OGONILAND AND THE NIGER DELTA:

MANGROVE RESTORATION AND CONSERVATION STRATEGY.

HYDROCARBON POLLUTION REMEDIATION PROJECT
(HYPREP)

OGONILAND AND THE NIGER DELTA:

MANGROVE RESTORATION AND CONSERVATION STRATEGY.

Federal Ministry Of Environment

HYDROCARBON POLLUTION REMEDIATION PROJECT

(HYPREP)

ACKNOWLEDGMENT

1. Olof Linden and Nenibarini Zabbey co-authored this report as part of the United Nations Environment Programme (UNEP) Disasters and Conflicts Branch support to the Hydrocarbon Pollution Remediation Project (HYPREP). Ibby Kakulu and Yves Barthelemy contributed valuable data to the report, while Mike Cowing and Rita Cozma provided editorial input. However, the views expressed in the report are solely those of the authors.

CITATION:

The report should be cited as

Linden O. and Zabbey, N. (2023). Ogoniland and the Niger Delta: Mangrove Restoration and Conservation Strategy. Hydrocarbon Pollution Remediation Project (HYPREP) Technical Report No. 1. ISBN (plus the link to the report) or DOI XXXX.

ISBN:

DOI:

TABLE OF CONTENTS

LIST OF ACRONYMS

BMI	Bodo Mediation Initiative
CEHRD	Center for Environment, Human Rights And Development
CSO	Civil society organization
	Environmental impact assessment
GIS	Geographic Information Systems
HYPREP	Hydrocarbon Pollution Remediation Project
LGA	Local Government Area
NDDC	Niger Delta Development Commission
NDES	Niger Delta Environmental Survey
NEMA	National Emergency Management Agency
NGO	Non-governmental organization
NNPC	Nigeria National Petroleum Corporation
NOSDRA	National Oil Spill Detection and Response Agency
NUPRC	Nigerian Upstream Petroleum Regulatory Commission
SCAT	Shoreline Cleanup and Assessment Technique
SPDC	Shell Petroleum Development Company of Nigeria
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

1 BACKGROUND

This Mangrove Restoration and Conservation Strategy has the following two objectives:

1. The first objective is to discuss and describe the need for, and the content of, a Restoration Plan for the mangroves in the Niger Delta with a focus on the four Local Government Areas (LGAs) of Ogoniland and neighboring mangrove areas. It seeks to provide a roadmap to address diminishing natural ecosystems, increasing. environmental contamination and loss of traditional livelihoods. It will provide a strategy for environmental restoration in part through rehabilitation of mangroves in areas which have been devastated by decades of oil spills and other factors. Planting alone will not achieve rehabilitation of productive mangrove forests. As the report points out, planting must be supported by several other interventions.
2. The second objective is to widen the perspectives beyond Ogoniland, and to describe what is needed in order to develop a Conservation Plan for a network of nature reserves in the Niger Delta as a whole. This will seek to address the increasing exploitation and destruction of the natural vegetation, in particular mangrove forests. Ultimately, the Conservation Plan should seek registration of parts of the region as one or several Ramsar sites.

1.1 Wetlands in Nigeria

Wetlands are some of the most productive and diverse ecosystems on the planet. According to the Convention on Wetlands (Ramsar Convention) they are "areas of marsh, fen, peatland, or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water of which at low tides does not exceed 6 meters".

Wetlands play an important role in the environment, a few of the more important functions are purifying water in the landscape and retaining particles and nutrients, regulating the flow of water through the drainage area, and providing habitat for numerous species of invertebrates and vertebrates (Griffiths et al., 2021; Mitsch et al., 2014). In addition, wetland vegetation such as mangroves are extremely effective in taking up CO_2 from the atmosphere and depositing it in sediments (Mariano et al., 2022Figu; Sreelekshmi et al., 2022). Mangroves are at least about five times more effective than ordinary forests in sequestering Co_2.

The drainage basin of the Niger River is well over 2 million km² (Figure 1). There are several wetlands in Nigeria, the largest being the Niger River Delta which is about 21,000 km² in size measured as the area which hydrologically falls under the definition as the river delta 1. As such it is the largest wetland in Africa and the third largest in the1 Borders between different areas is a complex subject. Administrative boarders often do not coincide with borders determined by nature types. Hence the area of the states that falls under the administrative definition of the Niger Delta is about 70,000km². However, from a hydrological standpoint the river Niger delta is about 21,000km².

world. The Niger River Delta stretches about 450 km from the Benin River in the west to Imo River in the east. The delta is a vast flood plain built up by the accumulated sediments washed down the Niger and Benue rivers.

From south to north, the Niger Delta consist of a thin margin of coastal rainforest on elevated scattered barrier islands, then followed by mangrove swamps which are intersected by numerous estuaries, creeks, small rivers and manmade channels (Figure 2). Continuing northwards the brackish mangrove environment turns into freshwater swamps and rainforest gradually transforming into woodlands and savanna grassland at higher elevations (NDES, 1997; Kuenzer et al., 2014, Zabbey et al., 2019)

The Niger Delta wetlands are dominated by freshwater swamp forests in the central and northern parts, and by mangrove forests in the southern and southwestern parts. The freshwater swamp forests and mangroves are intersected by numerous channels and creeks which are to a varying extent influenced by the tidal fluctuations. The tides are semi-diumal and the range in Port Harcourt is around 2m

Figure 1 Map showing the Niger River drainage basin which is about 2274 million km²

The mangroves of Ogoniland, and the Niger Delta in general, become inundated during tidal flood conditions although elevated areas within the mangroves may be flooded only at spring floods (UNEP, 2011; Gundlach, 2018). Such areas are often characterized by high salinity conditions and the mangroves in such upper areas are often sparse, dwarf and not well developed Central areas of the mangroves are entirely drained during spring low-tidal conditions while at neap tides water will remain in low-lying parts of the mangroves.

The mangrove vegetation consisting of trees and shrubs are the keystone organisms in an ecosystem consisting of numerous species of insects (butterflies, bees, ants, mosquitos), a number of mollusks (periwinkles, cockles, oysters), crustaceans (crabs, shrimps), and fish. In addition, several birds and mammals are inhabitants of the mangrove ecosystem

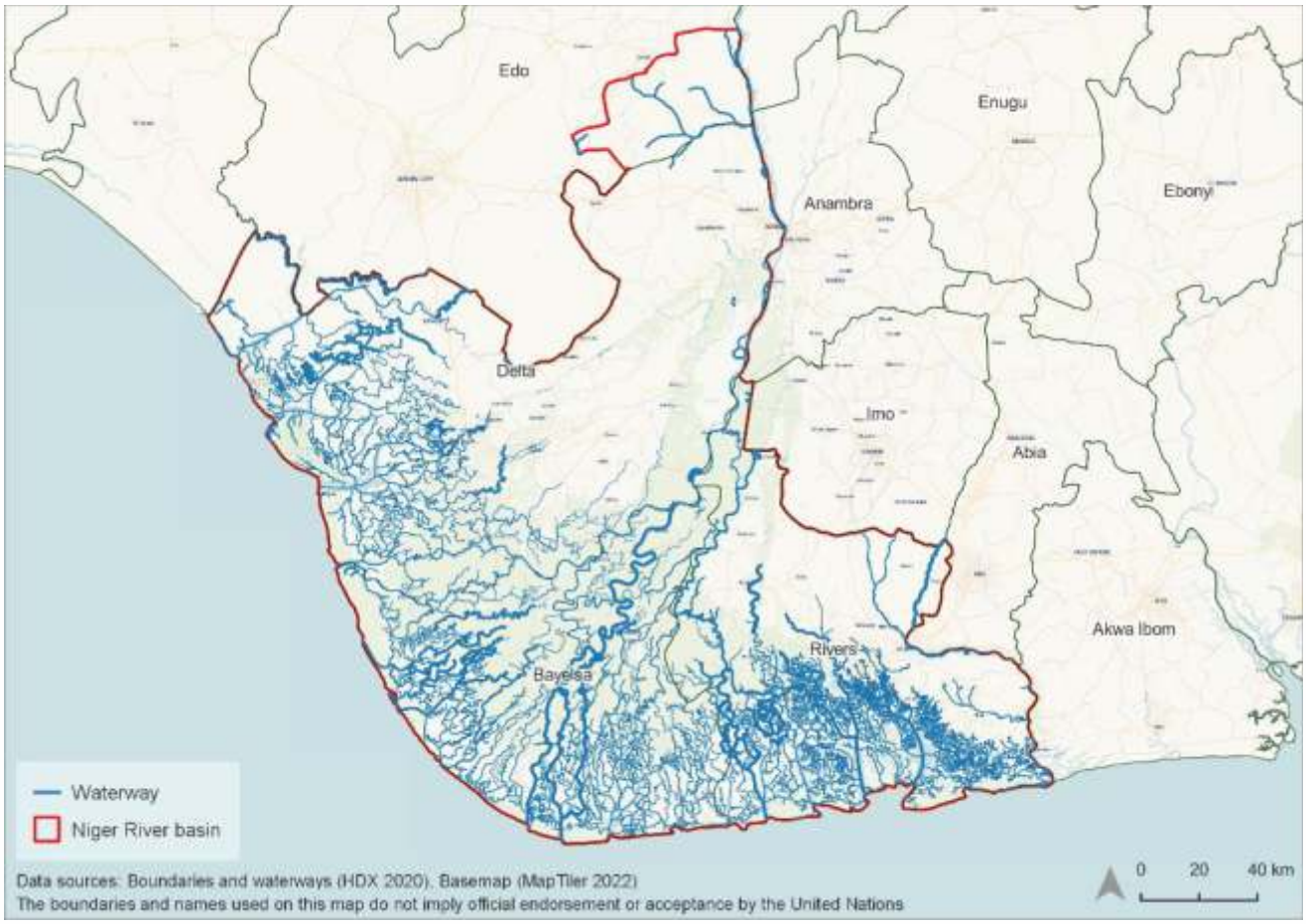


Figure 2: Map showing the Niger Delta with numerous rivers and creeks

1.2 Ramsar sites and the status of environmental protection in the delta

A few sites in the delta have been recognized on the Ramsar list (Figure 3). These are Apoi Creek, which is a tidal swamp forest in upper Bayelsa State, and the Upper Orashi Forest which is a freshwater swamp forest located in Rivers State. Each of these sites are about 250 km² in size (NDES, 1997; Phil-Eze and Okoro, 2009)

In addition, there are about 70 sites in the Niger Delta which are formally protected or proposed either as forest reserves (90%) or nature parks, nature reserves or game reserves. One is Andoni which has populations of Heslop's pygmy hippopotamus and African elephant.

The protection or management regime of the Ramsar sites, nature parks as well as other reserves in the Niger Delta is grossly ineffective. They are "paper-parks" as there is little to no management action on the ground to safeguard critical wildlife (e.g., red colobus, white-throated guenon) at the sites. Only Apoi Creek has a management plan although it is yet to be implemented..

A sustainable co-management framework is needed to effectively drive or strengthen community conservation actions that will complement active monitoring and supervisory oversight of government.

Real time data on the health integrity (e.g, status of the charismatic wildlife) of the sites are necessary for informed adaptive management decisions. Presently, such key datasets are sketchy or lacking.

Figure 3 Map showing the Niger Delta and the Ramsar sites.

The management regime in place is ad-hoc and tied to fragmentary annual budgets; that is, site specific annual budgets Government intervention usually includes enrichment planting, supporting communities with apiculture and orchard, provision of fishing boats and nets. Apoi Creek and the Upper Orashi are reported to have not had any of the above government interventions in the past four years.

SOCIOECONOMIC DATA FOR OGONILAND

Population

The 2006 National and Household Population Census (NPHC) placed the population of the four Ogoniland LGAs in Rivers State at 831,726 consisting of 428,560 males and 403,166 females. Based on an average annual growth rate of 3.4% (NHDS, 2018) the estimated current population of Ogoniland is approximately 1,216,986 people consisting of 627,071 males and 589,915 females as at 2021.

Healthcare

There are 670 health facilities in Rivers State consisting of 343 primary healthcare facilities all of which are publicly owned. There are 321 secondary healthcare facilities of which 300 are privately owned and 21 publicly owned, and six tertiary healthcare facilities of which four are publicly owned, one owned by the Federal Government and one privately owned. Ogoniland has 71 primary healthcare facilities spread across the four LGAS, four secondary healthcare facilities and nine private secondary healthcare facilities. There are 562 medical doctors in Rivers State. The infant mortality rate in 2021 is 48/1,000 live births, 117/1,000 for women aged 15-50 and 122/1000 for men aged 15-50 (NDHS, 2018). Utilization of healthcare facilities in Ogoniland in 2019 comprising facility attendance and outpatient care was as follows: Eleme LGA 113,551; Gokana LGA 97,100; Khana LGA 158,986; and Tai LGA 55,174 (RSMOH, 2019).

Labor force and employment

The labor force for Nigeria out of an estimated population of 206,139,587 in 2020 is 30.19%. This data, although not disaggregated to states or LGAS, can be assumed to be applicable in Ogoniland, Labor force comprises people aged 15 and older who supply labor for the production of goods and services during a specified period. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers. During the fourth quarter of 2020, employment rates in Nigeria were as follows: total unemployment at 33.3%; total underemployment at 22.8%; youth unemployment at 42.5%; and youth underemployment 21.0%. Labor force participation rate is the proportion of the population aged 15 and older that is economically active: all people who supply labor for the production of goods and services during a specified period - this stood at for Nigeria in 54.92% in 2019.

Education

The NDHS 2018 also reports on the educational attainment of males in Rivers State: 4.9% have no education, 17.5% have some primary education, and 11.7% have completed primary education. In terms of secondary education, 17% have some secondary education, 33.9% have completed secondary education and 15% have more than secondary education. As for females in Rivers State that, 7.5% have no education, 14.6% have some primary education, and 12.1% have completed primary education.

In terms of secondary education, 17% have some secondary education, 37.9% have completed secondary education and 15.8% have more than secondary education. Although this data is not disaggregated to LGAs it is safe to assume that it applies to Ogoniland. In Rivers State there are over 5,222 schools ranging from nursery through to primary, junior secondary and senior secondary schools.

Figure 4: Vegetation of the Niger Delta (1 and 2) aerial view of the wetlands, (3) mangroves, palm trees and nipa palm, and (4) farmland. (Maxime Paquin, UNEP, 2019),

MANGROVES OF THE NIGER DELTA

The mangrove ecosystem consists of a relatively few species of true mangrove plants and associates. The true mangrove plants consist of five families represented by nine species. These are Rhizophoracea *(Rhizophora racemosa, R. mangle and R. harissonii* - the red mangroves), Avicennacea *(Avicenna germinas* - black mangrove, called white mangrove in Nigeria), Combretacea represented by two species, *Laguncularia racemosa* (white mangrove, called black mangrove in Nigeria) and *Conocarpus erectus* (button wood), and Araceae *(Nypa fruticans* -nipa palm, an invasive species and alien in the Niger Delta), and the mangrove fern Pteridaceae *(Acrostichum aureum and A. danaeilfolium)* (Jackson and Lewis, 2000; Duke, 2017; Zabbey, 2020; Norman Duke, 2022 personal communication).

Overall, ***R. racemosa*** is the dominant mangrove in the Niger Delta, constituting about 70% of the total abundance of the true mangrove plants. The mangrove associated plants are the plants that can grow within and outside mangrove swamps. The mangrove associates include *Hibiscus tillaceus, Thespesia populnea, Drepanocarpus lanatus, Chrysobalanus spp., Pandanus candelabrum* (screw palm), *Phoenix reclinata* (date palm), ***Pasparum vaginatum*** (sedge) and *Cyperus articulates.*

Mangrove forests in the Niger Delta are home to many invertebrates (e.g., swim, hairy purple and fiddler crabs), fin fishes (e.g., mud skipper, sleeper gobiids), reptiles (e.g., Nile crocodile, West African black mud turtle), birds (e.g., parrots, cormorants, kingfishers and the endemic and endangered Anambra waxbill) and a number of mammals (e.g., Mona monkey, speckle-spotted otter, long-nose mongoose).

The Niger Delta environment has changed dramatically during the last decades as a result of population growth and human activities. The population in Ogoniland is now estimated at about 1.5 million, compared to 832,000 in 2006, which is a doubling of the population in 15 years.

Most of the lowland rainforests that used to characterize the areas landward from the swamp forests are now derived savannah where agriculture including plantations dominates (Ayanlade and Drake, 2016; Ayanlade and Howard, 2017; Enaruvbe and Atafo, 2014 (Figure 4). Only small areas of more or less degraded coastal rainforest are left. Agriculture has encroached into the wetlands.Fifty years ago, humans lived in few villages on elevated land in the mangrove areas. Now the mangrove swamps are crisscrossed with canals and roads often with more or less continuous houses, workshops and industrial activities along the sides of the roads. This development requires sand to elevate the land where housing, roads, etc., are built. The sand comes in most cases from unregulated dredging in rivers and canals.

The area covered with typical mangrove vegetation in the delta which in 2010 was estimated to about 10,515 km² (Spalding et al., 2010) decreased to about 8,240 km² in 2020, a reduction of about 230 km² per year (Table 1). Also, about 20% of the freshwater swamp forests have been logged between 2000 and 2020 (GMW Dataset

the freshwater swamp forest have been logged between 200 and 2020 (GMW Dataset and NASA satellite boundary). Figure 5 shows the extent of mangrove vegetation in the Niger Delta (including Calabar region) in 2020. About 10% of the total area covered by mangroves can be estimated to consist of nipa palms.

The high rainfall and river discharge during the rainy season combined with the low, flat terrain, and poorly drained soils cause frequent and widespread flooding and erosion. Often over 80% of the delta is affected by seasonal floods stretching from the Benin River in the west to Bonny River in the east. The tidal range at Port Harcourt is on average 2.0 m.

