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Coastal Biodiversity, Sustainable Livelihood and Ecological Scenarios in Marine Wetland of Asarama Andoni in Parts of Eastern Niger Delta Nigeria

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Abstract
Wetland ecosystems are very important natural environmental resource that forms part of the total wealth of a nation. The Asarama wetland in Andoni is amongst the important wetlands in coastal marine cosystems of the Niger Delta; fascinated by diverse rich biodiversity, wetland ecotypes of mangrove, mudflat, Nypa, estuary and fresh water forest habitats with range of critical ecosystem services they provide for mankind survival. The data gathering involved both primary and secondary sources of information. Result revealed diverse ecological scenarios: a livelihood system with diverse level of significant sources and benefit of the ecosystem services. Food, aquacultural practices and sea route logistic component of livelihood benefit from sources recorded significant (HS- 4) level of provisioning services, breeding / nursery benefit with high significant (HS- 4) level of supporting services among other levels recorded in Table 1. Ecological challenges revealed nypa palm invasion of the mangrove ecotypes and uncertainty of climatic relationship to hydrological tidal regime as natural scenarios; economic, social, institutional and infrastructural challenges as anthropogenic scenarios. Therefore a policy framework (legislature) as part of future directive and initiatives to enforce the practice of biodiversity priorities and sustainable livelihood is of immediate importance to Asarama - Andoni wetlands ecosystem.
Keywords: Likert scale, provisioning, cultural, regulatory, supporting, natural, anthropogenic.
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INTRODUCTION

The Asarama in Andoni is among the localities at the eastern fringes of shorelines in Rivers State. It is localized among the Islands of Andoni, physiographically crisscrossed by network of wetlands including estuaries, sand beaches, nypa palm habitat, mud flat, marshy land, creeks and creeklets, rivers and rivulets, often inundated under the influence of tidal hydrological dynamics of salt water from the Atlantic coast (Nsirim *et al*.,2020). Wetlands by the Ramser Convention (RCS, 2010a) encompass a broader range of ecosystems than is often realized, and by the Article 1.1 of the Convention they include variety of habitats such as areas of marsh, fen, peat lands, floodplains, rivers, and lakes, and coastal areas such as salt marshes, mangroves, and sea grass beds, as well as coral reefs and other marine areas of water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, in which the depth at low tide does not exceed six metres. Man made waste-water treatment ponds and reservoirs are also included in the catalogue of wetlands by the Ramser protocol. Wetland ecosystems are also part of the important landscape with major unique features of natural environmental resources in the wealth of a nation, particularly in parts of the earth with coastal and littoral physiognomy and ecology (Nsirim *et al*., 2020). The unique feature of wetlands is the fascinating rich biodiversity adapted to specific hydrological regimes and dynamics with range of critical ecosystem services they provide for sustainable utilization and livelihood to mankind (Anjan *et al*., 2017).

The concept of biodiversity across its trend of chronology to the era of the Rio de Janeiro Brazilian adoption and declaration of Agenda 21 at the Convention on Biological Diversity (CBD) has been highlighted in McNeely and Scherr, (2001). Biodiversity describes the degree of variety and variability within and among natural (plant, animals and micro organism) their genetic make up and variation as well as variation in the ecological processes of the ecosystem. Biological diversity can be measured in terms of different components (landscapes, ecosystems, communities, species / populations and genes), each of which has structural, compositional and functional attributes (Sandy *et al*., 2001). Similarly, it can be described. Simply put, as the diversity of life forms on Earth, the places they inhabit, and the ecological interaction between them. The position of Niger Delta as earlier X-rayed in Ajibola *et al*. (2015) and Edwin-Wosu *et al*. (2017) may not need over emphases. However, it is among the well endowed resourceful ecological zones on earth with largest

expanse of mangrove stand in Africa and the 5th among the 10 largest mangrove stand globally (Spalding *et al*., 2010; Ajibola *et al*., 2015). Geopolitically, Niger Delta covers the south-south zone and ecologically the true Deltans of Rivers, Bayelsa and Delta States in Nigeria (Fig. 1). The region is christened a "double edge sword" hence a hydrocarbon hub and nerve centre of the Nation's source of economic wealth and concurrently with regional environmental predicament due to unfavourable and unsustainable approach to the mineral resource exploration and exploitation (Edwin-Wosu and Elenwo, 2006; Ajibola *et al*., 2015). It is an incredibly enriched wetland biome with its ecosystem supporting services across all levels of livelihood endeavours. A livelihood entails capabilities, assets and activities required for a means of living. It is sustainable when it is resilience, recover from and cope with any form of stress and shocks while maintaining or enhancing its capabilities and assets without compromising the future, and not undermining the natural resource base (DFID, 2014). The 3rd Ramsar Conference of the Contracting Parties (COP3, 1987) defined the wise use of wetlands as:" their sustainable utilisation for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem." Also COP3 also defined "sustainable utilisation" as: "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations (RCS, 2010a).

