond direct use values but encompasses indirect use values, option values and non-use values. In this sense, TEV presents a more complete picture of the economic importance of ecosystems and also clearly demonstrates the high and wide-ranging economic costs associated with their degradation, which extend far beyond the loss of direct use values (IUCN 2006a).

However, understanding the economic costs and benefits or the economic value of Mangrove forests requires a primary consideration of the following:

1) What are the direct values of different mangrove goods (e.g. fuel wood, shrimp and fish)?
2) What are the indirect values of different mangrove ecosystem services (e.g. coastal protection and breeding grounds)?
3) What would be the economic and livelihood impact over time of continued mangrove loss?
4) How, overall, are the economic and financial benefits of different mangrove goods and services distributed between different beneficiaries (e.g. Local communities, Provincial economy, National economy, Global community)?
5) What is the overall economic efficiency of various competing uses of mangroves?
6) What is the economic rationale for mangrove rehabilitation and management?
7) How to allocate mangrove resources to improve human welfare? (IUCN, 2006b)

Use values and non-use values

Mangroves are rich ecosystems, capable of providing a range of goods and services of use to human populations. The value of these goods and services represent use values. The use values can be classified as direct and indirect use values. The direct use which could be consumptive or non-consumptive, has to do with the direct use orinteraction with a wetland's resources and services" Examples of such direct use valuesare plentiful and include, among others, wood from mangroves used as fuelwood, and for building purposes, fish and crabs caught in the waterways running through mangroves, nipaleaves for construction (roofing and walling), other products derived from nipapalms such as alcohol and vinegar, and traditional medicines derived from plants and other species found in mangrove ecosystems.

Indirect use values stem from "the indirect support and protection given to economic activity and property by the wetland's natural functions, or regulatory 'environmental' services". The classic example of an indirect use value of mangrove ecosystems is the support provided to off-site fisheries through their nursery function. Another is the protection provided against weather-related damage to productive activities located in or just behind mangrove ecosystems (aquaculture, agriculture) and to assets such as housing and infrastructure located inland. Other indirect support to economic activities include habitat provision, nutrient recycling, water purification, and flood control.

Non-use values, on the other hand, are derived "neither from current direct or indirect use of the wetland". Non-use values may arise, for example, from the satisfaction an individual derives from knowing that mangroves continue to exist, but is not necessarily planning to use them(sometimes referred to as existence value). Another possible motive of non-use value is the desire to preserve mangrove ecosystems for future generations (bequest value).

Option values

Option values of mangrove ecosystems refer to an individual's Willingness To Pay (WTP) to preserve the option of using a good in the future. Although it seems intuitively clear that OV would be positive for risk averse individuals, closer analysis has shown that this is not necessarily the case. OV can be either negative, zero or positive, depending on the particular combination of risk aversion and the source of uncertainty (uncertaintyabout future preferences, about future income, or about future availability of the good).

Quasi-option value

Quasi-option value relates to those planning decisions where the benefits of preservation are unknown, while at the same time development is irreversible, that is, the potential benefits of preservation will be lost forever. However, with the passage of time more information on the benefits of preservation may become available. Hence, there is some value in deferring the decision whether or not to develop the resource until such time as the uncertainty about the benefits of preservation is resolved. The expected value of the increase in total benefits that can be obtained by deferring the development decision to the period when the uncertainty will be resolved is the so-called quasi-option value. It is also known as the expected value of perfect information. Quasi-option value may be a useful concept in mangrove management. Given the state of current knowledge about the nursery function, it is still extremely uncertain how these will be affected by alternative management regimes. At the same time, many think that the value (damage) of any impairment of this function might be very high. By delaying a decision, more scientific information of the effects of a loss of this function might become available, and therefore may result in better understanding for more informed decision making.

Given some prior expectation of the outcome of the delay (for example, there is a 50% probability that more information will show that there will be no damage if the function is impaired, and a 50% probability that damage will be some amount X) the expected value of the increase in total benefits that can be obtained by waiting until the information is available can be calculated. If this expected value of information is higher than the benefits forgone by not developing now, then it is optimal to wait for the decision until that moment.

A problem here is that some development might be necessary in order to be able to resolve the uncertainty. In the literature on option value this is known as dependent learning, in contrast to the case of so-called independent learning where information will become available independently of any development.

An alternative classification

More recently, another classification of wetland values has been suggested. In this approach, it is argued that the TEV is not necessarily equivalent to the Total

Environmental Value (TV) of a resource. TV includes TEV values plus other instrumental values that are not of human concern (non-anthropocentric instrumental value). Under this approach, the TV is made of three different uses of wetland ecosystem: (1) for its own development and maintenance which can refer to the build-up and self-organizing capacity of the wetland itself; (2) exports to other ecosystems; and (3) exports to human society.

Based on these different kinds of uses, a wetland's TV can be classified into two categories: 1) the primary value or 'glue value' (i.e., the value of the ecosystem's self-organizing capacity), and 2) the secondary value, which is the value of the other two uses, and can be described as the value of outputs, life-support and ecological services that the self-organizing capacity generates. In other words, the TV of a wetland ecosystem comprises the primary value which is actually a non-anthropocentric instrumental value and the secondary value which includes both anthropocentric instrumental and intrinsic values. The latter is consistent with the TEV. Even though primary value may not be directly linked to humans, it is a prior value inherent to the system's existence and continuity. Nevertheless, the value can be roughly estimated by employing damage avoidance, preventive expenditure, or replacement cost methods.

Conclusion

The destruction of mangrove ecosystems is caused mainly because of the conservation benefits of mangroves not receiving importance and the little understanding of the role mangroves play for sustenance of other economic systems. This has led to mangroves being considered as wastelands with little use, and no value.

A good understanding of the Total Economic value of the Mangrove forest is therefore essential to inform and encourage policy makers in taking favourable and appropriate decision for sustainable development of Mangrove forest

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