Table 1: Temporal extent of mangrove area (km2) in the Niger Delta

2010*	2020**
10,515	8,240

** Spalding et al. 2010*
*** GMW Dataset and NASA satellite boundary*

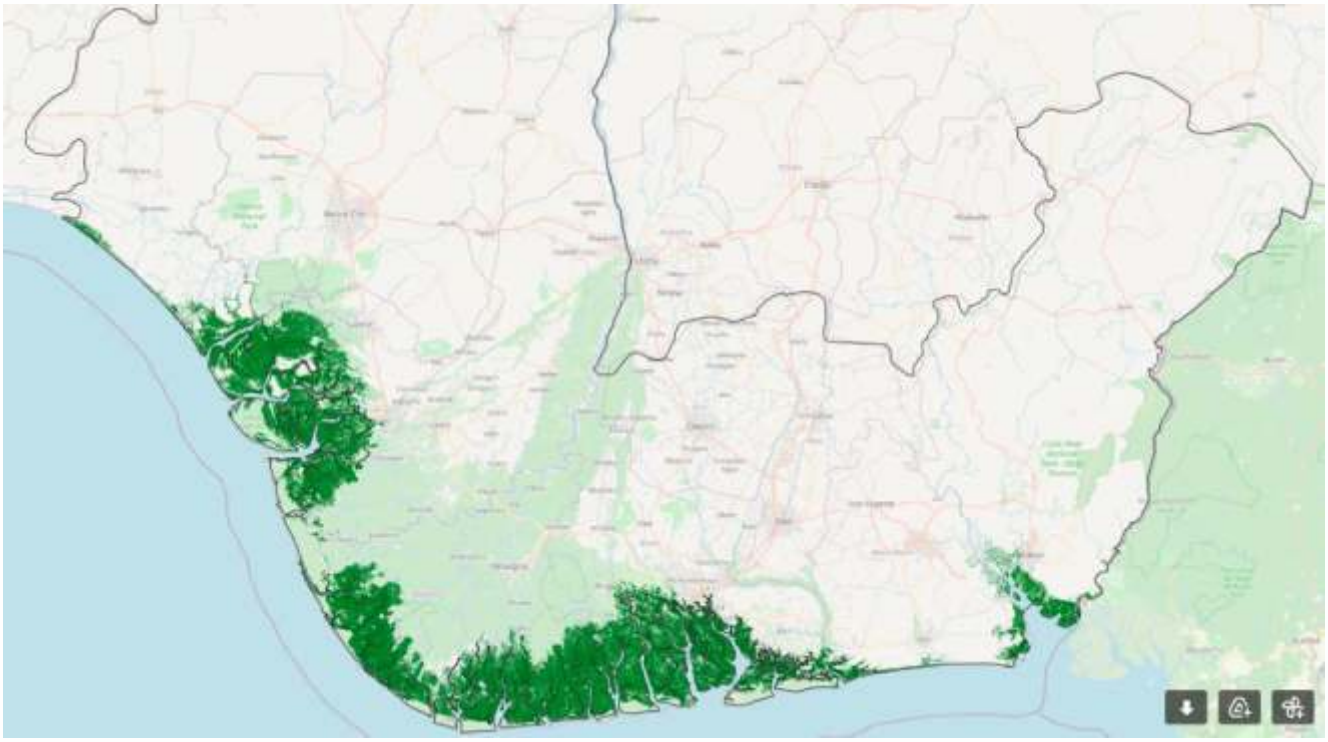


Figure 5: The extent of mangrove vegetation (8,240 km²) including nipa palm (about 10%) in 2020 based on GMW Dataset and NASA satellite images.

1.3 Impacts of the oil industry in the Niger Delta

Oil spills have occurred repeatedly for decades in the Niger Delta since commercial oil production started in 1956 and significant parts of the land and wetlands are more or less chronically affected by oil spills (see below). Due to the influence of the tides and floods in connection with the wet seasons, spilt oil is remobilized and distributed over larger areas (UNEP, 2011; Gundlach et al., 2021, Obida et al., 2021).

The oil originates from leaking pipelines, wellheads, and flow stations; from spills in connection with transport of stolen oil; from spills in connection with illegal tapping of the pipelines and wellheads, and from artisanal refining under very primitive conditions (Linden and Palsson, 2013).

As a result of the contamination of oil in mangroves and other wetlands as well as on land, oil has penetrated soils down to several meters and has contaminated ground waters over large areas. This has resulted in the contamination of domestic water- wells as a particularly serious concern from a human health perspective (UNEP, 2011).

The widespread oil contamination of wetlands and forests has caused deterioration and mortality of plants, bushes and trees and their associated animals in Ogoniland. Figure 6 shows the oil infrastructure in the 4 LGAs which constitute Ogoniland. At present (2021), based on recent satellite images, the reduction in the areas covered with mangroves can be estimated to

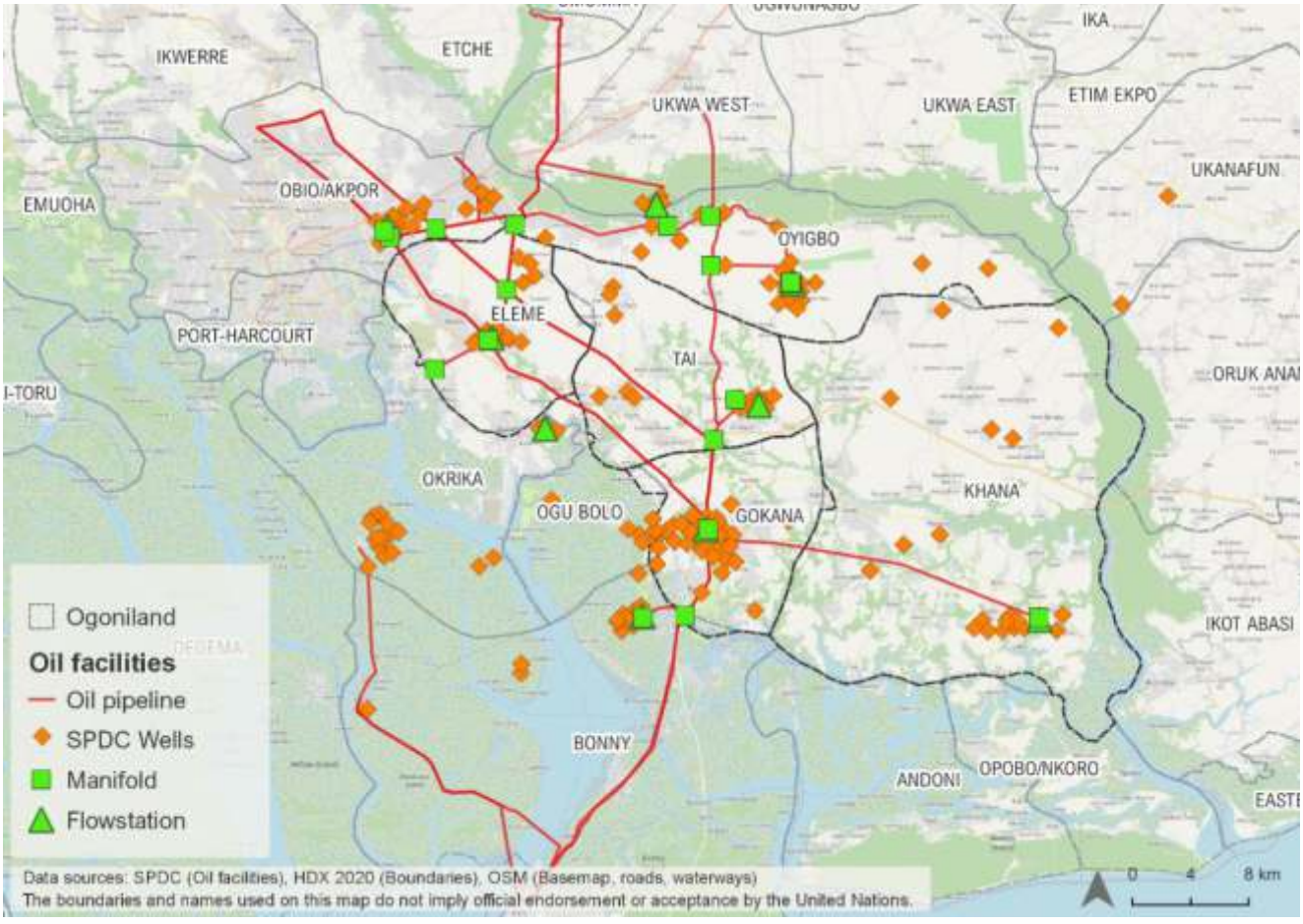


Figure 6: Oil facilities within Ogoniland and the surrounding areas

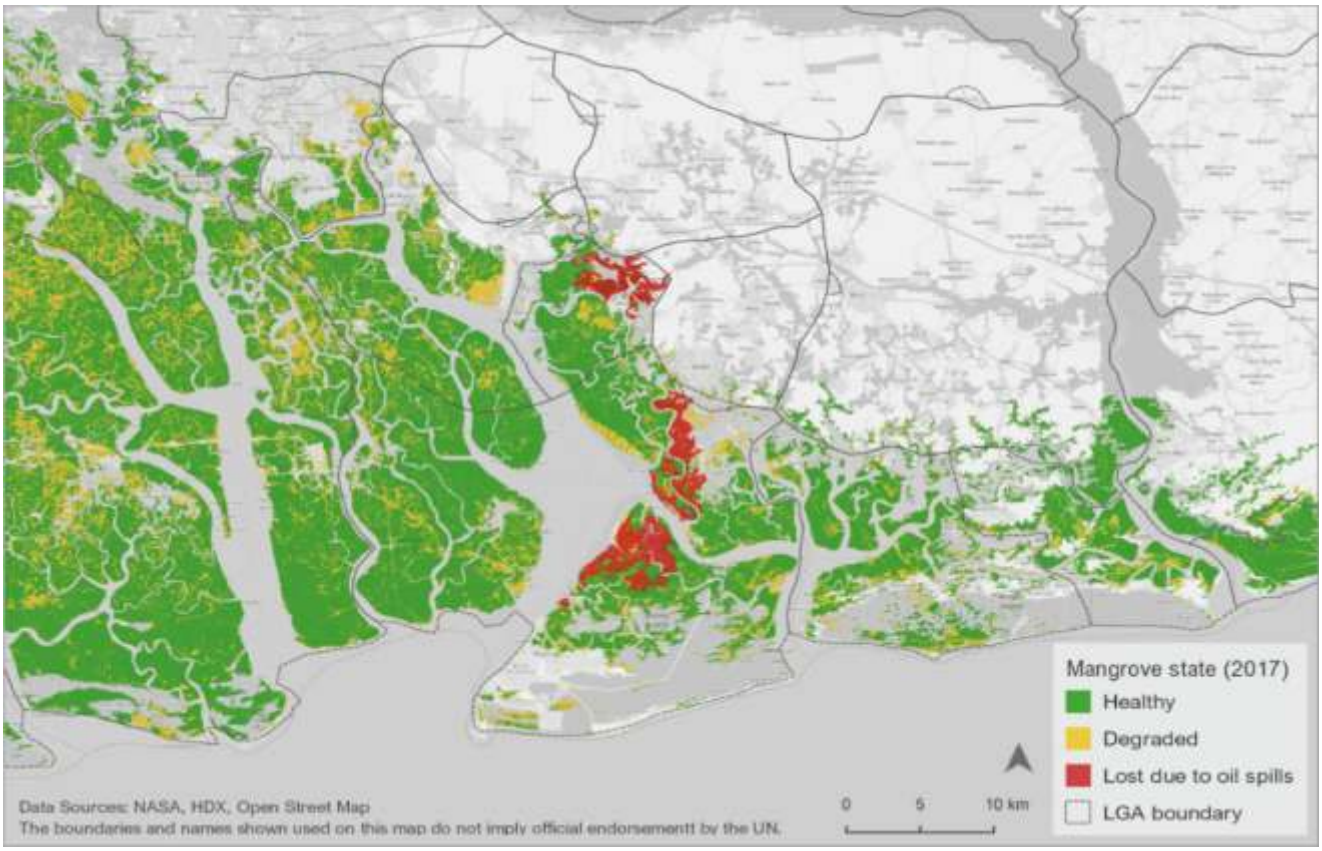


Figure 7: Mangrove health and distribution in and around Ogoniland.

Figure 8: (1-3) Oil spills in the Niger Delta and (4) pipelines in the LGA (UNEP, 2011).

The corresponding figure for mangrove reduction in the Niger Delta as a whole is 23,000 hectares (Table 1). The topic of mangrove degradation due to oil spills and other oil industry related activities is discussed below (Sections 4 and 5).

Oil contamination is not the sole reason for degradation of the natural vegetation in the delta. As pointed out above, cutting of mangroves, small trees and bushes, and logging of larger trees for fuel wood and timber is taking place in many areas. Road construction and building of houses have also affected the natural vegetation as the hydraulic cycle is changed aside direct removal of the vegetation through reclamation (Numbere, 2021a; Zabbey et al., 2021). Roads and canals are important for transport and communication in the delta. However, their construction has led the way for extensive environmental degradation as farmers establish new plots in the natural forest and loggers and hunters gain access to the forests and swamps.

Another factor causing serious damage to the mangroves of the delta is sand mining which is carried out on a semi-industrial scale (Osuji et al., 2010; Akani et al., 2018; Numbere, 2021b). The sand mining is leading to erosion along the creeks and rivers leading to loss of sediment in mangrove areas.

Since the last decades the invasive nipa palm ***(Nypa fruticans)*** has spread into the delta from the east. Areas along the Imo River and creeks and tributaries connected to the Imo River have been seriously affected. Areas of native mangroves which are already stressed are particularly sensitive to the invasion of the nipa palm (Nwobi et al., 2020; Adekola and Mitchell 2011, Zabbey and Tanee, 2016; Zabbey et al., 2021).

2 OBJECTIVES OF THE REPORT

The present report has two objectives. The first objective is to discuss and describe the need for, and the content of, a restoration plan for the wetlands in Ogoniland with a focus on the four LGAs (Eleme, Gokana, Khana and Tai) with neighboring mangrove areas to the west and south (Figure 9). As in the Niger River Delta as a whole, the area which falls under these four LGAs has undergone dramatic changes during the last 50 years. Much of this change has resulted in diminishing natural ecosystems, increasing environmental contamination and loss of traditional livelihoods. In order for the human population of Ogoniland to be able to enjoy life in a cleaner and healthier environment in the future, changes will have to take place when it comes to how human activities expand at the expense of the natural environment. The report will serve as a roadmap which will provide a strategy for how the vegetation in the area, in particular the mangrove environment, can be restored through plantation of mangroves in areas where the vegetation has been lost due to pollution by oil or other factors.

The second objective of this report is to widen the perspectives beyond Ogoniland and describe what is needed in order for the Niger Delta as a whole to change the course of increasing exploitation and destruction of the natural vegetation, in particular mangrove forests. The people of the Niger Delta can only look forward to a prosperous future if the destruction of the environment soon comes to an end. A vision for the future may be that the people of the Niger Delta should adopt a plan to improve the state of the environment in the delta in order to be able to seek registration of parts of the region as a Ramsar site. Such a vision may not be impossible to achieve on the ground in the delta. There are a number of factors that could contribute positively, for example the environmental conditions with temperatures and humidity that favors rapid degradation of contaminants, and the fact that the population overall is educated and aware of the need for a more sustainable way of developing their societies. This topic is discussed further in Chapter 8.

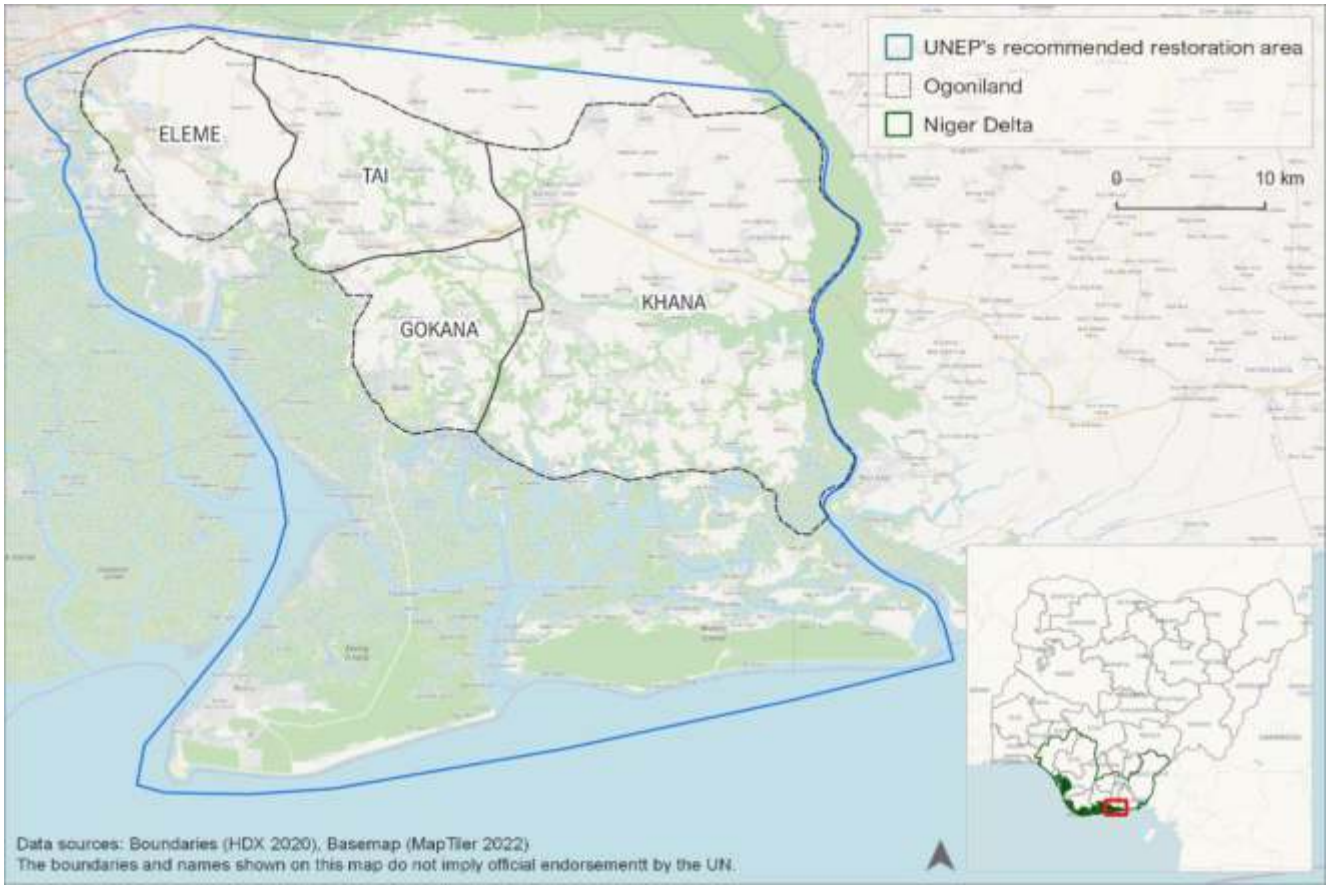


Figure 9: Overview of the LGAs of Ogoniland within the focus area of the restoration plan, the first objective of this report.

2.1 Preparation of a restoration plan

The restoration plan will discuss and describe the strategy for restoration of the vegetation in Ogoniland and neighboring areas to the west and south (Figure 9). The plan will focus on mangroves and related plants that have suffered from oil spillages and other anthropogenic impacts.