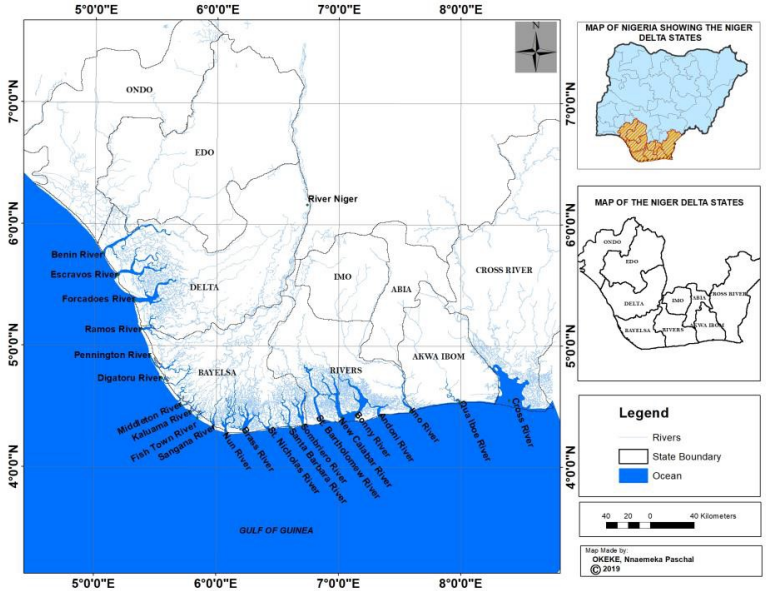


Fig. 1: Niger Delta indicating the various regions

Some available documented reports in parts of Niger Delta wetlands dealing with mangal ecosystem and biodiversity for conservation priorities and sustainable livelihood include: Dirisu *et al*. (2019) on plankton diversity and community structure of Asarama estuary in the Niger Delta; Edu *et al*. (2015) on bio-monitoring of mangal sediments and tissues for heavy metal accumulation in the mangrove forest of Cross River estuary; Edu *et al*. (2015) on evaluation of bioactive compounds in mangrove; Edu *et al*. (2014) on carbon credit assessment in a mixed mangrove forest vegetation of Cross River estuary; and Edu *et al*. (2014) on monitoring and assessment of leaf litter dynamics in a mixed mangal forest of Cross River estuary. Other related documented studies on parts of Niger Delta biodiversity include: Ecological and Sustainable Livelihoods Assessment of Project Communities in the Nigeria's Niger Delta (John *et al*., 2013), the development of Sustainable Livelihoods and Biodiversity Project (SLBP) communities' operational plans in the Niger Delta, Nigeria (Anthony and Adeleke, 2014), assessment and valuation of wetland ecosystem services in the Niger Delta, Nigeria (Ajibola *et al*., 2015), assessing wetland degradation and loss of ecosystem services in the Niger Delta, Nigeria (Ayansina and Ulrike, 2015), using GIS techniques in delineating mangroves sites of conservation interest in Asarama area, Eastern part of Niger Delta (John *et al*., 2016) and use of Pleiades high-resolution imagery for delineation of selected site of mangrove and Nypa in Asarama (Onwuteaka, 2014) for biodiversity conservation among others. Thence on the foregoing, this informed the need for a more understanding of the biodiversity complex of Asarama wetland ecosystem. Hence this study aims to evaluate the sustainable livelihood opportunities of the wetland biodiversity; with the objectives of documenting the ecological scenarios associated with the wetland ecosystem of the area, its future directions and initiatives for sustainable development planning and restoring wetland biodiversity for conservation priorities.

2.0. MATERIALS AND METHODS

2.1. Study area, location and site

The Andoni study area located in Rivers State, is situated within the coordinates Lat. 4° 18'0"N to 4°38'30"N and Long. 7°14'0'E to 7° 34'30"E (Fig. 2). The area comprises nine major autonomous communities / towns including **Asarama - study location.** All of these localities are situated across four major Islands of the ecological zone. The Asarama study location with its geographical situate between Lat. 4o30'30"N to 4o36'0"N and Long. 7o22'0"E to 7o27'30"E of Rivers State (Fig. 3) has two common communities (Ataijong and Amaubong) as sampled sites (Fig.4) characterized with semi-diurnal tidal estuary system. The study sites have common boundaries at the eastern fringe linking the Andoni coastal communities with Ogoni hinterland region and also a common shoreline boundary at the southern flank; as well characterized by physiognomic features of wetlands flora and edaphic landscapes (Nsirim *et al.* 2020; John *et al.* 2016)