An obvious prerequisite for successful rehabilitation of mangroves is that the oil spills are stopped (UNEP, 2011). The degree of oil contamination on the surface and deeper down within the soil profile must be assessed in advance of any planting. If the substrate is heavily oil contaminated, cleanup is necessary prior to any planting. The approaches and techniques for this has been described in detail by Gundlach et al. (2021).

Also, the bio-physical factors must be determined in advance. It is necessary that the hydrological regime is still reasonably intact, that is, the sites chosen for restoration are exposed to tidal fluctuations of the water on a regular basis (Lewis et al., 2019; Zimmer et al., 2022).

However, it is not only chemical and physical factors that are of importance. The attitudes in the local communities must be evaluated in advance of any activity related to rehabilitation. It is necessary that local people are positive towards activities related to the restoration of mangrove forests and that there is a willingness to take a part in the rehabilitation and protection of the planted mangroves. To achieve positive attitudes often requires targeted information campaigns that provide data regarding

the benefits to the society and to individuals of recreating the natural vegetation, and the inclusion of the locals in the entire restoration process (i.e., from planning to execution and monitoring).

2.2 Preparation of a conservation plan

A conservation plan (to be developed) is a wider and more holistic plan than the strategy plan. The focus of the conservation plan is the Niger Delta as a whole. Obviously, the mangroves and other ecosystems of the Niger Delta are closely interlinked with those of Ogoniland and therefore the two plans are to some extent connected. The conservation plan for the Niger Delta will discuss and describe what needs to be done in the delta in terms of protection of the environment and rehabilitation of mangroves and other natural ecosystems in order to promote sustainability and improve the living conditions for present and future generations. For further discussion about the conservation plan for the Niger Delta, see chapter 8.

3 SCOPE OF THE REPORT

The present report is geographically focused on Ogoniland for the mangrove restoration part. This means primarily the four LGAs Eleme, Gokana, Khana and Tai - and the mangroves to the south and west (Figures 6 and 9). The more visionary and ambitious section of the report is targeting the Niger Delta as a whole.

The report concentrates on the conditions necessary for successful rehabilitation of the mangrove environment, and how to carry out the restoration of this environment in areas that have been affected by oil spills, but also in areas where the mangroves have been degraded due to other reasons. Hence the report will discuss the effects of oil contamination of the soils, the requirements in terms of how much contamination the vegetation can tolerate, the need for viable and healthy seedlings, the need for protection from invasive species as well as from people who may damage the plants. The report will also discuss socio-economic aspects, awareness building, and Information sharing.

The conservation plan focuses on the Niger Delta as a whole. To a large extent the rest of the delta has suffered from similar environmental degradation as Ogoniland. Therefor environmental protection must be stepped up. Areas that still contain diverse biodiversity must be protected as a matter of urgency. In Chapter 8, examples of such areas which may form a network of protected sites which, to some extent, meets the criteria for being designated as Ramsar sites, are discussed.

4 KEY ELEMENTS OF DESTRUCTION OF WETLANDS IN OGONILAND WITH NEIGHBORING AREAS TO THE WEST AND SOUTH

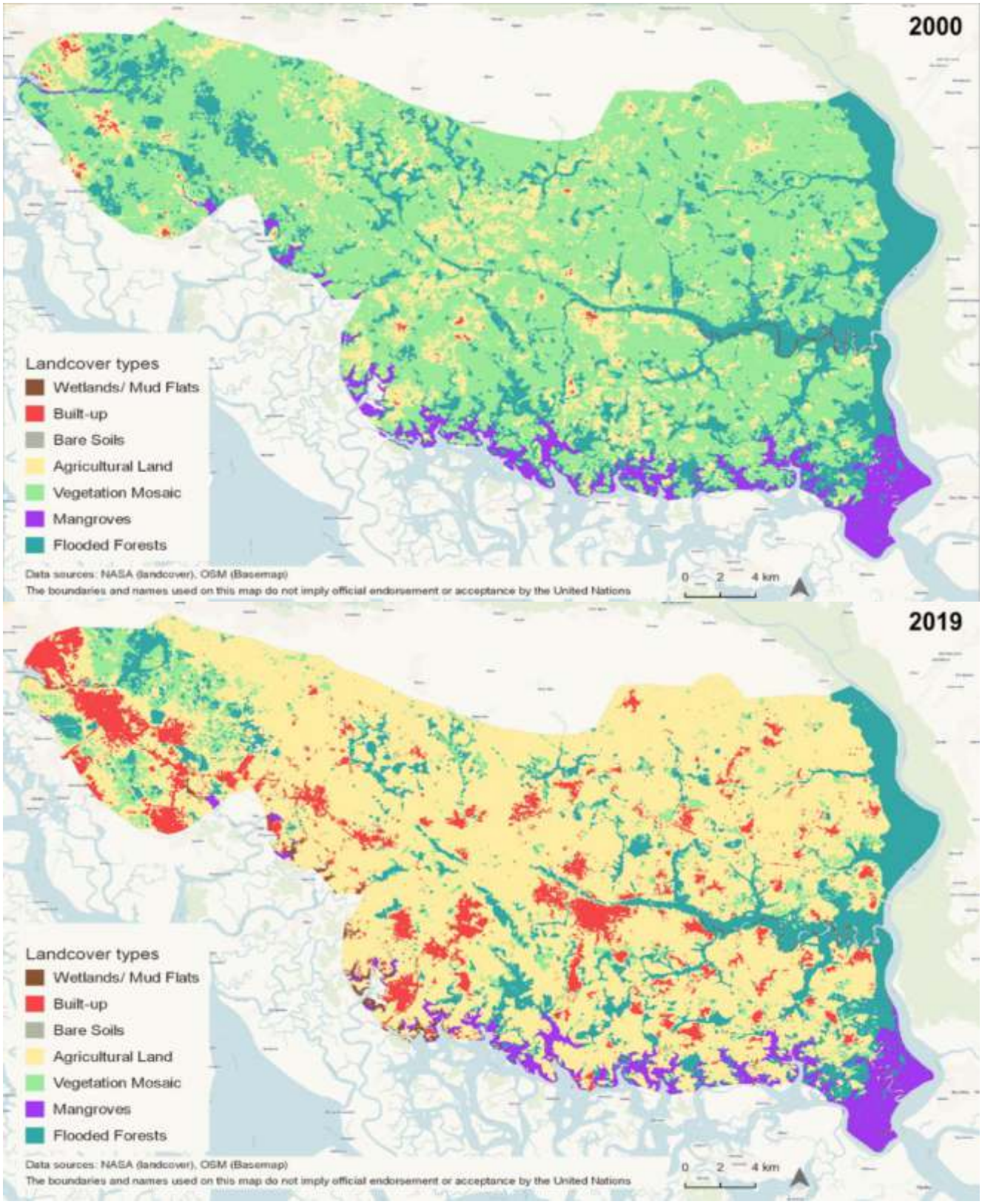


Figure 10. Land cover changes in Ogoniland between 2000 and 2019. Note the very significant increase in built up areas and agricultural land and the corresponding decrease in vegetation mosaic which stands for more or less forested areas.

As can be seen in Figures 10, 11 and 12 there have been dramatic changes in the Niger Delta landscape in the last decades. The changes are greatest when it comes to deforestation including reduction of areas covered by swamp forests ("flooded forests") and mangroves, expansion of farmland ("secondary/open tree covered areas and "tree/grass mosaic") and the expansion of housing and settlements. The main explanation for these dramatic changes is obviously related to the rapid population increase in the country including the Niger Delta and poorly regulated resource exploitation (Ayanlade and Howard, 2017; Enaruvbe and Atafo, 2014). The population increase is around 2.6% per year which means a doubling in a little more than ten years. This explains the increase in urban/built up areas and the increase in agriculture and farmland.

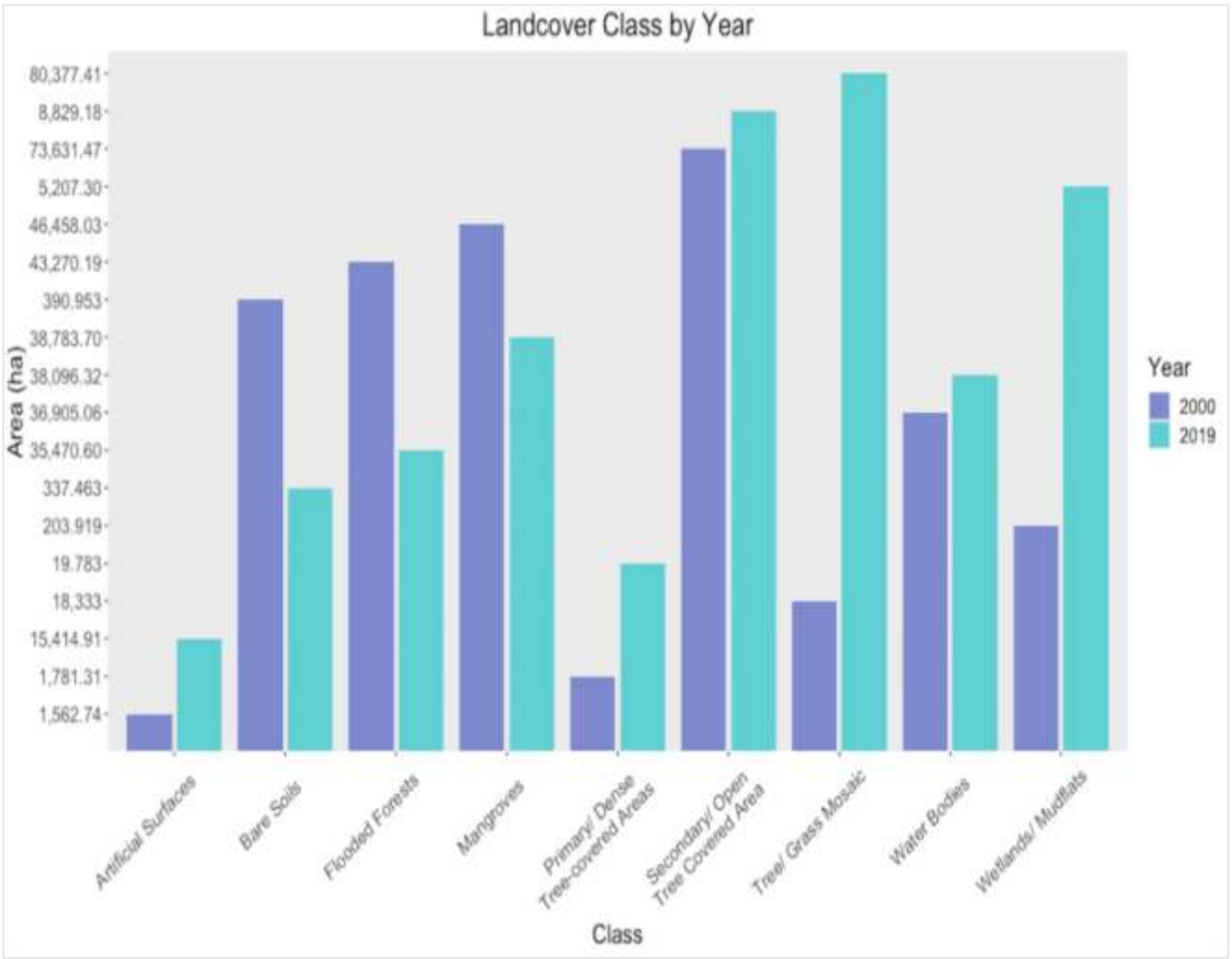


Figure 11: Land cover class changes year 2000 and 2019 measured in ha (source: NASA).

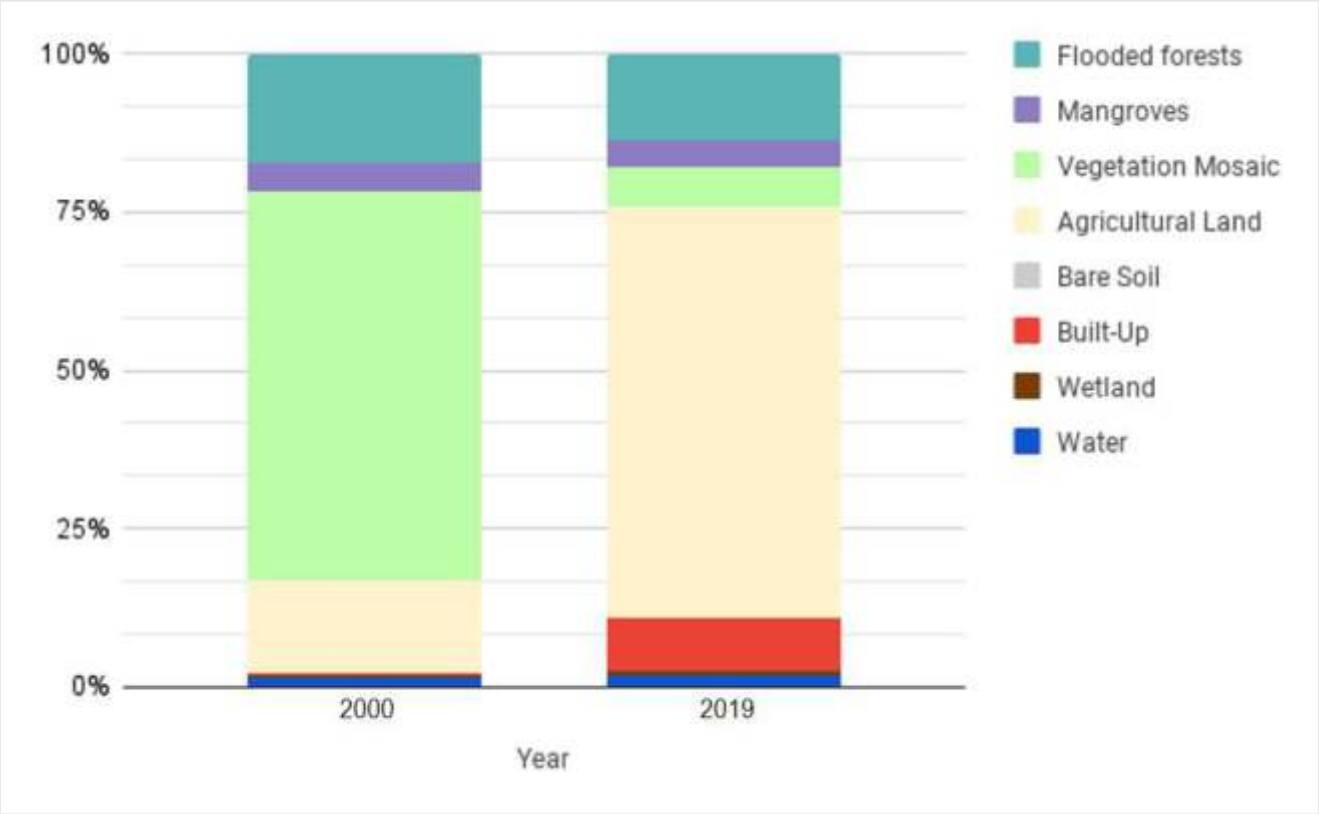


Figure 12: Land cover class changes year 2000 and 2019 as a percentage (source: NASA).

4.1 Oil exploration and production activities

Oil exploration in Ogoniland started in the 1950s and extensive production facilities were established during the following three decades. The most important export facility is the Bonny Terminal. The operations are managed by Shell Petroleum Development Company (Nigeria) Ltd (SPDC), a joint venture between Nigeria National Petroleum Corporation (NNPC) and Shell International, Elf and Agip.

During the exploration phase, long before any oil had been produced, a number of environmental impacts may have occurred. Hence land surveying, clearance for roads, housing of staff, seismic lines, etc., all cause direct impacts on the environment. Indirect impacts are caused by increasing pressure from other human activities in the areas which become accessible due to the exploration activities. Accordingly, hunting and agriculture will expand as a result of oil exploration in previously more or less virgin areas.

When exploratory drilling starts there will be impacts due to exhaust from machinery, deposition of drilling-muds (often containing a range of more or less toxic chemicals) and produced water, gas flares, and eventually also oil spills.The activities related to oil exploration and production have taken place in all types of environments throughout the delta. However, the types of activities carried out in freshwater swamp forests and mangroves often lead to oil spills which are easily spread by tidal water movements and flooding in connection with heavy rains (UNEP, 2011; Linden and Palsson, 2013; Gundlach, 2018).

The oil exploration and production of oil in Ogoniland came to a stop in 1993 after several years of protests by the local communities against oil spills and gas flares (Mitee, 1999; UNEP, 2011; Zabbey and Uyi, 2014). Even though no oil has been produced in Ogoniland since 1993, spills of oil have continued from old installations and from pipelines carrying oil produced outside of Ogoniland and passing through the area (see Figure 5).

Spilis may be caused as the result of corrosion and badly maintained oil infrastructure but also, to a large extent, from stolen oil in connection with "tapping". Tapping is the term used in the delta to describe how oil from an oil installation is removed for example by drilling a hole in a pipeline and putting a tap over the hole (SDN, 2012; Katsouris and Sayne, 2013; Naanen and Tolani, 2014; Social Action, 2014). Unfortunately, often no tap is installed, and the site is left after buckets and drums have been filled. The leaking oil contaminates the surrounding environment and often substantial areas are affected.

4.2 Artisanal refining activities

Artisanal, or illegal, refining of crude oil at a village level to produce fuel oil, kerosine, and diesel has been going on for less than two decades in the Niger Delta. The distillery process is simple using drums and pipes. The crude oil in a drum is heated from an open fire fed either by wood, petroleum or vehicle tires or a combination of these. The volatile part of the oil is led through pipes to other drums for cooling and condensation. The crude oil comes from illegal tapping of pipelines or other oil infrastructure.

The process of artisanal refining is extremely dangerous to those involved in the activity. Explosions and fires are common and there are frequent fatalities every year. In addition, artisanal refining extraordinarily contaminates the environment resulting in air pollution and local spills around the sites where the activity takes place. Also, when oil is tapped from the source such as a pipeline and transported to the artisanal refinery, spills occur frequently (Linden and Palsson, 2013, Little et al., 2018, Naanen, 2019). The quantities of oil spills into the mangrove areas due to oil theft and illegal refining is probably significant but independent estimations are not available.

At present it is possible from satellite images to identify more than 200 sites within Ogoniland where this type of refining of crude oil is going on or did so until very recently (Figure 13). Reports as of 2021 suggest that several of the artisanal refineries have stopped operating probably due to high presence of military personnel. Other reports indicate that the sites have shifted to new locations (Figure 16).