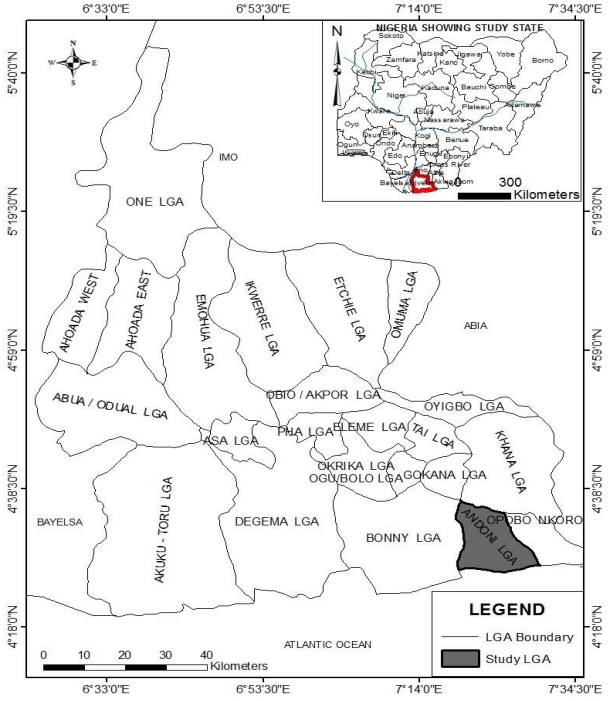


Fig. 2: Rivers State indicating the study area – Andoni LGA

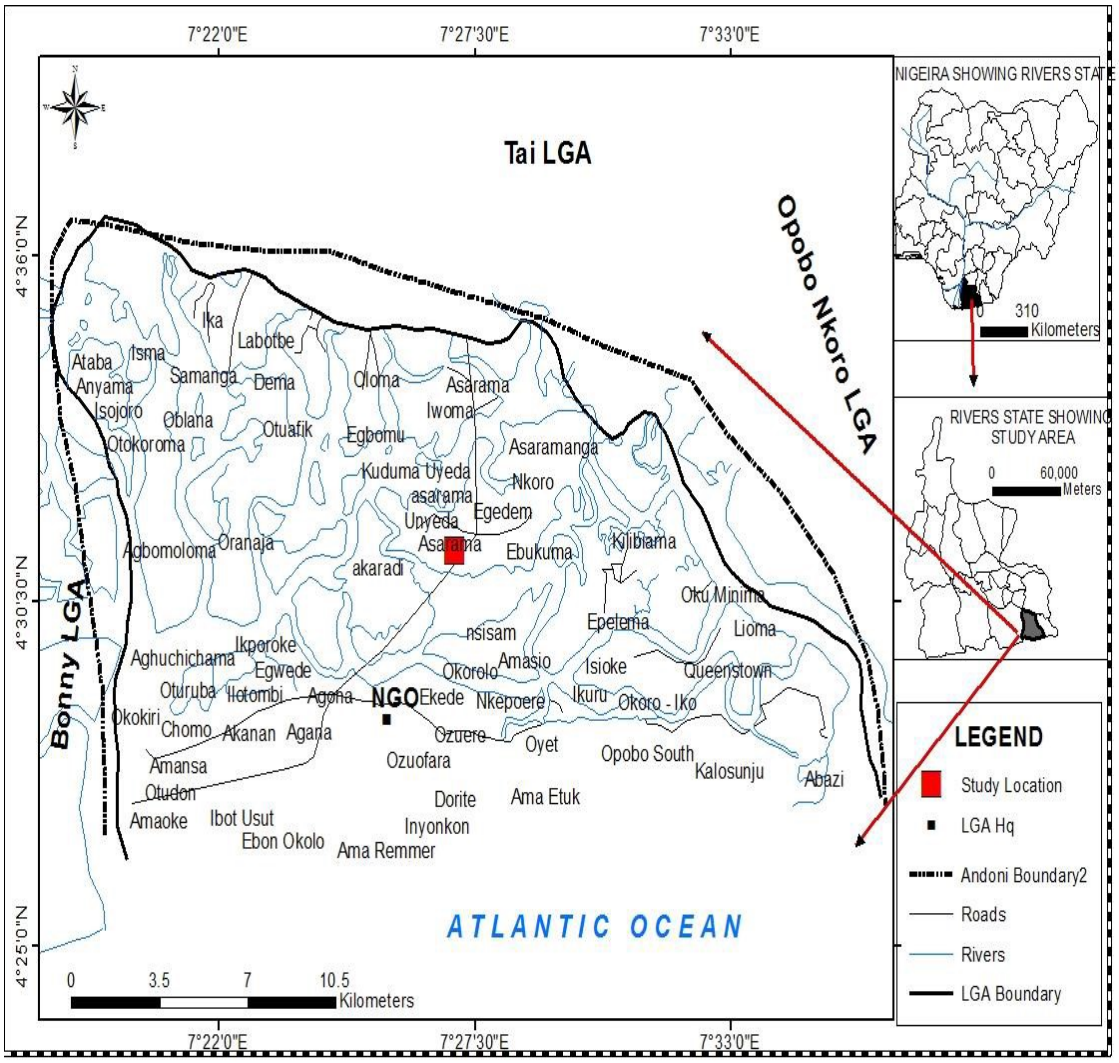


Fig. 3: Andoni indicating study location- Asarama Town

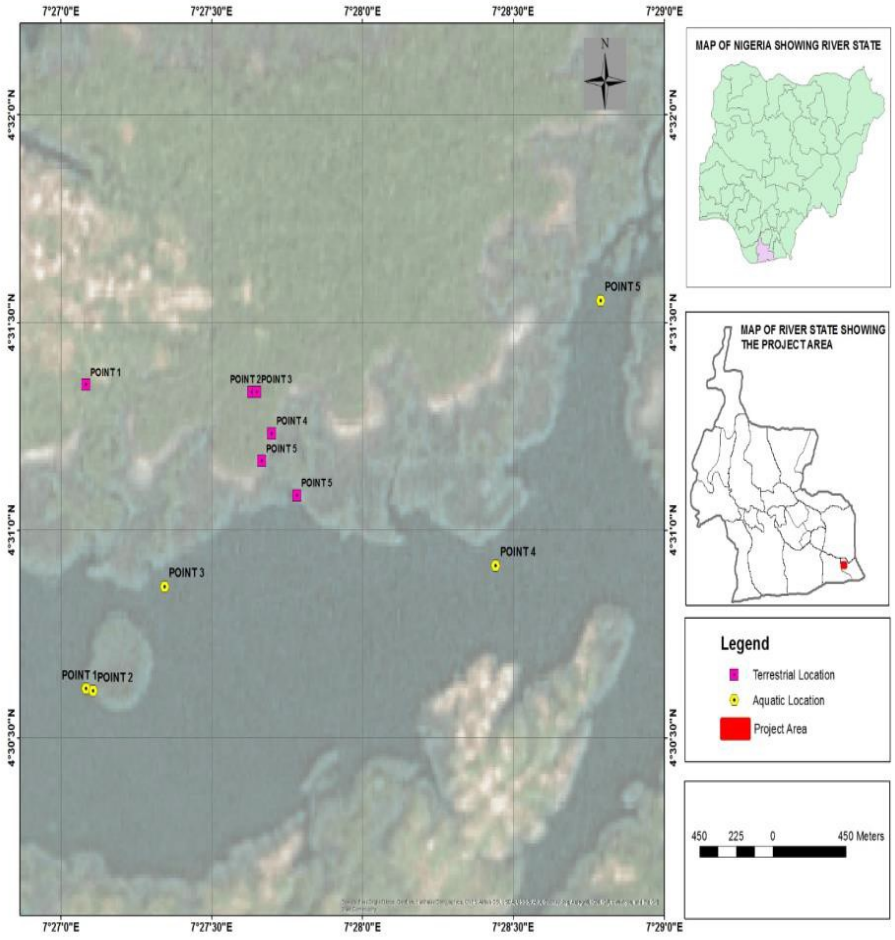


Fig. 4: Satellite imagery of sampled sites at Ataijong and Amaubong in Asarama

2.2. Field data collection

The field assessment for data gathering adopted both primary and secondary sources of information involving descriptive and exploratorative approach of literature review as primary source. The secondary source involved explanatory approach based on Participatory Rapid Appraisal (PRA) with the use of semi structured interviews / discussions, focused group discussions, key informant interviews, and ground-truthing) adopted in the study. The ground-truthing was adopted to validate the sampled site using a hand-held Garmin geographic positioning system (GPS - *Garmin Dakota 10 model*) for georeferencing of exact sampled point (Fig.4) and imagery production of the sampled location.

3.0. RESULT AND DISCUSSION

1. Ecological scenarios*:*

The ecological complexes in which variety of life forms exist are the intricate and inter dependent relationships that often occur among co-existing organisms, including on going ecosystem processes in either terrestrial or aquatic environment. Based on the various phases of information sources some levels of ecological scenarios as exemplified in the relative interaction between the community livelihood and ecosystem services of the wetlands in Asarama was recorded. Diverse interconnected food chains and food webs create an ecological balance in nature (Ndukwu, 2012). Such ecological scenario was expressed in the livelihood sources and benefits. Similarly were also challenging scenarios as a result of diverse ecological demand on the wetland resources by the community livelihood systems. Thus diverse ecological scenarios may threaten the existing ecological balance of nature leading to direct or indirect potential loss to humans (Ndukwu, 2012).

i. *Livelihood systems.*

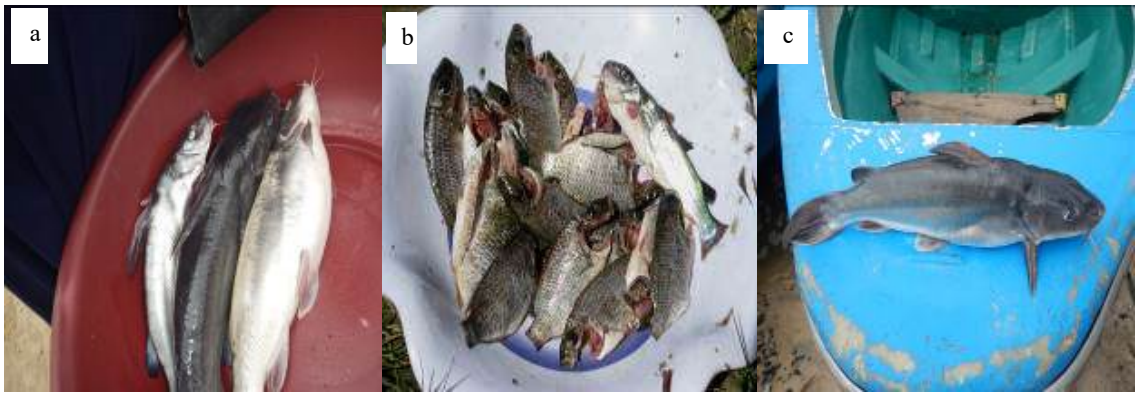
The PRA based on the 4-point Likert scale (Ifeanyi-Obi and Mathew-Njoku, 2014) has revealed different levels of significance in livelihood sources and benefits of the ecosystem services (Table 1) among members of the Asarama community. Key informant information revealed major livelihood of members of the communities to be fishing with the craftsmanship of fish nets, gears and fish traps as well as fish farming and the picking of periwinkle, crab and lobster (Figs. 5a-c, 6a-c, & 7a-d).