Oil theft and illegal artisanal oil refineries within the Niger Delta creating areas void of any vegetation (UNEP, 2019).Oil theft and illegal artisanal oil refining is a major threat to the environment and health of the people of the Niger Delta. The 2011 UNEP report on the environmental assessment of Ogoniland highlights the challenge of achieving effective and sustainable cleanup, remediation and restoration of degraded environment while pollution from oil theft and artisanal refining subsist "mopping the floor while the tap is on”.

Figure 13: Illegal oil refineries within the Niger Delta Creating area void of any vegetation (UNEP, 2019)

Artisanal oil refining contributes to poor air quality (soot pollution) in the region with numerous health effects. While there is variability in the number of area specific artisanal refining camps in the region, the average (region-wide) trend (as of 2021) shows an increasing number of the camps and an escalation to further inland and upland areas.

For example, in Rivers State, new refining camps have been established in Emouha, Abua-Odua, Ahoada West and Ahoada East LGAS. Such is the case in the Ohaji- Egbena area of Imo State. In the Ogoni area, there is significant reduction in the number of camps due to high security presence in the Bodo Creek in support of the ongoing Bodo Mediation Initiative (BMI) Cleanup. Bodo Creek was one of the major hubs of refining camps in Ogoniland.

In addition, there is the Operation Crocodile Smile (operations by the Nigerian Army). in the form of troops based in four houseboats stationed between K.Dere and Boro. The military presence has reduced the incidence of artisanal refining in that axis. However, it is reported that some bunkerers queue up to pay "license fees" to the military. It appears that most of the refiners from these hitherto major hubs have migrated to other less military patrolled zones.

The reduced incidence in the neighbouring Bayelsa State has relapsed as new camps now exist in the Southern Ijaw and Otuasega area as well as other riverine communities with low policing. There are two new refining camps at Agbaa and Orkarki, south of Mbiama on the Orashi River. Spills from these inland freshwater areas will impact on mangroves downstream in the coastal zone. The industry is emerging (but not yet aggressive) in the Ibeno area of Akwa Ibom State.

Despite the Federal Government's modular refinery policy response intended to create, in part, new oil related jobs, it is likely that the incidence of artisanal oil refining will soar when the planned government policy of no subsidy for petroleum products would be enforced. This will be exacerbated within Ogoniland with the completion of the BMI activities within the next 12 months or so. Therefore, a robust and sustainable framework is needed to tackle the menace of oil theft and artisanal refining in the Niger Delta. To achieve this objective, it is necessary for HYPREP to initiate a national dialogue on the topic, involving representatives from all key stakeholders - and seeking the highest level of political support, both nationally and locally.

4.3 Road construction, sand mining and settlements

Despite the relatively moderate geographical extent of the Niger Delta, there are anumber of challenges when it comes to travelling within it. As mentioned above, thereare numerous rivers and creeks crisscrossing the landscape (Figure 14) and the waterlevel in these waterways varies significantly depending on rains and the tidal situation.

The mangrove ecosystem consists of species of plants (trees, shrubs, palms and ferns) that are adapted to fluctuations in salt concentrations and the water table induced by tides. If these oscillations cease for example due to the construction of a road-bank between the sea and the mangrove swamp, the typical mangrove vegetation will not survive. Instead, either a freshwater swamp will develop if the areais dry, terrestrial plants and trees will gradually encroach.

Similarly, the dredging of channels in mangrove areas will often change the local hydrology so that the mangrove ecosystem will start to evolve into a new type of ecosystem. Many parts of the Niger Delta have been affected by road construction and the dredging of channels, dykes, etc., for example in the form of increasing the waterflow in the dredged areas which will increase the erosion of sediments in mangrove areas. Road building proposals should adopt a more holistic approach involving the effects of the road banks on the local hydrology.

Another related problem is extensive mining of sand from the riverbeds and creeks. Such activities increase erosion and may degrade existing mangrove areas. In section 6.2, the implications of the expanded road networks which leads to expansion of the settlements and farmland are discussed.

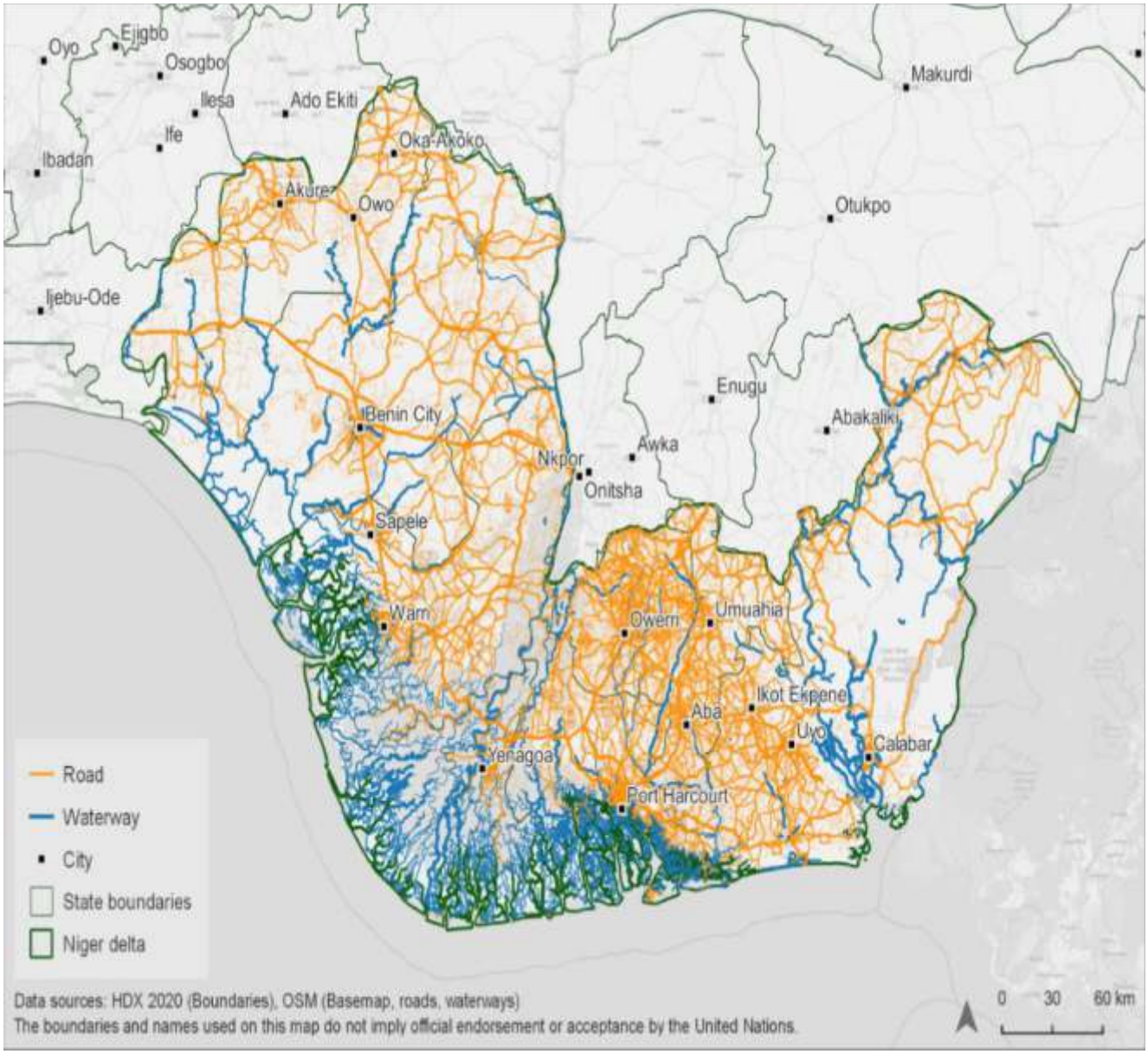


Figure 14: Roads and waterways within the Niger Delta.

4.4 Nipa palm invasion

In 2025, it will be 100 years since nipa palm was introduced to the coast of Nigeria with the erroneous intention to protect the shoreline against erosion. Nipa seedlings from Singapore were first planted on the shores of Calabar in 1906, followed by transplanting to Oron and Opobo in 1912, and the additional planting of 6,000 seedlings imported from Malaysia in 1945.

Being an invasive mangrove palm, and coupled with degrading human activities, nipapalm keeps spreading tremendously (see key references in Zabbey and Tanee, 2016) (Figure 15). A recent estimate indicates nipa palm now occupies 11,447 ha in the Niger Delta, an alarming 600% increase between 2007 and 2017 (Nwobi et al., 2019).

Tidal currents aid the distribution of nipa palm fruits to new areas (Figure 16). Several human activities contribute to nipa dispersal. These include pollution, fragmenting of mangrove swamps with roads, pipeline and electric powerline, deforestation, and unregulated logging. These undermine the resilience and resistance of native mangroves and create access for nipa to invade and spread further.

Another driver of nipa spreading in the delta that is potent, but less emphasized, is the use of nipa fruits in falling gear fishing. Fishers in the delta throw pawpaw, coconut or nipa fruit into the river water and cast their nets on it. The fruit landing in the water attracts fishes that congregate around it, and they get captured by the cast net. The cast net fishers in the delta prefer to use nipa fruits since they are accessible in the creeks and underutilized in the region. The nipa fruit is usually either abandoned at the last fishing ground or discarded during the return trip or at the landing site where it will sprout and establish a colony

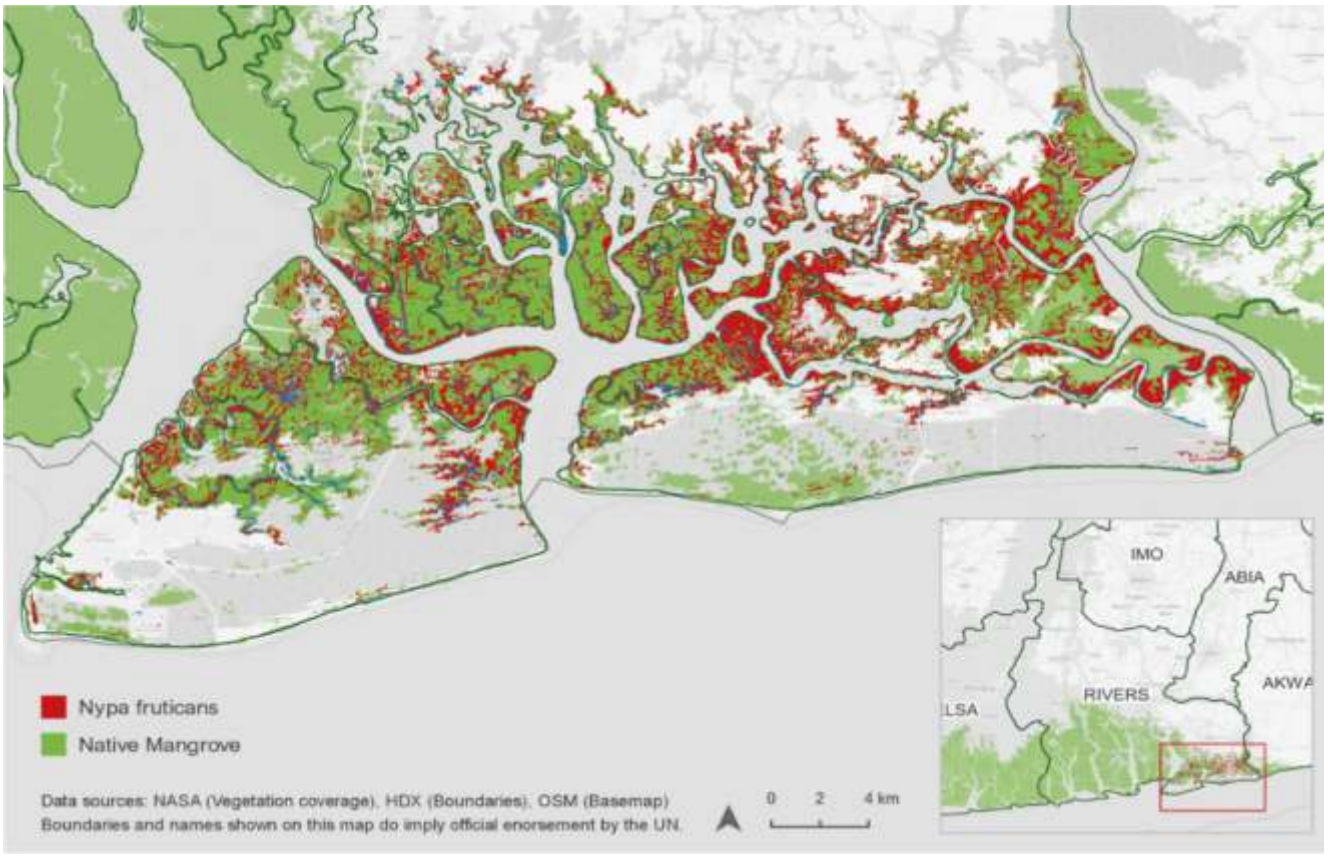


Figure 15: The extent of Nypa fruticans south of Ogoniland in 2020.

Figure 16: Nipa palms in the Niger Delta (UNEP, 2019).

4.5 Other impacts

Figures 10 to 12 illustrate dramatic changes that have taken place in Ogoniland including the mangrove areas in the south and west during the last 20 years. What is particularly obvious is the increase in built-up areas which are no longer confined to higher elevations but have now expanded into the mangrove areas. What also stands out is the dramatic increase in agricultural areas. Farmland (called "agricultural land" in Figure 10 and "tree/grass mosaic" in Figure 11) has increased more than four times between 2000 and 2019, from 18,000 hectares to 80,000 hectares.

The agricultural productivity in soils of the common type in the delta is often low. The limited use of agricultural inputs such as fertilizers means that yields are relatively low. A consequence of the rapidly increasing population is an increasing demand for products from farming for example cassava and yam. The result is the expansion of arming into marginal areas. The degradation of agricultural land has a central role in causing deforestation and exhausting soil fertility. Therefore, actions to address soil degradation are critical. The potential benefits are increasing agricultural output and prevention of expansion into mangroves and other forests.

VALUABLE AND UNDISTURBED MANGROVE STANDS

The Niger Delta, with its complex mangrove and swamp forest ecosystems, has a rich biodiversity of plants and animals. The delta is, in fact, a center of endemism in Africa (Luiselli et al., 2015). The opening up of the mangrove and freshwater swamp forest areas as a result of road construction and dredging of channels is a threat to the biological diversity of the delta (Zabbey et al., 2021). Increasing pressures from hunting and collection of forest products accompany improved access. Hunting is still a traditional source of income for many rural households. In a few cases, communities have protected small pockets of original forest for traditional reasons or religious purposes (shrines).

There is no mangrove conservation and restoration policy in Nigeria. Mangroves in the Niger Delta are communal resources, characterized by open access. The harvesting of mangrove wood for energy and other uses (e.g., net mending sticks, axe handles) as well as the reaping of the rich animal component for food is poorly regulated. However, few communities in the region have taken bold steps to conserve pockets of mangroves to sustain the numerous benefits (ecosystem goods and services) they get from them. A case in point is the Nwenua Mangrove Conservation Area in the Kono Creek, Khana LGA of Rivers State. Much of the Kono Creek mangrove area has been colonized by the invasive nipa palm since the late 1950s (NEDECO, 1961), except the Nwenua Mangrove Conservation Area, which has been precluded from exploitation and the protection is still subsisting (Zabbey and Tanee, 2016, HOMEF and CEHRD, 2021). The location of the Nwenua Mangrove Conservation Area and the contiguous farmlands is locally believed to be under the protection of Yor-ue Alior, an ancestral deity. Nobody is allowed to harvest the Nwenua mangroves. It has intact and luxuriant mangrove trees and it is a "safe" space for a rich colony of the grey parrot (Psittacus erithacus) that is now scarce in the Niger Delta. The complex root architecture of the Nwenua mangrove conservation area provides a secure space for a myriad of other species (e.g., juvenile fishes). It is a unique buffer zone for Kono Creek's productivity.

From the Industrial Directory of Rivers State there are few major industries in the Niger River Delta with the exception of the oil refinery and the fertilizer company. However, there are a number of small to medium size industries which may have a significant environmental footprint. These companies deal with transportation, service stations, workshops, etc., as well as wood products, plastics and synthetic fibers, rubber, cement and food industries.

Most of these industries are small and even if their waste management is not appropriate, the pollution footprint is in most cases small and local. The only industrial pollution of regional importance originates from the petroleum sector.

5 CURRENT STATUS

5.1 Mangrove areas are shrinking

Since UNEP's report in 2011, oil spills have continued from leaking pipelines and from tapping, spills from the transport of stolen oil and from artisanal refining. The frequency of spills and the number of locations where refining takes place has varied over the years. At present (October/November 2021) it is reported that the number of recent spills in Ogoniland as well as at locations where artisanal refining takes place in the area is comparatively low (Figure 17).

The National Oil Spill Detection and Response Agency (NOSDRA) Oil Spill Monitor? published data that shows nine times reduction in the number of oil spill incidents in 2021 compared to 2019 (36 in 2019 compared to four in 2021).

However, a large number of sites are heavily contaminated with oil and tar. There are at least 200 sites where artisanal refining has taken place in the area to the east of Bonny River. The maps show the location of oil damaged mangrove areas and the location of artisanal refineries.

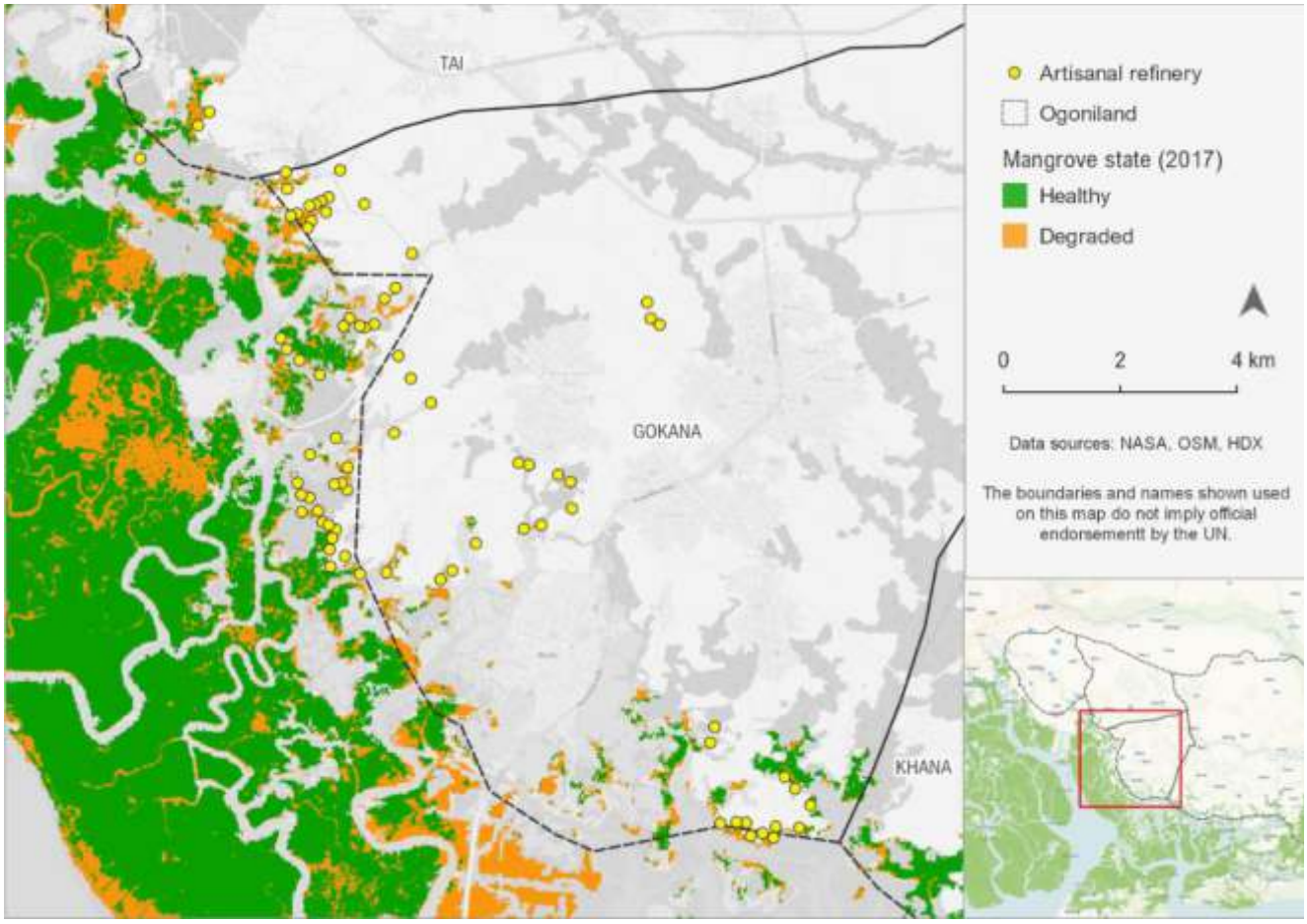


Figure 17: Artisanal refineries within and neighboring Ogoniland as of 2020.

[2] NOSDRA Oil Spill Monitor: https://oilspillmonitor.ng/

Based on the images (Figures 10 and 17) it is possible to calculate the size of the area in Ogoniland where mangroves and freshwater forests have disappeared in 2019 compared to 2000 to an area of approximately 16,000 hectares in size. If the areas that are tagged as "bare soils" are added the figure increases to over 21,000 hectares.

Also, in the Niger Delta as a whole, there have been very significant changes in the land-use similar to what has taken place in Ogoniland. Large areas of mangroves and freshwater forests have been degraded and the biodiversity is being lost at a rapid pace due to various human activities.

One way of halting the loss is by designating and maintaining as many Ramsar sites as possible. UNEP (2011) recommends declaring mangrove wetlands in Ogoniland as Ramsar sites as one of the pathways to sustainability. This report reinforces that recommendation.

In addition, there are several sites in the larger Niger Delta that meet, at least, one of the nine criteria for designating Ramsar sites. This topic with concrete examples of at least nine geographical sites is discussed further under section 8.2 below.

5.2 Ongoing restoration activities

In some places in the Delta, attempts have been made to rehabilitate the vegetation. The most significant such case is the BMI (Figure 18). Here about 817 ha of mangroves are being planted at this moment. This means planting of 1.5 to 2 million seedlings. During the last five to six years, the BMI has developed methods and strategies to restore the mangrove vegetation in areas where this ecosystem has been destroyed. There are a number of lessons from the BMI that are highly relevant to a larger restoration initiative in Ogoniland, see for example Gundlach et al. 2021.

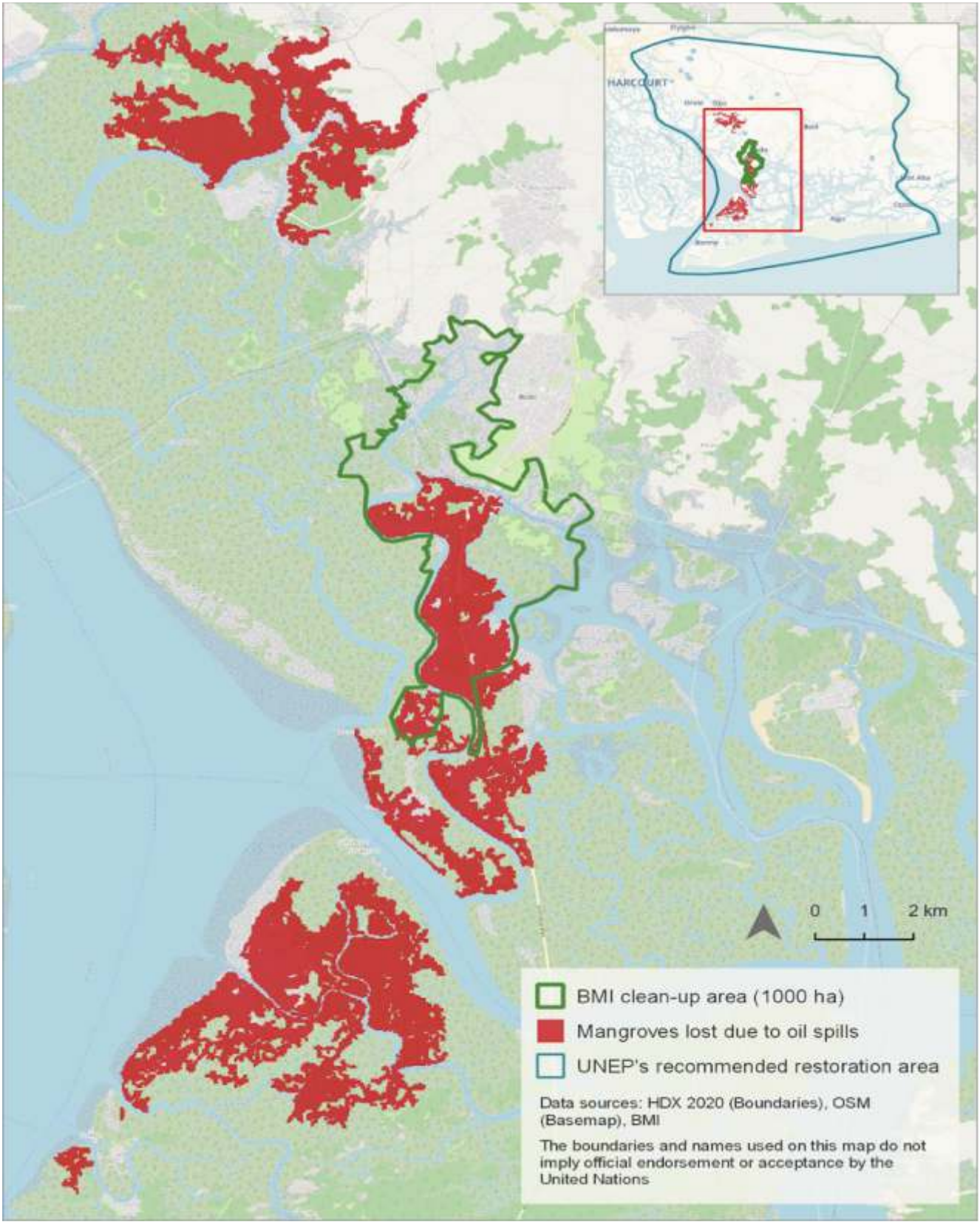


Figure 18: BMI clean-up area for Phase two.

6 FUTURE THREATS TO THE MANGROVES AND SWAMP FORESTS OF THE NIGER DELTA

A large number of factors are negatively affecting the mangrove vegetation, freshwater forests and in general the biodiversity in the delta. From the satellite maps it is easy to see how the urbanization and expansion of farmland are changing Ogoniland and the larger Niger Delta (Figures 10, 11 and 12). Urbanized areas have more than doubled in size since the year 2000. The conversion to agriculture is even greater.

6.1 Oil exploration and production

At present the future plans for exploration and production in the Niger Delta are somewhat unclear. Shell International has announced it intends to divest from SPDC and talks are reported to be taking place with the Government and potential buyers (see for example Nairametrics 2021). The focus of Shell's divestment is the onshore facilities with the intention of keeping its offshore activities. However, the divestment has reportedly been challenged in court (Offshore Technology 2022).

6.2 Expansion of settlements and the road network

Several major road projects are presently planned or being implemented in the Niger Delta. When completed, these roads will lead to the expansion of settlements as a result of improved accessibility. Work on two major projects within two major LGAS and extending beyond Ogoniland are expected to significantly improve the socio- economic outlook of the region in the coming years but at the same time will increase the pressure on the local environment. During the construction phase debris and sediment will find its way into swampland. Along the roads, settlements will expand and the natural environment will be transformed into farmland.

The Saakpenwa-Bori-Kono Road is a new construction which runs from Tai LGA through Gokana LGA to Khana LGA (Figure 19). Phase two of the road project which starts from Bori to Kono has now commenced. It is a 17-kilometre road and cuts. through several Ogoniland towns and communities.

The Bodo-Bonny Road, Rivers State, is the first road link between Bonny Island to therest of Rivers State. It is a very large infrastructure development project in the Niger Delta and will result in the continued development of Bonny Island which is considered a key industrial area in Nigeria as it is tied to the economic development of the nation as a whole.

Technically, this road is a very significant undertaking with many constructionchallenges due to the low-lying marshy area, muddy and swampy soil conditions and considerable tidal movements. The scope comprises construction of a 39 km long road, cross culverts and two mini bridges with a span of 23 m each as well as two creek bridges, "Afa Creek" Bridge of about 530 m length and Nanabie Creek Bridge of about 640 m length, in addition to the construction of a major river bridge of about 750 m length over the Opobo Channel.

Substantial dredging activities and a number of specialized soil stabilization methodologies are being carried out. The road runs 38 km across mangrove terrain. The road embankment may alter the hydrology of the network of creeks and mangrove swamps locally. In total 17 small and large bridges, 36 m to 713 m in length, will be built. About 3.1 million m^3 of sand are being dredged for the road construction activities. It is also anticipated that settlement expansion and farmland expansion will occur as a result of improved accessibility, as well as a major expansion in socioeconomic activities for Ogoniland communities along the entire road stretch.

Figure 19: Bodo-Bonny Road under construction and due to link the LGAs of Tai and Khana

There are also plans for several railroads which will affect the Niger Delta (Figure 20). One railroad is planned from Port Harcourt to Calabar with an arm to Onne in Ogoniland. Another coastal railroad is planned from Lagos to Calabar. These are Federal Government projects. Several Ogoniland communities in Eleme LGA are likely. to be affected. Settlements will expand as well as farmlands.

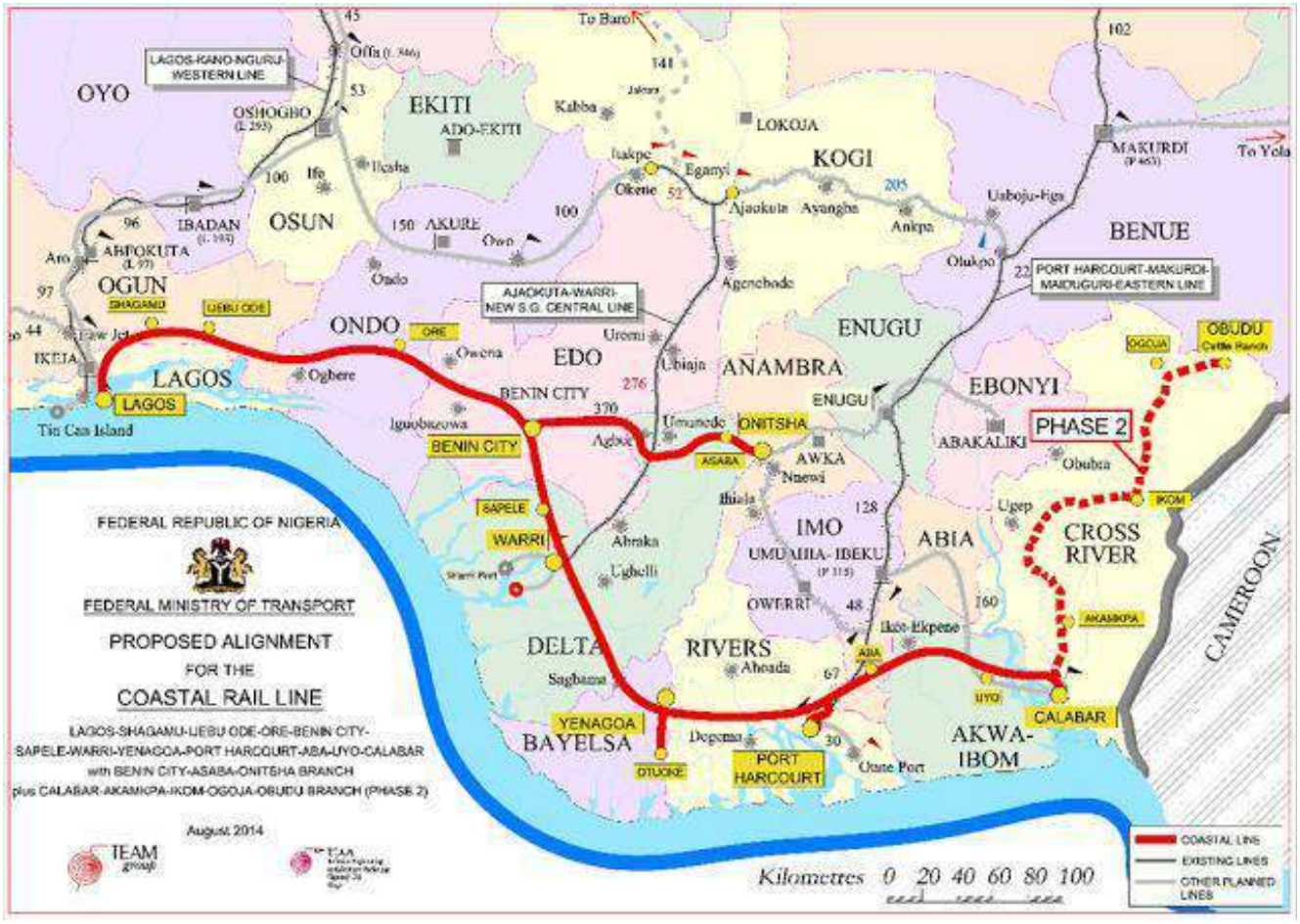


Figure 20: The plans for rail roads through the Niger River Delta.

6.3 Expansion of farmland

As communities expand into new areas opened up by road expansion, the likelihood of farming settlements expanding is very high as subsistence agriculture remains the predominant method of farming in Ogoniland.

The communities flanking either side of the newly constructed roads and bridges are expected to see development and construction activities moving outwards from currently habited areas towards the direction of new infrastructure. For further discussion about this topic, see section 4.3 above.

6.4 Climate change

The changing climate is affecting the Niger Delta as well as the entire country. Flooding as well as erosion along the coast and the barrier islands have characterized the environment of the delta for millions of years.

However, recent climate change has led to longer seasons of drought and more frequent and heavier rains which are affecting the natural environment, agriculture, and people's lives. Floods are now regular phenomena in the delta, affecting millions of people every year. In 2019 and 2020 about 1.9 million and 1.3 Nigerians respectively were temporarily displaced due to floods according to the National Emergency Management Agency (NEMA 2020).

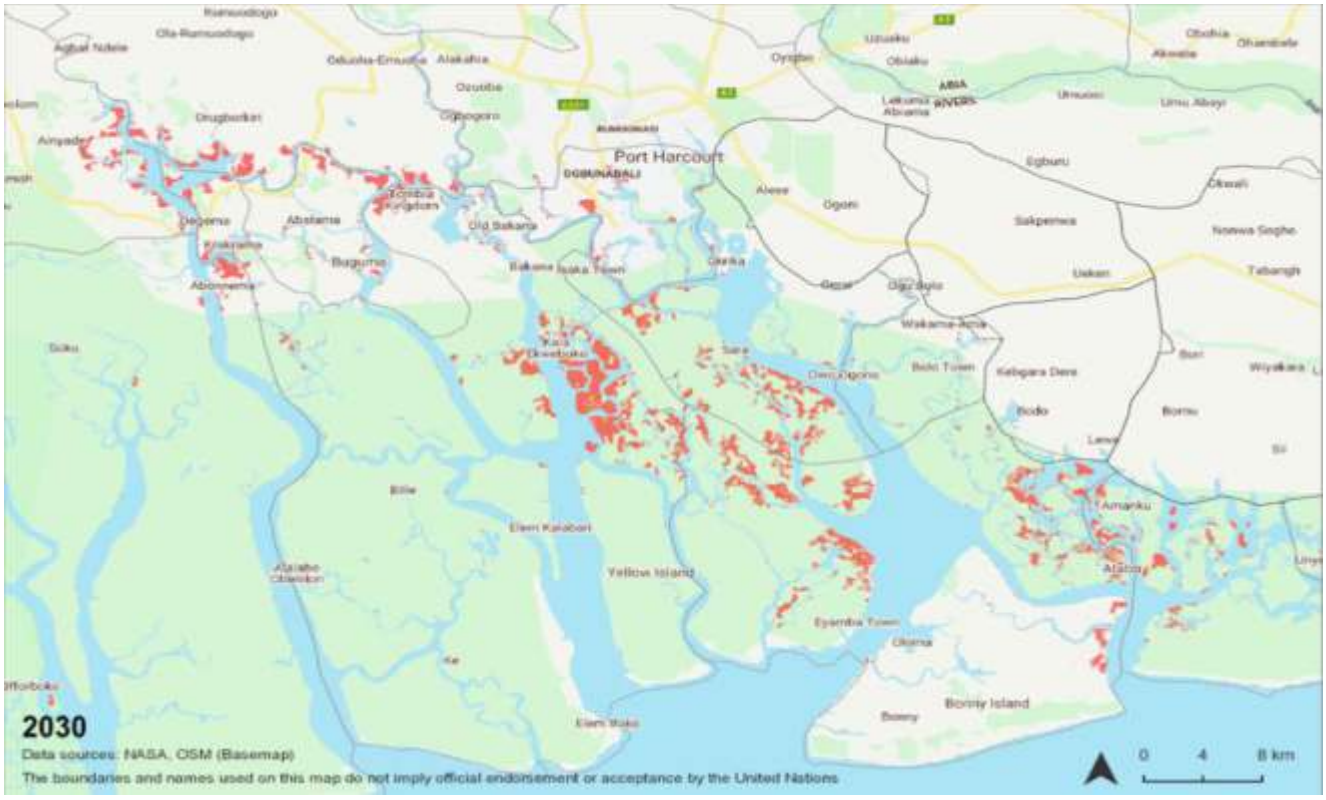
With increased urbanization, flooding during the last several years has affected more people than ever and resulted in loss of agricultural land as well as damage to houses and infrastructure (Figure 21). The deforestation and the loss of swamp forests and mangrove vegetation amplifies the problems related to floods.