Artisanal fishing such as aquaculture and / or mariculture of Oysters (*Castrostrea* sp) and Periwinkles (*Tympanotonus fuscatus v*ar. *Radular*) was predominantly the main traditional occupation of the people mainly occupied by men and women folks. Similar report (WIA, 2015) has recorded percentage proportion of male (50%) and female (30%) been accounted for in the fishing and aquaculture business. Though the fishing is a major occupation; information gained revealed that such production is at subsistence level for domestic consumption, despite high consumption and low income rate among members.

Table 1: Livelihood Benefit of Wetland Ecosystem Services in Asarama, Andoni

Ecosystem services	Livelihood benefit	Livelihood sources	Linkert scale of significance
Provisioning	Trading	Logging / Timber merchandising, Fishing net / gear making & selling,	3 3
		Dugout wooden boat building	2
	Fuel / Energy	Firewood, peat, logs	3
	Food	Aquaculture and /or mariculture in fishing, oyesters and periwinkle, crab and lobster picking	4
	Aquaculture practices	Periwinkle, Snail, clamps, bivalves	4
	Sea route logistic	Boat transport, wooden boat	4
	Hunting	Wild life	2
Regulating	Shore line embankment / protection	Protection of coastal settlement and structures	2
	Climate regulation	Sink for green house gases and particulate, carbon soot from the local refining activities, influence local & regional temperature, precipitation and other climatic processes.	3
	Erosion & flood control	Retention of soil and sediments, stabilization of shore line substrate	3
Sociocultural	Educational	Teaching and research study	2
	Spiritual inspiration	Sacred grove	3
	Recreation	Masquerade dance and boat race	3
	Burial	Mortal disposal	2
Supporting	Habitat	Aquatic lives, wild lifes, & insects	3
	Pollination	Insect pollinators	2
	Breeding / nursery	shrimp, crab, fish, crustaceans, mollusks	4
	Soil formation	Sediment retention and accumulation of organic matter soil – Chikoko.	3

Note: Level of significance in study communities (using the Linkert scale; 1- non significant (NS-1), 2- least significant (LS-2), 3- significant (S-3), 4- highly significant (HS-4))



Figs. 5a, b, c: Fish produce from the Asarama wetland
a, c = Silver catfish (*Chrysichthys nigrodigitatus*)
b = Blackchin tilapia (*Sarotherodon melanotheron*)

Figs. 6a, b, c: Artisanal aquaculture means of livelihood in the study area
a,b and c = Fence traps staked in the sediment. It is a stationary gear made of bamboo or fronds used to fish in shallow creeks, rivers and estuaries. It has an enclosed chamber with funneling entrance that allow easy entry of fishes into the chamber but prevent escape. The chamber is supported on both sides with extended funnel fences of staked woods and twigs. Facing the current, fishes follow the funnel fences until they eventually enter into the entrapping chamber. At low tide, the fencer (fisher) scoops out the entrapped fish. The device could also be used as an aquaculture enclosure.

Figs 7a, b, c, d: *Tympanotonus fuscatus* var. radula (Periwinkle) picking as means of livelihood in the study area
a = Children returning from Periwinkle gathering (picking)
b = Children sorting their gathered Periwinkles
c = A woman and a child picking Periwinkles on an expansive tidal flat.
d = Half basin of Periwinkle with a filled measuring bowl used in retailing

The result has also shown that land and sea transport system involving motor-bikes, wooden and engine boats is another livelihood source of the people (Figs. 8a-c). Study has indicated that Asarama estuary is one of the most important navigable water ways in the far reaches within Andoni land and it connects several communities therein (Dirisu *et al*., 2019). The Asarama community are engaged in subsistence level of agricultural activities in which *Musa paradisiaca* (plantain) and *Musa sapientum* (banana), *Manihot esculenta* (cassava), *Elaeis guineensis* (palm oil), vegetables such as *Telfairea occidentalis* (fluted pumpkin) *Talinium triangulare* (water leave) and*Vernonia amygdalina* (bitter leave) and root / tuber crops (*Colocasia esculenta, Xanthosoma maffafa* (Cocoyam) and *Dioscorea alata* (water yam) are among the cultivated crops in the area. This corroborates Nsirim *et al.,* 2020*;* and WIA, (2015).

Some of the rural dwellers in the area were involved in the artesianal local refining of petroleum products besides the observed oil films on water surface far upstream off the estuary at the north-western bank (Figs. 9a-c). Other livelihood sources in the area include coconut smoking, micro scale open and lock up shop trading businesses among various homes in the community. There were also civil servants, sand miners, restaurant owners, hairdressing/barbing salon, hunters, and firewood seller.

Figs. 8a, b, c: Engine and wooden boat transportation as means of livelihood in Asarama study area

Figs. 9a-d: Local artesianal Refinery facility at Asarama study site

ii. ***Wetland ecosystem services***

Wetland services prior to recent ecological and economic valuation was never considered as an index in policy decision making in several parts of the world especially in developing countries like Nigeria. This was based on past monotonous economic understanding of wetlands for infrastructural development through sand filling and sand mining or dredging (Ajibola *et al*., 2015). Presently wetlands are known for series of ecosystem services as been documented in several reports of Ramser Convention (2010a, 2010b & 2010c) with remarkable livelihood sources and benefit. It is known that the sustainable delivery of wetland ecosystem services can be related to the biotic and abiotic indicators of the ecological and biophysical functionality of the ecosystem dynamics. The Asarama wetland in *Sensu-stricto* and Niger Delta wetlands in *Sensu-lato* as corroborated in several reports of biodiversity and sustainable livelihood (John *et al*., 2013; Anthony and Adeleke, 2014; John *et al*., 2016) shows the wetland of the region as been characterized by diverse ecosystem dynamics. It is on this premise that the present study examined the ecosystem services of the wetland biodiversity, ecological scenarios associated with it and prospective initiatives for future directions. Although there are variations associated with the value derivation of ecosystem service categories, ranging from ecological values (Faber *et al*., 2002; MEA, 2003); sociocultural values (MEA, 2003) and economic values (Turner *et al*, 2003; Straton 2006). The Asarama wetland

ecosystem service is being categorized into four levels of services to livelihood sources and benefit. Beside the divergence in service levels of wetland ecosystem they are still acknowledged globally on account of convergence in services to sustainable livelihood and human welfare. Wetlands are known for diverse potential of varying services which actually depends on location, size, shape, and source of water, and other physiographic and general ecological characteristics. All these in one or more ways can determine the functionality and service delivery of wetlands. The mangal coastal marine wetland of Asarama is one of the most extensive ecosystem in Eastern Niger Delta and with it greater proportion of mangroves at the study sites provide services (Provisioning, Regulating, Sociocultural and Habitat support) for the sustainable livelihood of the community members in the area.

Provisioning services:

The Asarama wetland has recorded provisioning services including Artisanal fishing such as aquaculture and /or mariculture in Oyesters and periwinkle, crab and lobster picking and practices (Figs. 5a-c, 6a-c, & 7a-d). The provisions of food, medicines, energy and raw materials, air and water purification have been documented among wetlands (Mitsch and Gosselink 2000; Brander *et al.* 2006). At low tides between 08:263 30 and 10:00 it has been reported that local in the area engage in indiscriminate harvesting of periwinkles (Dirisu *et al*., 2019). Other than the invasive encroachment of Nypa palm thus replacing the mangroves of the Asarama wetlands, the mangrove species are massively subjected to domestic logging for fuel energy as source of livelihood to the community members (Figs. 10a-d). The trees of mangrove ecosystem contribute directly to the livelihood of most local communities by providing products such as wood fuel, thatch materials, timber logs and as well breeding ground for sea food nutrients (Nwilo, 2007).

The Asarama wetland has also provided sources of water and sea rout transport systems to other riverine areas that may have been difficult to access through land transport (Figs. 8a-c). Provision of rapid transport routes in an otherwise difficult terrain, with many urban and rural settlements has been accessible only through the wetland (Wolf *et al*. 2002). Past and current human activity in the Niger Delta, including within its Ramsar-listed wetlands, is diverse. On a local scale, timber logging, fishery and wetland farming of sugarcane, cocoyam and rice, are carried out (Alagoa and Derefaka 2002; Adekola and Mitchell 2011). The mangroves are substantial part of Ataijong and Amaubong study sites' of Asarama vegetation known to provide food and timber. The wetland mangrove are economically known for their therapeutic potentials as well as important resource of other important ecological services such as house building, furniture, transmission as well as telephone poles and certain household items (Bandaranayake, 2003; John *et al*., 2016). Similar report of wetland provisioning services has been recorded in other parts of Niger Delta like Bayelsa (Adekola *et al*., 2015).

Regulating services:

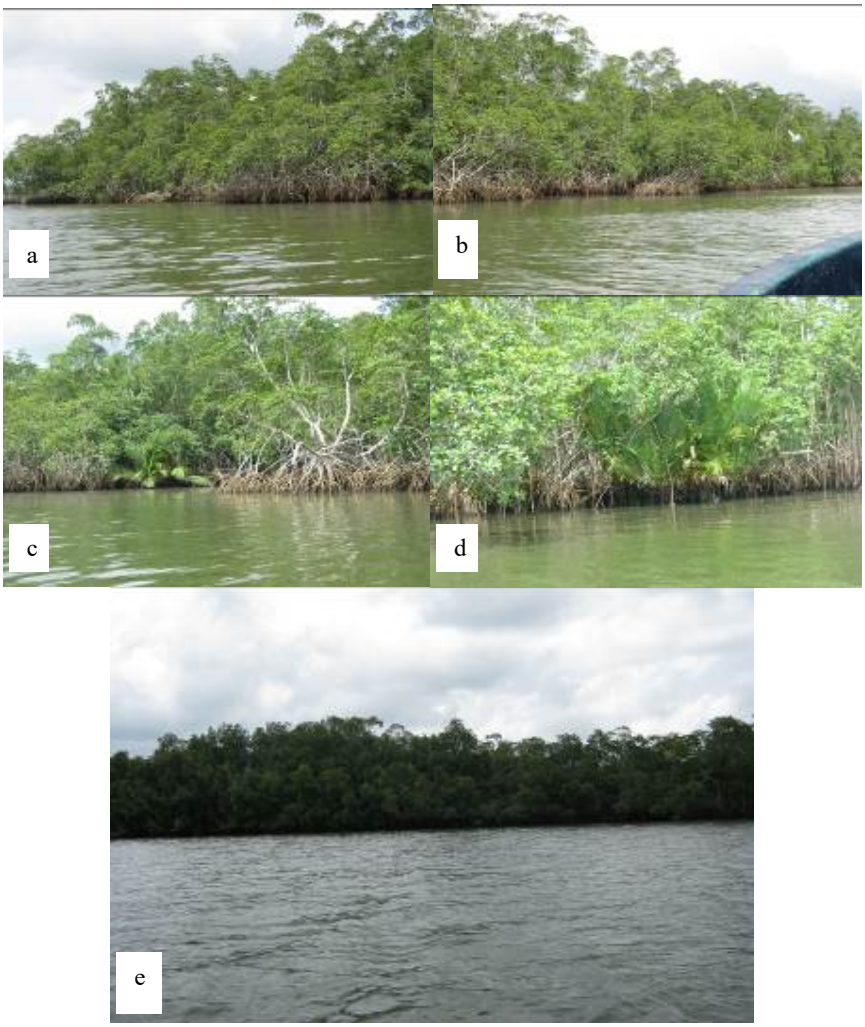
The discrete intermingling, dichotomous branching and heterogeneous continuum of intricately entangled above-ground mangrove root physiognomy has shown to proffer regulatory services of wetland in erosion control, shoreline embankment and protection as they act as barrier to wave action in parts of Asarama study location. Also aid in atmospheric regulation of pollutant release from the local refining activities. The presence of shrubs and other trees within wetland environment reduces the damaging effects of erosion on both top soil and properties near and within wetland environments (Ajibola *et al*., 2015). Wetlands help regulate climate, store surface water, control pollution and flooding, replenish aquifers, promote nutrient cycling, protect shorelines, maintain natural communities of plants and animals, regenerate soils and pollinate crops, serve as critical nursery areas, and contribute to carbon sequestration (Mitsch and Gosselink 2000; Uluocha and Okeke 2004; Brander *et al*. 2006; NRAC, 2010; Chidi and Ominigbo, 2010; Ajibola *et al*., 2015).

Figs. 10a-d: Mangrove logging for fuel energy as means of livelihood in Asarama study area. (a) Cutting of mangrove logs, (b-c) Stacked mangrove logs (d) Mangrove log transportation via local wooden canoe.