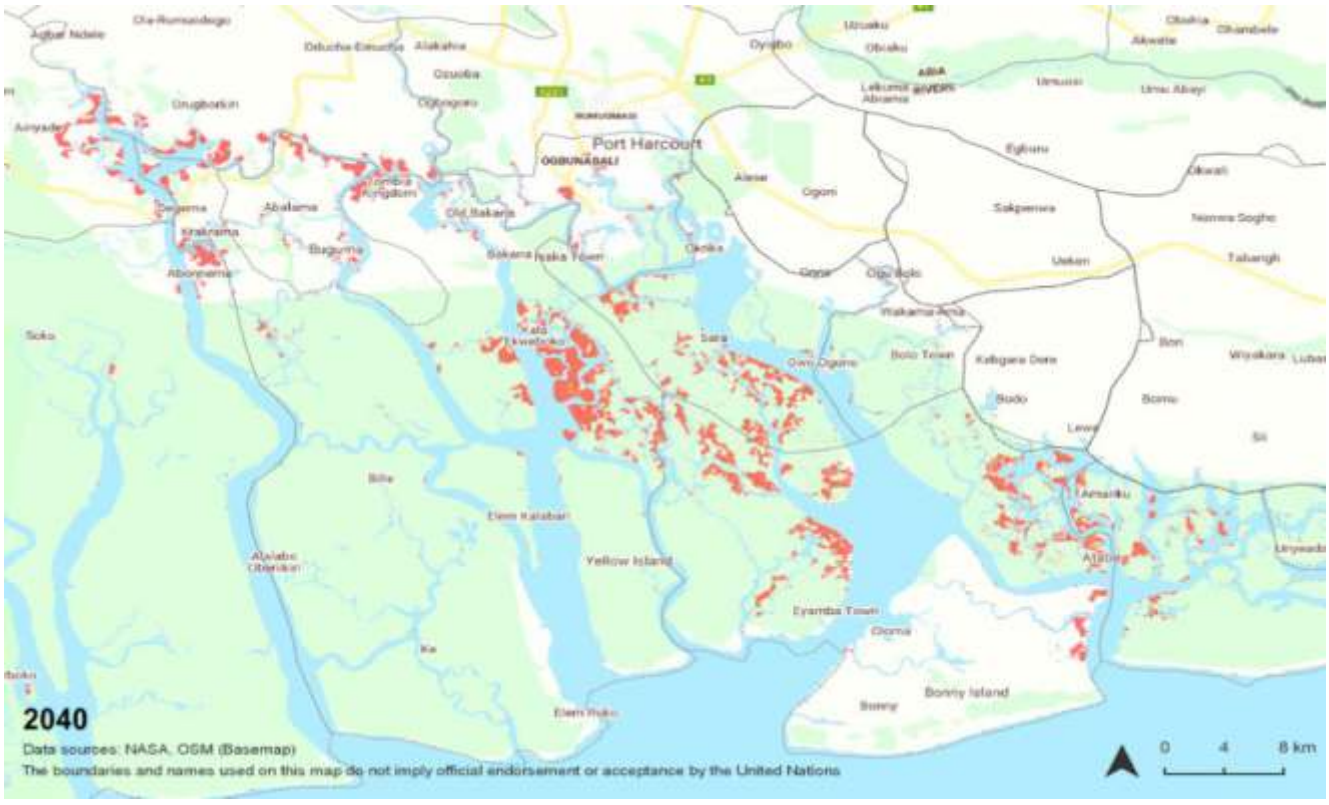
Large parts of the delta are only a few meters above sea level. With increasing sea levels, increasing portions of the delta will experience more problems with floods. The maps (Figure 22) show future decadal scenarios illustrating the sea level rise. According to the IPCC scenario for the Niger Delta, a one-meter increase of the sea level would cause flooding over about 18,000 km² or 2 percent of the land area of the country.

Figure 21: (a) Settlement in Ogoniland prone to flooding (UNEP 2019),

(b) Photo from 2018 of Niger River floods in Bayelsa State (Modupe Gbadeyanka, 2018).

However, it should be pointed out that catastrophic flooding may happen long before what the IPCC scenarios predict or are indicated on the maps below. This is because it is the combination of wind direction and speed, high tides and excess river water that cause the catastrophic situations.





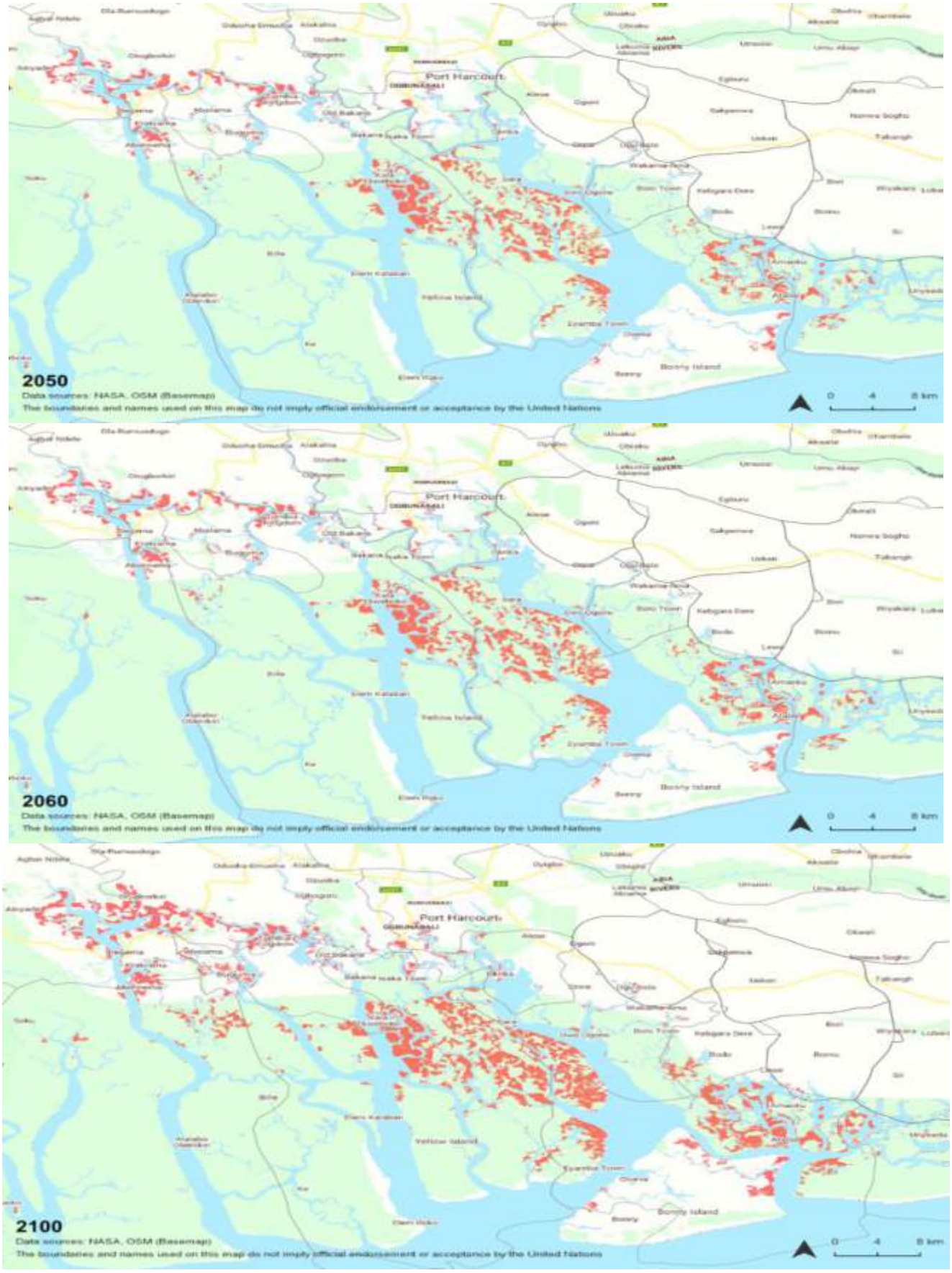


Figure 22: Sea level rise predictions from 2030 to 2100 for the Niger Delta. The maps illustrate which areas will be affected by rising water levels in the case of the IPCC RCP 45 scenario.

7 RESTORATION PLAN

BMI provides the basis for a roadmap for the methods and strategy for an expanded remediation and rehabilitation project in Ogoniland with surrounding mangroves to the south and west (Gundlach et al. 2021).In order for restoration of mangrove vegetation to be successful a number of factors related to the selection of sites, the combination of species, the engagement of local communities, future threats, etc., have to be considered.

The selection of suitable restoration sites is critical. Site assessment may start with satellite imagery, aerial overflights or drones to determine possible sites, the extent of the sites, possible threats to the planted mangrove seedlings, etc.

Possible sites must be confirmed by thorough ground-truthing (field confirmation). During such field investigations, data should be collected regarding the extent of oiling on the surface as well as how deep the oil has penetrated into the subsurface layers (down to 25-40 cm). Surviving plants as well as other biota shall be examined.

7.1 Creating the desired hydraulic situation for restoration

As mentioned previously, mangrove ecosystems are adapted to tidal variations and can only exist where there are suitable variable water conditions. The mangrove seedlings should be planted at sites where there is an influence of tides so that the plants are partially inundated several hours per 24 hours. The tides in the delta are diurnal. If the tidal influence is too weak, other species of trees and bushes will gradually take over the area.

7.2 Creating the desired sociological situation for restoration, including community involvement

For restoration to be successful, participation of the local community is key. Representatives from the local communities should be involved in deciding on the objectives of the work, the technical planning for restoration as well as monitoring of the success of the effort. Informed community representatives (i.e., individuals with indigenous or technical knowledge) should be included in the planning, operational, and monitoring teams of the restoration project. Such community delegates should include direct users or beneficiaries of the ecosystem goods and services of the intended restoration sites (e.g., fisherfolks, especially women) who integrate their expectations into the recovery framework.

Community participatory approaches will enable communities to drive the development and take ownership of the process in a manner that enables them to protect its implementation process and progress. Community participation can be promoted through intensive awareness building and information campaigns which should target all groups.

7.3 Stopping ongoing threats

The importance of stopping ongoing oil spills cannot be overemphasized. Mangroves can tolerate quite high concentrations of oil in the sediment, but fresh oil contaminating prop-roots, pneumatophores, propagules and leaves will very often kill the mangroves. Therefore, new and fresh oil spills must be prevented if the restoration should succeed.

Clean-up of heavily oiled sediments can be done through flushing of the sediment with water under high pressure. The water is pumped from a boat with a high-pressure pump which pushes water through hoses equipped with a metal one-meter-long nozzle. The nozzle is inserted into the sediment and the pumped water will liberate contained oil and transport it in the sediment to the surface. The oil can then be collected by absorbents or using shovels.

Floating oil must be contained and concentrated by oil containment booms. Clean-up of oil on the surface of the sediment can be done using raking and tilling as well as flushing. The surface of the sediment is often covered by tar and a mat of algae. It is important to remove such tar and algae in order to oxygenate the sediment. Tilling may also support natural degradation by oxygenating the contaminated sediments. Manual shovels may be used but care must be taken not to push surface oil into the sediment. Therefore, heavy equipment cannot be used, neither should chemicals such as dispersants or hot water because of the negative impacts such treatment will have on the environment.

It is important to collect and remove any oil or tar that is removed from the site in order to prevent the contamination of new areas. Oil and contaminated material shall be assembled at a temporary central storage facility and from this storage facility transported to a government approved treatment facility.

7.4 Mapping of areas needing restoration and tools for such mapping

In order to map areas in need of restoration, a workplan should be developed using Geographic Information Systems (GIS) and site observations to determine the variations in the elevation of the area in question. A technique which may simplify the work, and subsequent monitoring activities, is to grid and map the areas to be planted. The Bodo Mediation Project has developed such techniques for the Niger Delta (Gundlach et al. 2021).

7.5 Removal of hydraulic barriers

In areas where the normal water fluctuation has stopped due to road construction for example, it may be possible to restore some of the previous conditions by opening the road bank and putting in bridges and road drums/culverts. To achieve conditions that resemble the natural situation, several bridges and road drums should be established to allow enough volumes of water to flow. Recommendations for such restoration should be prepared by the Federal Ministry of Environment and submitted to the Ministry of Works for implementation.

Furthermore, when new roads are planned, the circulation of water must be secured by building bridges and installing culverts. In planning new road construction, it is important that the planners and developers are educated about the importance of these aspects.

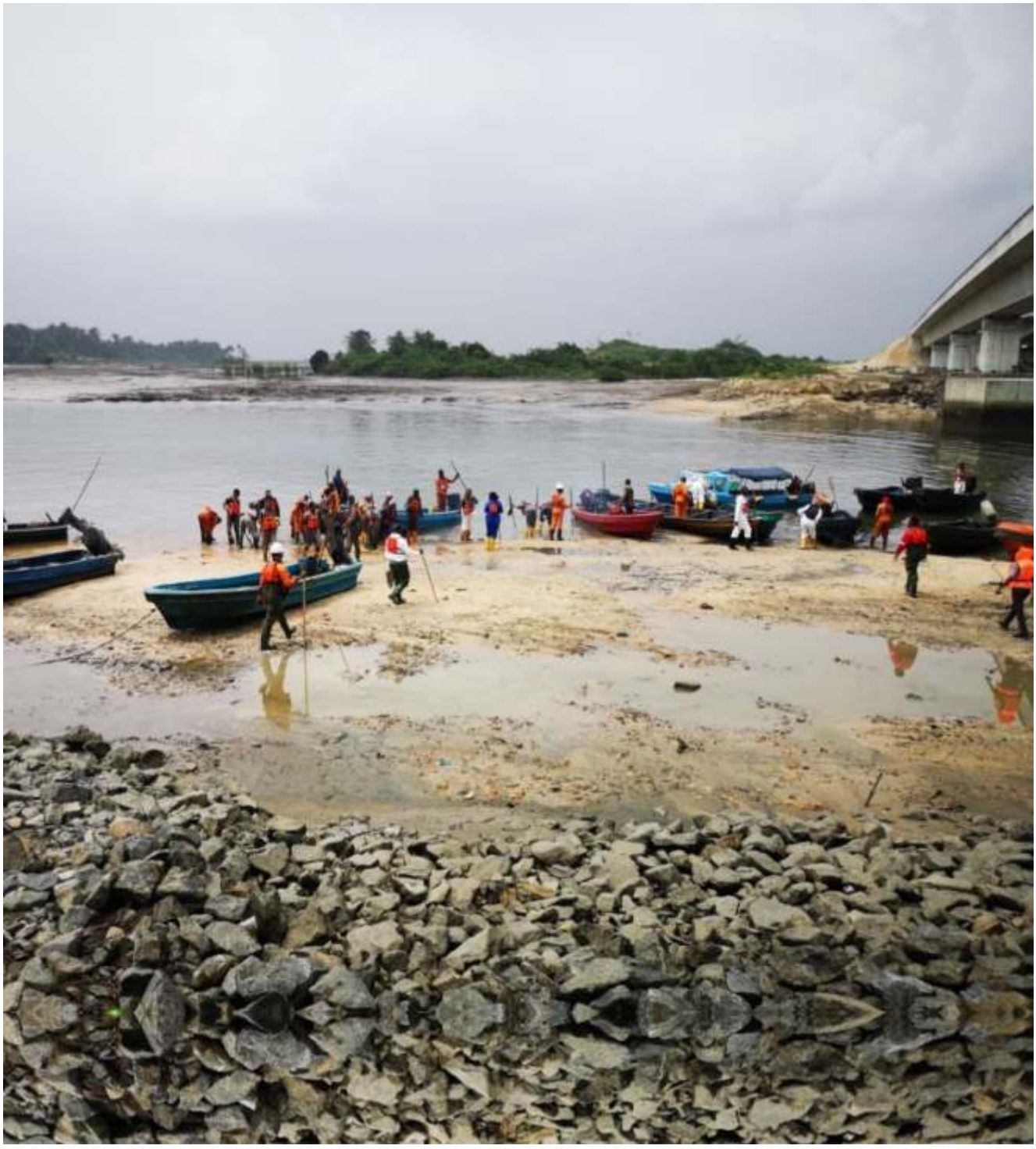


Figure 23: Patrick's Landing (Sivibilagbara) is the point of departure for Bodo cleanup operations. It is located between the bridge in construction (right) and newly planted mangroves (across the water to the left).

7.6 Approaches to restoration

Restoration of mangrove areas has been attempted in many regions around the world where mangroves have been degraded or destroyed. There are many reasons for undertaking such restoration measures, which include the benefits ("goods and services") that well-developed mangrove areas provide to local communities.In addition, there is a growing interest to plant mangroves in order to utilize their capacity to sequester carbon. Mangroves may have been destroyed because of cyclones/hurricanes, flooding, or overharvesting (Marois and Mitsch, 2015; Smith e al., 2009).

Furthermore, mangroves are sometimes planted in attempts to restore areas where aquaculture for fish or shrimp has been carried out (Primavera and Esteban, 2008; Zimmer et al., 2022). Restoration of mangrove vegetation after oil spills has also been carried out in some cases in different parts of the world, including in Panama, Mozambique, Kenya and the Philippines.

The world's largest mangrove restoration project as a result of oil spills is presently carried out in the Bodo community in Gokana, Ogoniland the BMI project. The planning for this project started in 2013 and the actual field work in the oil contaminated areas started in 2015. At present (September 10, 2022) 817 ha have been cleaned from oil and partly planted with 1.5-2 million plants.

Before any restoration is started the existing oil contamination of the area must be investigated and, if necessary, removed. Based on the results from such an investigation the strategy and techniques for mangrove restoration can be determined.

There are various techniques for such initial surveys. In the Bodo project, a Shoreline Cleanup and Assessment Technique (SCAT) has been adapted to the Niger Delta conditions and applied in the work. SCAT is an internationally accepted scientific method for assessing oil contamination levels and suitable clean-up techniques for shorelines.