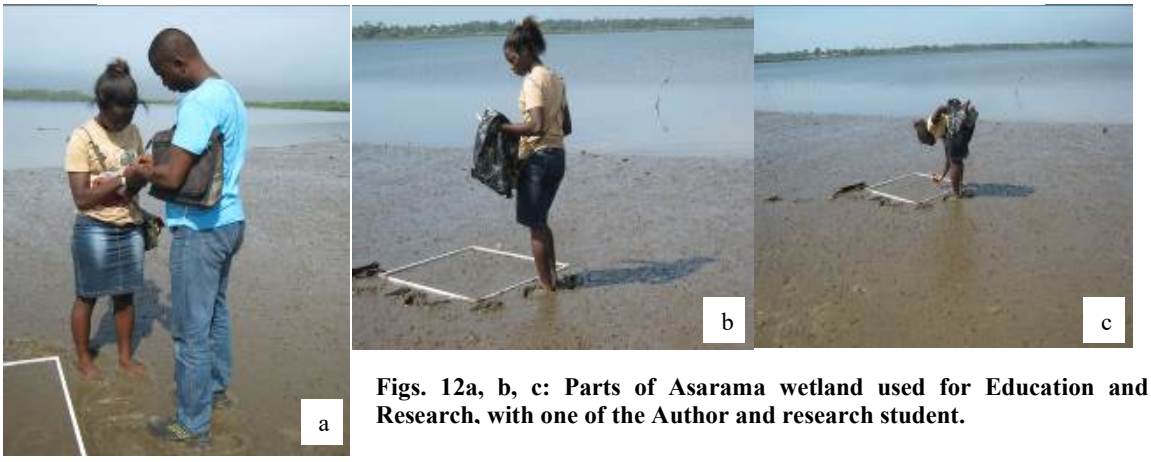
Report on wetland valuation in parts of Niger Delta has shown that 80% erosion control, 80% flood control and 73.6% of climatic regulation are the prominent services provided by the wetlands in the region (Ajibola *et al*., 2015). Other reports have shown how mangroves counteract tropical storms and act as buffer between land and sea with the capacity to stabilize shoreline substrate thereby protecting it from erosion (Mazda *et al*., 2006). Mangroves not only help in preventing soil erosion but also act as a catalyst in reclaiming land from seas and by their unique above-ground root systems, do 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 (John *et al*., 2016). Mangrove ecosystems serve as sink for the deposition of heavy metals from anthropogenic 300 sources such as domestic, industrial and agricultural discharges. Thus their use as bio-indicators for pollution monitoring in phytoinfiltration and phytoextraction technology programmes (Edu *et al*., 2015).

Sociocultural services:

The cultural value of some mangrove protected area such as the sacred ASO Mangrove Island (Figs. 11a-c) is noted for traditional and cultural practices such as burial ground, and sacred groves among the people of Asarama, Andoni. Wetlands especially the mangrove ecosystem in Asarama also provides opportunities for education and research (Figs. 12a-c) for pupil from other parts of the Niger Delta region. Similarly, on annual end bases the wetlands with its network of cannals serve for recreation event involving boat races and masquerade dance. Recreation, aesthetic, spiritual renewal and enrichment and market based goods and services of wetlands has been documented (Kings and Mazzotta, 2000; Mitsch and Gosselink 2000; Brander *et al*. 2006). Very little is written of the spiritual values and sacred sites in the Niger Delta wetlands. This is likely due to the secrecy that surrounds these services in most African society (Speranza *et al*. 2008). However, it is known that the wetland has many essential spiritual and sacred sites (Bisina, 2006). Report has recorded 67.3% of spiritual and inspirational values as prominent services by wetlands in the Niger Delta region (Ajibola *et al.,* 2015).



Figs.11a-e: Parts of ASO Conservation mangrove forest (over 100 years old with area coverage of 165,350.371m^2)



Figs. 12a, b, c: Parts of Asarama wetland used for Education and Research, with one of the Author and research student.

Supporting services:

The Asarama wetlands ecosystem is known for habitat support services for a wide range of wildlife fauna mostly birds, bee hives, crabs, molluscs and other aquatic life support, and human well-being and pollination centers for pollinators. This present study shows that the ASO mangrove conservation area is a hub for honey production

with lots of honey comb habitat for bees (Figs. 13a-c). The critical role of wetlands in supporting the livelihoods of millions of people in littoral and coastal regions has been revealed (Chidi and Ominigbo, 2010). Similar study has revealed mangroves of wetlands as important breeding, refugia and nursery sites for many commercially important shrimp, crab, fish, crustaceans, mollusks, birds, monkeys, phytoplanktons and reptiles. Some of which are obligatory residents (such as oysters, dog whelk, etc), while some are facultative residents –associated with mangroves at one stage of their life history. Juvenile fish and shrimp have been found to move substantial distances into mangrove forest habitat at high tide, where they gain protection from predation by larger fish, which remain in or near mangrove water ways. (Llewellyn, 2004; Zabbey *et al*., 2010; Lee, *et al*. 2014; Dirisu *et al*., 2019). Wetlands support vulnerable, endangered, or critically endangered species or threatened ecological communities. It supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity' (Ramsar Convention Secretariat 2007, 2010a). The Asarama wetland by ground-truthing assessment was observed to support soil formation by its mixture of sediment retention of silt-clay, clay-loam and mud flat substratum observed at low ebbing tide and by the peaty soil accumulation with organic matter of dead mangrove tissues forming a unique membranous soil commonly called "chikoko" soils across the Islands. This corroborates the assertion by Ajibola *et al*., (2015) on Niger Delta wetlands.

Figs. 13a, b, c: Parts of the interior view of the Aso mangrove site, coexisting with honey bee combs in association with Foliose lichens

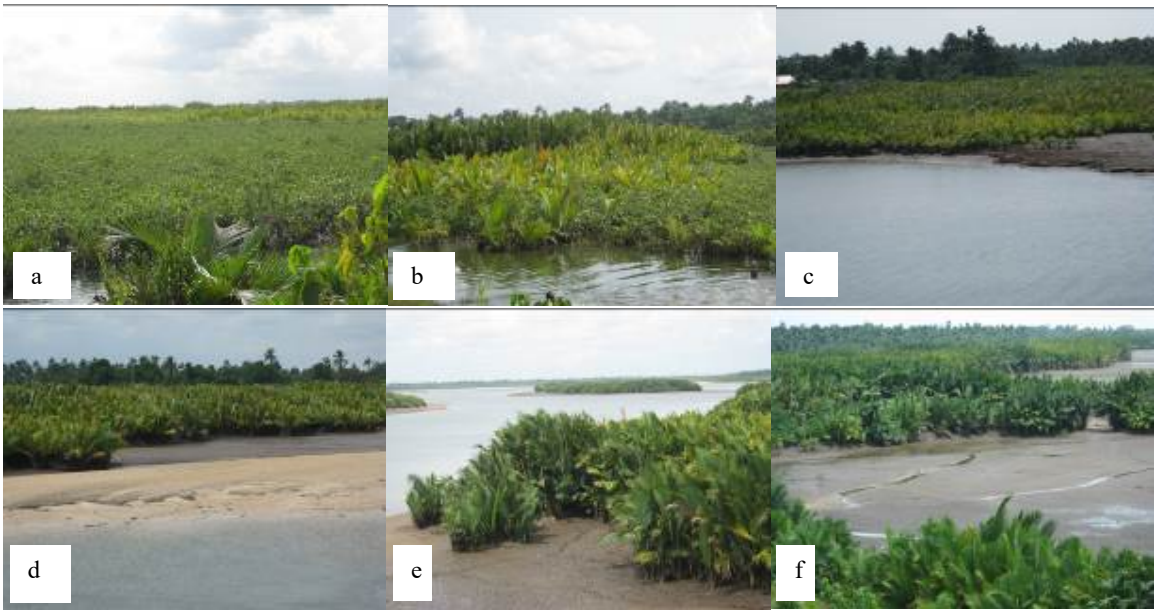
iii. *Ecological challenges*

Wetlands are known for diverse ecosystem services in qualitative and quantitative valuation in different parts of the world including the Eastern Niger Delta regions of Nigeria. However, in Asarama the wetland is being subject to diverse ecological demand on the ecosystem biodiversity with concomitant series of negative challenges of the ecological scenarios in parts of the study area. The negative ecological scenarios in Asarama wetland ecosystem can be categorized into two ecological challenges viz: *natural* and *anthropogenic challenges*. This corroborates the assertion that it is exposed to both natural factors and human exploitation activities daily (Ansa and Francis, 2007).

Natural challenge

i. The mangrove ecotypes in Asarama community as observed in the two study sites have been overtaken by Nypa palm (*Nypa fruiticans*) invasion and encroachment (Figs. 14a-f) thus leading to comparative advances and replacement of the mangrove species. This has led to the loss of supporting habitat services of the wetland for fisheries and their spawning grounds and other aquatic resources. Subsequently, it also hindered navigation in some parts of the infested areas. Invasion of Nypa palm in the east of Niger Delta is the biggest threat to mangrove disappearance as been recorded in parts of Imo, Qua Iboe and Cross River estuaries with more than 50% mangrove loss (Holzlohner and Nwosu 1997; Ukoima, 1998) with the consequences of loss of valuable ecosystem services to livelihood systems (Umoren, 2001 and Ukpong, 2001).

ii. Uncertainty in the variation of climatic relationship to the trend of hydrological tidal regime makes it difficult for the conventional approach to wetland monitoring processes to be carried out in relation to time Allotment and sea route navigation for such monitoring.



Figs. 14.a, b, c, d, e, & f: Parts of Nypa palm invaded mangrove site in parts of Asarama study area

Anthropogenic challenge

The anthropogenic agents implicated for wetland degradation in parts of Asarama can be categorized into four levels of challenges, viz: economic, social, institutional and infrastructural challenges. Several studies have recorded degradation of freshwater swamp and mangrove ecosystems due to demographic, societal, economic and biophysical shifts and/or political factors (Ite 2005; Kalu and Izekor 2006). Regardless of the adopted approach of ecological demand on the wetland, it is obvious that human activities in the two study sites of Asarama have had a substantial impact on the wetlands and their ecosystem services. This can be established based on the following challenges:

Economic challenges

Poverty: Wetland degradation in Asarama due to loss of mangrove and associated forest species is factually due to unsustainable domestic logging and firewood collection (see Figs. 10a-d) by the local people for domestic cooking and clearing of the forest for agricultural purposes. The impact of these activities have been investigated for Bayelsa with results showing that 200 000 trees, or, 3% of the forest, are lost annually (Ibaba 2010). Timber logging, however, has been liked with the extensive excavation of channels, which compromises the local hydrology and leads to the reduction in fish habitat (Ramsar Convention Secretariat, 2007). Human factors such as poverty and economic inequality, pressure from population growth, immigration and unmanaged tourism, and social and cultural conflicts have been revealed as challenges to the sustenance and service delivery of wetlands (Skourtos *et al.,* 2003). Environmental perturbation associated with the Asarama estuary has been linked to human activities including transportation / navigation and over harvesting of periwinkle (*Tympanotonus fuscatus*) (Dirisu *et al*., 2019).

Lack of education: At low ebbing tides some of the locals were often engaged in unsystematic periwinkles picking or harvesting without been regulated. It is an unsustainable approach in which premature and juvenile Periwinkles were included in the harvest. This corroborates Dirisu *et al*. (2019).

Unemployment & Quick rich syndrome: Artesianal illegal local refinery of petroleum products was observed in Asarama far upstream off the estuary at the north-western bank (see Figs. 9a-c). The water surface was observed to be associated with hydrocarbon soot and oil slicks (Figs. 15a-b) emanating from the local artesian refineries in the area. This could corroborates the rising cases of local and international demand for crude oil in the Niger Delta and consequent environmental change through a high demand for wetland area for oil exploration and exploitation (Olalekan and Gordon, 2011). Several studies have indicated oil industry operations as been responsible for most widespread and severe environmental pollution in the Niger Delta region (Eregha and Irughe 2009; UNEP-WCMC 2011; Adekola *et al*., 2015). Of major concern have been the loss of major mangrove ecosystems and regular disturbance of wildlife (Figs. 15c-d). In Nigeria especially in the Niger Delta mangroves are disappearing due to many threats which include seismic exploration activities, urbanization, oil spill, construction of oil and gas facilities. Between the mid-1980s and 2003, 21,340 ha of mangroves have been

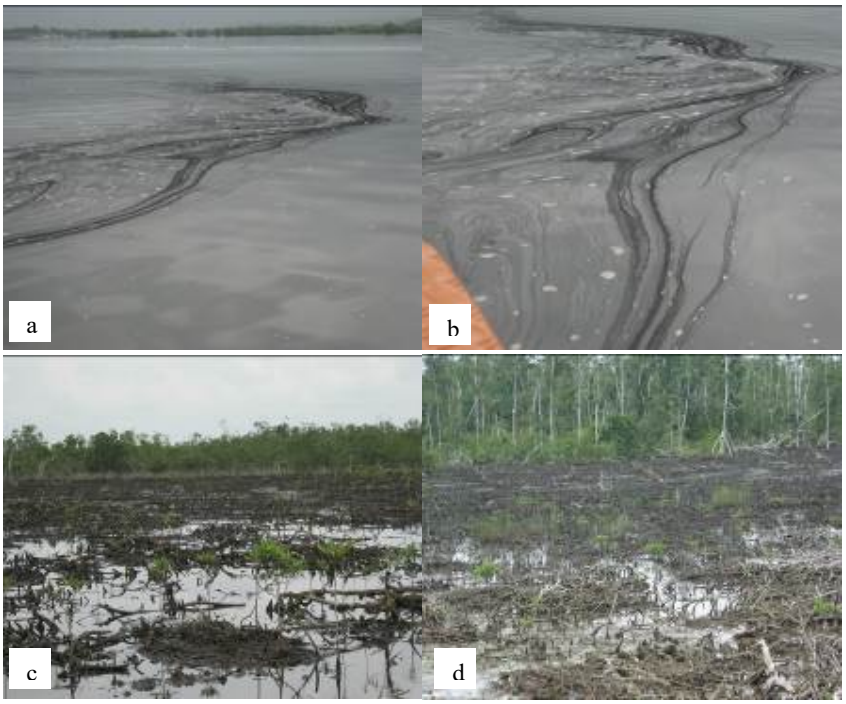
lost across the whole Niger Delta due to urbanisation and oil- and gas-extraction activities (James *et al*., 2007). Study has also revealed the impact of total hydrocarbon content on the abundance and diversity of phytoplankton community in the area (Dirisu *et al*., 2019).