The SCAT method applied in the Bodo project, developed by the BMI in its SCAT Manual (Story et al., 2022) determines the level of contamination at each location and, based on this assessment, the best clean-up technique for the different areas can be determined. SCAT teams should also monitor the effectiveness of the clean-up and recommend changes if necessary.

Clean-up methods vary depending on degree of oiling and the characteristics of the site under consideration. Heavily oiled soft muds may have to be cleaned using water flushing where water is pumped through a nozzle into one meter below the surface. Thereby most of the oil in the sediment will flow to the surface. If the degree of oiling is less, it may be enough to use rakes and shovels and possibly also low-pressureflushing to remove oil and avoid sediment removal.In order to prevent re-oiling, it is important to apply booms and use sorbents to preventspreading of the oil to new areas. Some agricultural waste material such as bagasse,straw from rice production, etc., may be used as sorbents. For this stage of the clean-up to be effective it is important that the booms are constantly monitored andadjusted so that shifting currents and tides will not make the booms ineffective.

A key principle that has been established within the BMI is to prioritize areas near communities before starting with more distant areas. Cleaning areas near settlements as the first priority will create goodwill among residents who have suffered from oil contamination.

Even after very intensive clean-up there will always be some oil left and it is important to remember that at some stage further clean-up will do more harm than good when the integrity of the environment such as the sediment structure is highly altered.

It is also important to understand that mangroves are quite hardy and can tolerate certain levels of oil in the sediment. Overtime, the mangrove plants also help to reduce the level of residual oil in the sediment by increasing air inputs and thereby stimulating biodegradation ("phytoremediation").

7.7 Ecologically sensitive restoration

A mangrove forest is a complex ecosystem comprising the unvegetated low tidal mudflats, mangrove bushes and trees, and associated salt tolerant plants, as well as many invertebrates and vertebrates, and the interacting abiotic parts of the ecosystem. (e.g., salinity, temperature, sediment).

It is important that restoration efforts broadly target the return of the complex system. The restoration should not create a simple ecosystem with only one or two species of mangrove plants. It is also wrong to try to vegetate, or plant in, the naturally unvegetated low tidal flat. More so, a community such as a mangrove forest exhibits structural and functional attributes that should be targeted during the restoration. There are mangrove species with varied relative abundance depending on distance to the seafront. Therefore, the restoration should try to mimic the zonation pattern in natural mangrove forests.

In addition, the restoration should aim at preserving the local species and not be based on species taken from distant areas. In the Niger Delta, the multiflorous red mangrove ***(R. racemosa)*** constitutes at least 70% of the mangrove plants. Other common species are ***R. mangle, R. harisonii,*** and ***A. germinas. L racemosa*** is less common, while ***C. erectus*** is rare.

However, because it is easier to nurse or plant directly the pencil-like propagules of the red mangroves, several restoration programs in the region have focused on planting red mangroves only. This practice must change to include all native species of mangroves. More so, the mangrove ferns ***(Acrostichum aureum*** and ***A. danaeilfolium)*** grow mostly in the high (landward) intertidal zone of the mangrove forest. The ferns can also grow at the channel fringes on elevated (berm) sediment and may survive an oil pollution assault. In some cases, ferns have been cut during the attempts to plant the woody mangrove species. However, the above ferns are mangroves and should not be removed when efforts are made to restore the woodymangrove species.

7.8 The use of remote sensing to support mangrove restoration and monitoring

Mapping mangrove extent is rather simple as mangrove signature is very characteristic and artificial intelligence already gives the possibility to produce accurate mangrove cover maps. In the future, it will be possible to merge information coming from multiple satellite sensors and combine more effectively optical and radar sensors to produce up-to-date and new generation mangrove maps with more details such as mangrove species, height of the vegetation, mangrove health, etc.

In the past years, Google has developed the Google Earth Engine platform where users from around the world can process thousands of satellite images directly in the cloud without downloading a single image. Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Scientists, researchers, and developers use the Google Earth Engine to detect changes, map trends, and quantify differences on the Earth's surface.

If satellite imagery can provide timely and actionable information on large territories, the use of drones for mangrove restoration monitoring will be key at all phases of the Niger Delta restoration, Drones can help plan restoration, monitor rehabilitation activities happening in the field and monitor the success of seedlings on the longer term.

Drones will also complement satellite imagery by providing sufficient details for training remote sensing algorithms. Drones will also provide new digital livelihood opportunities in the delta. Current drone regulation in Ogoniland and the Niger Delta should be reviewed, along with recommendations to regulators (the Military) to ensure they will authorize drone operations for Niger Delta restoration purposes.

8 CONSERVATION PLAN FOR THE NIGER DELTA

8.1 Objective of a conservation plan

As in Ogoniland, the Niger Delta as a whole, is experiencing increasing pollution, coupled with decreasing natural environments and biodiversity. In order to halt this negative development and enter a path towards sustainability, a conservation plan for the Niger Delta should be developed.

A Conservation Plan is a wider and more holistic plan than the Restoration Plan for Ogoniland, discussed above. The focus of the conservation plan is the Niger Delta as a whole. Obviously, the mangroves and other ecosystems of Ogoniland are closely interlinked with the environment in the delta as a whole.

The conservation plan (to be developed) should discuss and describe what must be done in the Niger Delta in terms of protection of the natural environment and restoration of the ecosystem including mangroves, freshwater swamp forests and other natural environments in order to protect biodiversity and promote sustainability and thereby improve the living conditions for the human population.A vision for the future should be to improve the management of the environment in the Niger Delta as a whole and make it possible for the human population to improve their standard of living in ways that do not lead to environmental degradation or endanger the biodiversity of the delta. Such a vision may entail the goal that a large portion of the Niger Delta in the future would qualify to become a site under the Convention on Wetlands, also called the Ramsar Convention.

The Convention on Wetlands is an inter-governmental environmental treaty established in 1971 by the United Nations Educational, Scientific and Cultural Organization (UNESCO). The treaty came into force in 1975. It provides for national action and international cooperation regarding the conservation of wetlands, and wise sustainable use of their resources. As of July 2021, there are 2,424 Ramsar sites around the world, protecting some 255 million hectares, and 171 governments are participating.

For a wetland area to be considered under the Ramsar Convention, one or several of the criteria listed below must apply:

- **Criterion 1:** 'it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region."
- **Criterion 2:** 'it supports vulnerable, endangered, or critically endangered species or threatened ecological communities."
- **Criterion 3:** "it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region."
- **Criterion 4:** "it supports plant and/or animal species at a critical stage in their life cycles or provides refuge during adverse conditions."
- **Criterion 5:** "it regularly supports 20,000 or more waterbirds."
- **Criterion 6:** "it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird."

- **Criterion 7:** "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."
- **Criterion 8:** "it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend."
- **Criterion 9:** "it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species."

Several of the characteristics of the Niger Delta make it a unique environment with very extensive natural wetlands supporting a number of vulnerable and threatened ecosystems and species, such as:

- Intertidal mud, sand and salt flats;
- Intertidal marshes;
- Intertidal mangroves and forested wetlands;
- Coastal brackish lagoons and estuaries;
- Permanent inland river deltas;
- Rivers, creeks and streams;
- Lakes and pools, and
- Freshwater swamp forests.

This means that several parts of the Niger Delta already meet one or more of the key criteria for becoming a Ramsar site under the Convention on Wetlands, However, there are a growing number of threats to the environment of the delta.

8.2 Scope of the conservation areas

More urbanized areas of the Niger Delta cannot be included in a Niger Delta conservation area. However, there are several parts of the Niger Delta that still possess valuable biodiversity often in the form of more or less intact mangroves and freshwater forests. Fourteen such sites are listed below.

Figure 24 below is the suggested locations of this assemblage of Niger Delta conservation areas. These would be areas where human activities must be managed in such ways that the economic development is not causing environmental degradation.

Depending on the commitments by local and central governments and the acceptance and willingness of the local communities to actively support and participate, the goal would be to be able to declare and effectively manage these parts of the Niger Delta as a network of protected conservation areas which may become Ramsar sites, before the end of the decade. The potential sites include:

- Andoni Game Reserve;
- Bonny Island Nature Park (Finima Nature Park);
- Lower Orashi River Forest Reserve;
- Taylor Creek Forest Reserve;
- Lower Imo River Forest Reserve;

- Upper Imo River Forest Reserve;
- Otamiri Forest Rreserve,
- Sombreiro River Forest;
- Ikwerre Estate Area Forest;
- Biseni Forest Reserve;
- Udoda Forest Reserve;
- Yar Forest Reserve;
- Akassa Coastal Wetland; and
- Ramos-Dodo-Pennington-Digatoro Area.

These prospective protected sites have special ecological attributes that fit the Ramsar designation criteria. For example, the African fish eagle (Haliaeetus vocifer), flocks of the white-face whistling duck (Dendrocygna viduata) and the African grey parrot (P. erithacus) have been sighted at the Finima Nature Park. The white-collared mangabey, the chimpanzee, the West African manatee, the African elephant, the olive colobus and the white throated guenon have been reported at the Taylor Creek Forest Reserve, while the Andoni Game Reserve has African elephants and hippopotamus.Figure 24. There are 14 sites which may qualify as Ramsar in the Niger Delta provided that effective management plans can be established and implemented

Figure 24: There are 14 sites which may qualify as Ramsar in the Niger Delta provided that effective management plans can be established and implemented.

8.3 Key stakeholders

Stakeholders which need to be engaged within the process of establishing the rules and regulations which are required to be able to declare the "Niger Delta Conservation Area" include the following:

- Central, regional and local governments;
- Local communities and community groups including NGOS;
- Representatives of the business community, and
- Academia.

8.4 Water management

Water is key to preserve and manage the environment of the delta. Activities that will, or may, affect water quality and water-flow through the delta must be assessed in advance through a rigorous environmental impact assessment (EIA) process. The current application of the existing EIA regulation (EIA act 86/1992) is not adequate. The EIA processes as applied in the delta are mostly seen as an administrative formality rather than a serious attempt to avoid environmentally destructive activities.

What is necessary for future sustainable development is that EIAs are carried out by competent parties with the highest ethical standards. The organization/ experts must be independent and with no ties to the investors and proponents of the proposed activity and the resultant environmental management plan be effectively implemented. The EIAs should be available at the State Ministry for Environment and the host LGA headquarters for the public to review them. Announcements should be made when such documents are available.

At the Rivers State level, the Department of Environment Planning, Research and Statistics of the Rivers State Ministry of Environment supervises EIAs of proposed projects with a view to determining the likely environmental impact(s) of such projects on the human environment. Rivers State Environmental Protection and Management Bill No. 7 of 2019 is the enabling law.

8.5 Sustainable management of economic activities in the area

Sustainable management is the application of sustainable practices in the different categories of economic activities (such as agriculture, industry, society) in a way that will benefit current and future generations and the living environment. Sustainable management includes aspects such as water management, management of air pollution, waste management, hazardous waste management as well as compliance management.

Over the past few decades, the importance of implementing sustainable development provisions into all types of economic activities including industrial and agricultural, has been constantly increasing. The goals of sustainable development are that the enterprises must be responsible to the society and future generations for their impact on the environment, the rational use of natural resources, as well as the safety of goods and services offered on the market.

Environmental problems are both global and local in nature, and industrial activities are obliged to develop environmental management systems that consider the total impact of the activities. Due to the increasing demand for even better performance, and the challenges because of the variability in the external environment, environmental management of industrial activities requires regular improvements and stricter monitoring and enforcement on the part of the government actors.

Environmental management systems, or action plans, relevant for the activities of small and medium size industries as well as agriculture in the Niger Delta have been published in various documents. These include the Regional Master Plan of the Niger Delta Development Commission (NDDC), the Niger Delta Environmental Survey report (NDES), and UNEP's Environmental Assessment of Ogoniland report. There is a need to articulate the recommended piecemeal action plans to form a composite framework for environmental sustainability of the Niger Delta.

8.6 Management and buffer zones

Particularly valuable conservation areas must be surrounded by buffer zones which in effect extend the habitat contained within the protected area into the buffer zone.Examples of human activities that may be tolerated in such buffer zones can include selectively logged forests, hunting areas, or natural forests for firewood collection, agriculture or grazing.

When deciding on suitable buffer crops it is important to consider the feeding habits of local wildlife. For instance, bananas and maize may not be suitable near populations of monkeys. Such buffer zones must be continuously surveilled by the relevant authorities (Department of Environment) in order to ensure that encroachment into the conservation areas is not taking place or that the human activities in the buffer zones do not cause indirect damage to the species and habitats in the conservation area.

When deciding on the management needs of buffer zones the following factors should be considered:

- The behavior of threatened wildlife such as the Niger Delta red colobus monkey, the pygmy hippopotamus, the white-throated guenon, Sclater's guenon and other mammal and reptile species to roam into the buffer zones;
- The habits of such species will give an indication of how large such buffer zones should be;
- The disturbance caused by wildlife which enter into the buffer zones must be determined in dialogue with surrounding communities;
- Procedures should be developed to compensate farmers for damage to crops in the buffer zones for example, Buffer zones may also serve other protective functions, such as water or soil conservation.

8.7 Preparing a management plan in consultation with stakeholders

A management plan for each of the conservation areas mentioned under section 8.2 is a document which sets out management approaches and goals, together with a framework for decision making, to apply in a specific protected area over a given period of time. Critical to the plan is the widest possible participation of all stakeholders in order to consider and adapt to their needs and circumstances. Objectives must be developed, agreed and adhered to by all who have an interest in the use and ongoing survival of the area concerned. Participants in this process should be the stakeholders, including local communities, non-governmental organizations (NGOs), representatives of the local, state and federal government as well as the business community and academia. The management plan should be based on global best practice drawn from different areas, in particular from elsewhere in the Niger Delta.

The Niger Delta is undergoing development, and infrastructure and housing are developing rapidly. A prerequisite for success in the development of protected sites such as the ones discussed here is that the local communities are involved in the different stages of the process leading up to the designation of a protected area, and particularly in having a commitment from local people to take an active part in keeping it protected.

A positive attitude towards environmental protection can only be achieved if communities are involved in the planning and the development of measures that will protect the area in question (Rodriguez-Izquierdo et al., 2010). Community participatory approaches will enable the communities to drive the process and take ownership of the development. Community participation can be promoted through fair and honest engagement and awareness building which develop capacity for making contributions to decision making.

9 SUMMARY AND RECOMMENDATIONS

9.1 Restoration Plan for the Wetlands of Ogoniland

Summary

A significant portion of Ogoniland and the Niger Delta at large are covered with mangroves and freshwater swamp forests. Such wetlands are some of the most productive and diverse ecosystems on the planet. If in good condition, they provide numerous ecosystem goods and services. For example, they act as feeding and nursery grounds for commercially important fish and shellfish which can be fished in surrounding creeks, rivers and coastal waters. They play an essential role in protecting land against erosion, buffering flooding, filtrating, and thereby retaining particles, nutrients and contaminants, and they are effective in taking up CO_2 from the atmosphere and storing it in the sediment

However, the wetlands of Ogoniland, as well as the Niger Delta as a whole, are under severe pressure from decades of oil spills and a multitude of other human stress factors including unregulated resource exploitation, urbanization, road construction and agriculture.

Since the year 2000, there has been a loss of about 20% of the mangrove and freshwater forests in Ogoniland. Such a loss of valuable ecosystems must be taken very seriously and with a sense of urgency. The time to act is now to reverse the degradation trend towards sustainability. Accordingly, this report provides a number of contextual recommendations.

Recommendations

1. An obvious prerequisite before starting activities related to mangrove rehabilitation is that all oil spills cease. For that to happen, adequate integrity check and maintenance of oil infrastructures is imminent to prevent avoidable oil spills. Concurrently, stealing of oil from oil infrastructures in order to refine it in remote parts of the delta must be prevented. The existing regime for surveillance of oil pipelines needs comprehensive overhauling and strengthening for effective protection. The use of state-of-the-art technology (e.g., drones and random overflights by helicopter) will help in policing remote areas and to identify suspected sites where artisanal refining are carried out and to stop such activities. However, the problems cannot simply be addressed by enhanced enforcement. Part of the solution must address the livelihoods problems faced by the youth and alternative means of employment stimulated. An effective partnership between the Office of the National Security Adviser, the Ministry of Petroleum, the Nigerian Upstream Petroleum Regulatory Commission (NUPRC), NOSDRA, HYPREP, UNEP, state government and the oil companies is necessary to achieve this goal.

2. Mangrove environments in the delta have, in several cases, been lost due to poor planning in connection with road construction, Road banks have been built without consideration of their effects on the hydrology of the surrounding areas. Any new road construction must consider the impacts on the flow of water in the surrounding landscape and construct bridges and tunnels in order to compensate for the blockage that otherwise will prevent the free flow of water. In cases where already-existing road banks are causing obstruction to the flow of water with the result that mangrove environments have died, it is meaningless to restore the mangroves unless the previous water regime is re- established. A close collaboration between the Federal and State Ministries of Works and Environment is a first step to achieving this. It will drive a robust and effective EIA regime whereby the resultant environmental management plan will be better implemented.
3. Any mangrove restoration must be preceded by careful planning both related to the strategy to be used in different areas, and the exact fit-for-purpose methods to be applied. Mapping based on remote sensing coupled with ground-truthing should help in producing maps with a grid network which will facilitate the work on the ground. Laboratory analysis, or as an alternative, field measurements will determine the degree of contamination. Based on such results the method of clean-up that will precede the restoration can be determined. The national and sub-national Ministries of Environment should provide overarching coordination of ecosystem restoration in active partnership with the Ministry of Niger Delta, the NDDC, HYPREP, the private sector, civil society organizations (CSOs), and the local communities. It is important to stress that the private business community operating in the delta, particularly the oil and gas companies whose operations have impacted mangroves in the region, should invest in mangrove restoration. The rehabilitation initiative could form an integral part of their remedial efforts, biodiversity offset or climate action programmes. The role of CSOs in sensitizing the citizens about the importance of proactive participation in mangrove restoration and management cannot be overemphasized.
4. Successful restoration of mangrove vegetation does involve the reforestation of the native mangrove species in the Niger Delta. Hence several species should be planted to protect genetic diversity depending on the local situation, which must consider aspects such as elevation, distance to the waterfront, etc. The decision on which species to be planted where should be made in advance and should be informed by sound science of mangrove ecology. This needs to be reflected in the mangrove species being produced within local nurseries.
5. Concurrently with the mapping, local communities in and near the areas to be rehabilitated should be fully involved in the process starting from the initial stage of formulating the objectives. The locals have historical knowledge on the sites that will be invaluable to the restoration effort. The goals of the work and the workplan should be shared with the community members and their views and inputs integrated into the plan to facilitate community ownership. Community members shall be invited to take part in the work and ideally the communities should take on the work as a community-based rehabilitationproject. In so doing, it will create much needed alternative employment forcommunity members.