Social challenges

Social apathy: Wetlands are known for wide range of ecosystem services that contributes to the well-being of society in parts of Niger Delta yet, are not been appreciated in parts of the Eastern Niger Delta, hence are been treated as wastelands and problem areas to be drained or sand filled while some also serve as sewage dump site.

Ecosystem stigmatization: In Asarama, wetland are been earmarked as sources for social convenience including it use as toilet and bathing facility as well as domestic solid waste dump site.

Domestic violence: Due to the ongoing partisan conflict, domestic unrest and other forms of social vises (cultism, kidnapping, banditry etc) in parts of Asarama, scientific study based on conventional approach to vegetation, water, soil and other abiotic sampling measures for monitoring wetlands is currently difficult to carry out.



Figs. 15a, b,: Observed emergence of hydrocarbon soots and oil slicks in parts of the study site in Asarama.
15c, d: Parts of the impacted mangrove sites

Institutional challenges

Disparity in legal instrument: In view of regulatory instrument, there are series of disparity in which the existing institutional and legal frameworks are giving priority to oil exploration over protection of the wetland.

Unsustainable institution: Lack of formidable monitoring institutions for wetland ecosystems. For instance it is on record that Nigeria has several biodiversity conservation and environmental protection laws and policies which are not properly and comprehensively enforced. The prohibiting of certain activities such as farming in specific areas but not addressing the complex causes behind habitat destruction is one instance of legal instrument toward protecting wetlands (Ebeku 2004; Adekola *et al*. 2012).

Insufficient funding: No sustainable or sufficient counterpart funding (if ever in existence) among the Government Institution, NGOs and private organizations for the advancement of wetland biodiversity conservation and its' livelihood benefit.

Failure or poor under standing by decision / policy makers: Decision and policy makers do not understand the potential implications as well as benefits of wetland ecosystem services and thus have not come up with possibly flexible laws and policies that might favour their usage, inculcate more awareness or proper harnessing by various sectors for the livelihood and well-being of the society. Beside the global clarion call for management of mangroves (World Bank, 2004), degradation and persistent destruction of mangroves have continued unabated in parts of Niger Delta, with policy makers paying little or no attention to mangrove conservation.

Infrastructural challenges

Based on descriptive sources of information the Nigerian legal Act and regulatory instrument is associated with several legal loopholes that allowed polluters such as the oil industry to avoid fines. Besides the general enforcement of the Act had been largely ineffective due to lack of funding, staff, equipment and skills. In addition, corruption within and outside the agency's administration, and a strong influence of the petroleum industry on the government, also hindered the success of the Act. Current reality indicates that increasing pressure from anthropogenic activities such as conversion to intensive agricultural, residential uses; pollution due to hydrocarbon activities has impacted on the wetland ecosystem of Asarama.

3.2. Future directions and initiatives

Despite the critical importance of mangroves, they are disappearing at an alarming rate around the world with a documented loss of at least 35 percent reportedly linked to human development, industrial activity, climate change and aquaculture (Alongi, 2002; Duke *et al*., 2007). Such loss has also been reported to have exceeded the disappearance rate of tropical rainforests (Rideout *et al*., 2013, DasGupta and Shaw, 2013; Daru *et al*., 2013 and Rahman *et al*., 2013). This unpleasant reality is generating considerable concern which requires concerted efforts (as outlined below) for mangrove conservation priorities through the retention of existing forest via afforestation and reforestation programmes (Figs. 16a-b) particularly in areas like Asarama where deforestation has taken place.

Figs. 16a, b: Mangrove nursery for revegetation programme in parts of Asarama study area

i. Monitoring of wetland status is a crucial part of effective conservation and management efforts that should entail biotic and abiotic sampling on a local scale and earth observation techniques on a regional scale. It is the only measure to evaluate the degree of ecosystem change.

ii. Conventional vegetation, water and soil sampling for monitoring wetlands is currently very difficult to be carried out in the Niger Delta due to the afformentioned domestic violence enumerated. This makes the region unprotected, making sustainable development impossible. Thus, the use of geospatial tools (GPS, GIS and remote sensing) is a suitable and safe approach to measure the extent and character of wetland change in the area over stipulated period.

iii. Wetland degradation in Asarama and the Niger Delta generally can be stopped by proper implementation of policies and enforcement of the existing environmental laws with more advocacies on national wetland policy necessary.

iv. GIS geo-spatial delineation and implementation of conservation priorities for mangroves in Asarama and the Niger Delta need to be largely conducted to have comprehensive and well synthesized species-specific phytosociology information of the region. This shall improve on the existing record by John *et al*. (2016).

v. Species information including the presence of threatened species is imperative for refining conservation priorities such as the designation of critical habitat, biodiversity hot spot, buffer zone, or marine protected areas.

vi. Such comprehensive and systematic species-specific data collation shall inform policies to regulate resource extraction or coastal development.

vii. It shall inform a sustainable delineation of mangrove ecotypes of Niger Delta ecological zone and the minimum viable population size.

viii. Such data collation shall be used to determine the probability of extinction for all known species of Niger Delta Mangal vegetation under the categories and criteria of the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species.

ix. There should be the formation of rural conservationists: The Mangrove Restoration and Conservation Committee (MRCC) for proper implementation of afforestation and reforestation programmes.
x. There is need for comprehensive assessment of the biological and physicochemical oceanography of Asarama wetland ecosystem amidst the developmental drive in parts of Niger Delta, Nigeria.

CONCLUSION

The study on Asarama wetland ecosystem has revealed diverse trend of ecosystem services and their relative significance to the livelihood system of the community members in the area. Using the explanatory based Participatory Rapid Appraisal (PRA) approach in the study to identify the various ecosystem services and their ranking significance to livelihood it was evident that Food, Aquaculture practices and Sea route logistic are the most important livelihood benefit of wetland provisioning service. Climate regulation and erosion & flood control of livelihood benefit are the most important regulatory service of the wetland, while spiritual inspiration and recreation are the most livelihood benefit of the sociocultural wetland service and Breeding / nursery as most important of the supporting service. The coastline of Asarama in the Andoni marine ecosystem is highly dynamic with rapid natural and anthropogenic processes occurring. The great instability, spontaneous, and periodic mass mortality and disappearance of the mangrove ecotypes of the area is almost certainly related to the prevalent invasion of the Nypa palm encroachment in the area besides the possible coastal current in the region. The results of our study further highlight that, in the Asarama area, wetland degradation continued to occur despite the regulatory measures being in place. This study has highlighted that broad-scale changes in the condition of the wetlands in Asarama can be assessed as this may assist the government in executing the legislation at its disposal.

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Conflict of interest

This paper is devoid of any conflict of interest neither within nor outside the authorship of this paper

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