6. Due to the variation in tides, careful planning of the clean-up is essential. Clean- up and planting can only be done during a period between high and low tides or low and high tides when the tidal flats where mangroves occur are exposed. This window of time may be rather limited depending on the local conditions. Therefore, it is essential that the logistics have been worked out in advance and that personnel and equipment are ready at the right time.
7. The clean-up methodology to be used for the removal of oil and tar in mangrove areas in Ogoniland, as well as in the Niger Delta, and mangrove restoration procedures have been described in various reports and manuals, including the CEHRD Mangrove Restoration Manual, the BMI Clean-up Protocol and the upcoming Mangroves in the Niger Delta: Restoration Manual. It is important that the clean-up of one site does not mobilize oil that will contaminate other areas. Therefore, it is essential that effective booms are used to contain any floating oil which should be collected and transported to the designated storage sites for subsequent evacuation.
8. Planting of mangroves is obligatory to re-establish lost mangrove forests in the delta due to prevailing conditions (e.g., oil contamination, limited seedlings to facilitate natural recruitment). Planting of mangroves shall be done according to the instructions in a number of manuals. In order to drive the re- establishment of a natural mangrove ecosystem, it is important that the choice of species is made based on the location where planting is carried out. The hydrology and degree of exposure to waves and currents are key factors to consider.
9. Monitoring of the survival and production of the planted mangroves is an essential element in restoration and should be carried out during several years after the planting started. Often a certain percentage of the original plants die and should be replanted. The initial five-year monitoring should be carried out by the organization that undertakes the restoration project in conjunction with designated units in the local universities. Such an arrangement will allow the universities to carry out long-term monitoring and research related to mangrove ecosystem restoration.

9.2 Conservation Plan for the Niger Delta

Summary

During the last decades large portions of the natural environment in the Niger Delta have been transformed into agricultural land, production forests, and built-up areas. Natural mangroves and forests have been cut or otherwise degraded or destroyed.

However, there are still some areas with relatively intact ecosystems consisting of mangroves, freshwater forests, intertidal marshes, etc. Considering the rapid pace of change in the delta the development and implementation of a Conservation Plan for the Niger Delta is of outmost importance. The small pockets of relatively intact remaining ecosystems must be protected before they disappear.

A Conservation Plan should be developed to outline the strategy for the protection of about 14 areas in the delta which had been identified as particularly important to protect. A vision for the future is that, when these areas have effective management measures in place, they can form a network of protected reserves that may qualify as sites under the Convention on Wetlands, also called the Ramsar Convention. Furthermore, some areas targeted for restoration, like the mangrove wetlands in Ogoniland, meet certain criteria to be designated Ramsar sites. The UNEP (2011) Environmental Assessment of Ogoniland identifies this opportunity.

Recommendations

1. A working group should be established to draft a Conservation Plan for the Niger Delta. The Working Group should be chaired by the Minister of Environment and consist of all stakeholders including the federal, state and local governments, local communities and civil society groups including NGOs, representatives of the business community, the academia, the Niger Delta Ministry, and the NDDC. The funding for this work should come from the national budget.
2. The Conservation Plan should be developed by the end of 2024 and should seek to improve the protection of key sites with high ecological value in the Niger Delta. It must be developed in close collaboration with local communities. Consideration of the needs and wishes of local people are critical to the success of any conservation plan. The plan should have co-managementprinciples and practices in order to be sustainable. This means that the local people will not only participate in the design of the Conservation Plan but will also own and lead its implementation under the coordination of the Ministry of Environment.
3. A prerequisite for the successful conservation and management of the remaining ecosystems including the network of protected areas is the maintenance of water flow through the delta. The water quantity and quality must be guaranteed through a rigorous EIA process, whereby all activities that may have an effect on the water flow, water quality, or cause contamination must be assessed for effective mitigation. An EIA must be much more than just an administrative formality. Competent expert organizations with the highest ethical standards, certification, and experiences that meet international best practices shall carry out the EIA for the Federal and State Ministry of Environment. The local communities should be actively involved in the EIA process.

4. There is growing demand for improved environmental performance among oil and gas industries and agriculture in the Niger Delta. Several action plans for improved environmental sustainability focusing on the local and regional levels have been presented but there has been little action in terms of improvements due to weak government institutions. There is an urgent need to step up the speed of concrete action led by the Ministry of Environment in partnership with the Ministries of Petroleum, Works, and Transportation, in order to halt the destruction of biodiversity hotspots and sensitive ecosystems throughout the delta.
5. Surrounding each protected site, a buffer zone must be established. In the buffer zone certain human activities may be allowed, activities that are not destructive to the ecosystem in the protected area. The type of activities to be allowed have to be determined in each case depending on the local socio- ecological conditions. The Ministry of Environment should oversee the buffer zones with funding from the national budget. The private sector should contribute funding as part of their commitments to environmental sustainability as well as corporate social responsibility

10 REFERENCES

1. Akanni, A., Onwuteaka, J., Uwagbae, M., Mulwa, R., Elegbede, 1.0. (2018). The Values of Mangrove Ecosystem Services in the Niger Delta Region of Nigeria. In The Political Ecology of Oil and Gas Activities in the Nigerian Aquatic Ecosystem; Elsevier BV: Amsterdam, The Netherlands, pp. 387-437. https://doi.org/10.1016/8978-0-12-809399-3.00025-2

2. Ayanlade, A. and Drake, N. (2016). Forest loss in different ecological zones of the Niger Delta, Nigeria: evidence from remote sensing, GeoJournal 81: 717-735. https://doi.org/10.1007/s10708-015-9658-y

3. Ayanlade, A. and Howard, M.T. (2017). Understanding changes in a Tropical Delta: A multi-method narrative of landuse/landcover change in the Niger Delta. EcologicalModellinghttps://doi.org/10.1016/j.ecolmodel.2017.09.012364:53-65.

4. Duke, N.C. 2017. Mangrove floristics and biogeography revisited: further deductions from biodiversity hot spots, ancestral discontinuities and common evolutionary processes. Mangrove Ecosystems: A Global Biogeographic Perspective. Structure, Function and Services. V. H. Rivera-Monroy, S.Y. Lee, E Kristensen and R.R.Twilley, Springer. 2: 17-53. https://doi.org/10.1007/978-3- 319-62206-4_2

5. Enaruvbe, G.O. and Atafo, O.P. (2014). Analysis of deforestation pattern in the Niger Delta region of Nigeria, Journal of Land Use Science, http://dx.doi.org/10.1080/1747423X.2014.965279

6. Griffiths, L.N., Haupt, T.N., Zhang, L. and Bitsch, W.J. (2021), Role of emergent and submerged vegetation and algal communities on nutrient retention and management in a subtropical urban stormwater treatment wetland. Wetlands Ecol Manage 29, 245-264 (2021). https://doi.org/10.1007/s11273-020-09781-6

7. Gundlach, E., Giadom, F.D., Akpokodje, E.G., Bonte, M., Tse, A.C., Ekeocha, N.E., Story, K.T. and Acra, EJ. (2021). Core sediments and oil chemistry from contaminated mangroves in eastern Niger Delta, Ogoniland, Nigeria. Marine Pollution Bulletin 171 (2021) 112714.https://doi.org/10.1016/j.marpolbul 2021.112714.

8. Health of the Mother Earth Foundation (HOMEF) and Centre for Environment, Human Rights and Development (CEHRD) (2021). Stilt roots stories from Bundu and Kono communities, Niger Delta, Nigeria. https://homef.org/wp- content/uploads/2022/04/STILT-ROOTS-STORIES-DY-HOMEF.pdf.

9. Jackson, L. and R.R. Lewis. 2000. Restoration of mangroves in Nigeria for the petroleum industry. Prepared for Chevron Research and Technology Company, 12pp.

10. Katsouris, C., Sayne, A. (2013). Nigeria's Criminal Crude: International Options to Combat the Export of Stolen Oil, Chatham House Publication, London. www.chathamhouse org/nigeriaoil)

11. Kuenzer, C., van Beijma, S., Gessner, U. and Dech, S. (2014). Land surface dynamics and environmental challenges of the Niger Delta, Africa: Remote sensing-based analyses spanning three decades (1986 2013). Applied Geography 53 (2014) 354-368.http://dx.doi.org/10.1016/j.apgeog.2014.07.002

12. Luiselli, L., Amori, G., Akani, G.C. and Eniang, E.A. (2015). Ecological diversity, community structure and conservation of Niger Delta mammals. Biodversity Conservation 24, 2809-2830 (2015). https://doi.org/10.1007/s10531-015-0975-8

13. Mariano, H., Aguilos, M., Dagoc, F.L., Sumalinab, B. and Amparado, R. Jr. (2022). Abandoned Fishpond Reversal to Mangrove Forest: Will the Carbon Storage Potential Match the Natural Stand 30 Years after Reforestation? Forests 2022, 13, 847. https://doi.org/10.3390/113060847

14. Netherlands Development Company (NEDECO). 1961. The waters of the Niger Delta. Reports on an investigation by Netherlands Engineering Consultants. (2nd edn). The Hague: Netherlands Engineering Consultants.

15. NEMA, (2013) Nigeria Post-Disaster Needs Assessment 2012 Floods: A report by the Federal Republic of Nigeria with technical support from the World Bank, the European Union, and the United Nations. https://www.gfdrr.org/sites/default/files/publication/NIGERIA PONA PRINT 0529 2013 WEB.pdf

16. Ledum Mitee (1999) Oil, arms and terror The Ogoni experience, Interventions, 1:3, 430-438, http://dx.doi.org/10.1080/13698019900510641.

17. Lewis III, R.R., Brown, B.M., Flynn, L.L. (2019). Methods and Criteria for Successful Mangrove Forest Rehabilitation. In: Perillo, G.M.E., Wolanski, E., Cahoon, D.R. and Hopkinson, C. S. (eds.). Coastal Wetlands: an integrated ecosystem approach. Second edition. Pp 863 887. https://doi.org/10.1016/0978-0-444-63893- 9.00024-1

18. Linden, L. and Palsson, J. (2013). Oil Contamination in Ogoniland, Niger Delta. AMBIO https://doi.org/10.1007/s13280-013-0412-8.

19. Marois, D.E and Mitsch, W.J. (2015): Coastal protection from tsunamis and cyclones provided by mangrove wetlands a review, International Journal of Biodiversity Science, Ecosystem Services https://doi.org/10.1080/21513732.2014 997292 & Management

20. Mitsch, W.J., Zhang, L., Waletzko, E and Bernal, B. (2014) Validation of the ecosystem services of created wetlands. Two decades of plant succession, nutrient retention, and carbon sequestration in experimental riverine marshes. Ecol Eng 72:11-24. https://doi.org/10.1016/J.ECOLENG.2014.09.108

21. Moffat, D. and Linden, O. (1995). 'Perception and Reality: Assessing Priorities for Sustainable Development in the Niger Rivers Delta, AMBIO 24(7/8), 527-538

22. Naanen, B. (2019). When extractive governance fails: Oil theft as resistance in Nigeria. The Extractive Industries and Society 6: 702-710.https://doi.org/10.1016/j.exis.2019.03.019

23. Naanen, D. and Tolani, P. (2014). Private Gain, Public Disaster: Social Context of Illegal Oil Bunkering and Artisanal Refining in the Niger Delta. https://www.africabib.org/htp.php?RID=406874204

24. Nairametrics (2021). Shell puts up SPDC for sale, launches major divestment from Nigeria. Nairametrics, July 31, 2021.

25. NEMA (2020). National Emergency Management Agency. Yearly Report 2020.26. Niger Delta Environmental Survey (NDES). (1997). Final Report Phase 1. Environmental and socio-economic https://www.researchgate.net/publication/31580041225. NEMA (2020). National Emergency Management Agency. Yearly Report 2020.

26. Niger Delta Environmental Survey (NDES). (1997). Final Report Phase 1. Environmental and socio-economic https://www.researchgate.net/publication/315800412

27. Numbere, A.O. (2021a). Impact of Urbanization and Crude Oil Exploration in Niger Delta Mangrove Ecosystem and Its Livelihood Opportunities: A Footprint Perspective, In: Banerjee, A., Meena, R.S., Jhariya, M.K., Yadav, D.K. (eds) Agroecological Footprints Management for Sustainable Food System. Springer, Singapore https://doi.org/10.1007/978-981-15-9496-010

28. Numbere A. O. (20215). Natural seedling recruitment and regeneration in deforested and sand-filled Mangrove forest at Eagle Island, Niger Delta, Nigeria. Ecol Evol. 2021;11:3148-3158. https://doi.org/10.1002/ece3.7262

29. Nwobi, C., Williams, M. and Mitchard, E. T. A. (2020). Rapid mangrove forest loss and nipa palm (Nypa fruticans) expansion in the Niger Delta, 2007-2017. Remote Sensing 12(14):2344. https://doi.org/10.3390/rs12142344

30. Obida, C.B., Blackburn,G.A., Whyatt, J.D., and Semple, K.T. (2021). Counting the cost of the Niger Delta's largest oil spills: Satellite remote sensing reveals extensive environmental damage with 1million people in the impact zone. Science of the Total Environment 775 (2021) 145854. https://doi.org/10.1016/jscitotenv 2021.145854.

31. Offshore Technology (2020). Shell defers plans to divest Nigerian onshore assets. Offshore Technology, news, July 2022.

32. Olalekan Adekola and Gordon Mitchell (2011): The Niger Delta wetlands: threats to ecosystem services, their importance to dependent communities and possible management measures, Intemational Journal of Biodiversity Science, Ecosystem Services & Management, http://dx.doi.org/10.1080/21513732.2011.603138 7:1, 50-68

33. Ologunorisa, T.E, Adeyemo, A. Public Perception of Flood Hazard in the Niger Delta, Nigeria. Environmentalist 25, https://doi.org/10.1007/s10669-005-3095-2 39-45 (2005).

34. Osuji, L.C., Erondu, E.S. and Ogali, R.E. (2010), Upstream Petroleum Degradation of Mangroves and Intertidal Shores: The Niger Delta Experience, Cheminform, 41, 18 https://doi.org/10.1002/cbdv.200900203

35. Phil-Eze, P. O. and Okoro, I. C. (2009). Sustainable biodiversity conservation in the Niger Delta: a practical approach to conservation site selection. Biodiversity Conservation 18:1247-1257. https://doi.org/10.1007/s10531-008-9451-z

36. Primavera, J. H. and Esteban, J. M. A. (2008). A review of mangrove rehabilitation in the Philippines: successes, failures and future prospects, Wetlands Ecology Management 16:345-358 DOI 10.1007/s11273-008-9101-y

37. Rodríguez-Izquierdo, E., Gavin, M.C. and Macedo-bravo, M.O. (2010). Barriers and triggers to community participation across different stages of conservation management. Environmental Conservation 37(3):239-249. https://doi.org/10.1017/S0376892910000500

38. Smith, T.J., Anderson, G.H., Balentine, K., Ginger Tiling, G., Ward,G.A. and Whelan, K.R.T. (2009) Cumulative impacts of hurricanes on Florida mangrove ecosystems: Sediment deposition, storm surges and vegetation. Wetlands 29: 24-34 https://doi.org/10.1672/08-40.1

39. Social Action (2014). Crude business: oil theft, communities and poverty in Nigeria, https://saction.org/crude-business-oil-theft-communities-and-poverty-in- nigeria/

40. Spalding, M., Kainuma, M., and Collins, L. (2010). World Atlas of Mangroves. London, UK: Earthscan. ISBN 978-1-84407-657-4.https://doi.org/10.1007/s10745-010-9366-7

41. Sreelekshmi, S., Harikrishnan, M., Nandan, S.B., Kaimal, S.V. and Hershey, R. N. (2022). Ecosystem Carbon Stock and Stable Isotopic Signatures of Soil Organic Carbon Sources Across the Mangrove Ecosystems of Kerala, Southern India. Wetlands 42, 29 (2022), https://doi.org/10.1007/s13157-022-01540-y

42. Stakeholder Democracy Network (SDN) (2012). Communities not criminals-illegal oil refining in the Niger Delta. https://www.stakeholderdemocracy.org/sdn-report-communities-not-criminals-illegal-oil-refining-in-the-niger-delta/

43. Story, N. I., Gundlach, E., Iroakasi O., Visigah K. G., Lenu P., Uche I., and Giadom V. (2022). Shoreline Cleanup Assessment Technique (SCAT) Manual. Available upon request, BMI Communications Officer, bmicommunications2@gmail.com

44. Zabbey, N., Giadom, F.D. and Babatunde, B.B. (2019). Nigerian coastal environments. In: Sheppard, C. (ed.) World Seas: an environmental evaluation, volume 1: Europe, The Americas and West Africa. Second Edition, Elsevier, UK. 835-854 https://doi.org/10.1016/C2015-0-04330-1

45. Zabbey, N., Ekpenyong, I. G., Nwipie, G. N., Chris, I. D. and Sam, K (2021). Effects of Fragmented Mangroves on macrozoobenthos. A case study of mangrove clearance for Power-line Right-of-Way at Oproama Creek, Nigeria. African Journal of Aquatic Science https://doi.org/10.2989/16085914.2020.1832437

46. Zabbey, N. and Uyi, H. (2014). Community responses of intertidal soft-bottom macrozoobenthos to oil pollution in a tropical mangrove ecosystem, Niger Delta, Nigeria. Marine Pollution Bulletin 82: 174.167http://dx.doi.org/10.1016/j.marpolbul.2014.03.002

47. Zabbey, N. and Tanee, F.B.G. (2016). Assessment of asymmetric mangrove restoration Trials in Ogoniland, Niger Delta, Nigeria: Lessons for Future Intervention. Ecological Restoration. 34(3): 245-257 http://er.uwpress.org

48. Zimmer, M., Ajonina, G.N., Amir, A.A., Cragg, S.M., Crooks, S., Dahdouh-Guebas, F., Duke, N.C., Fratini, S., Friess, D.A., Helfer, V., Huxham, M., Kathiresan, K., Kodikara, K.A.S., Koedam, N., Lee, S.Y., Mangora, M.M., Primavera, J., Satyanarayana, B., Yong J.W.H. and Wodehouse, D. (2022) When nature needs a helping hand Different levels of human intervention for mangrove (re-)establishment. Frontier Forest and Global Change 5:784322 https://doi.org/10.3389/ffgc. 2022.784322

HYDROCARBON POLLUTION REMEDIATION PROJECT
HYPREP
8 Ken Saro-Wiwa Road, Port Harcourt
info@hyprep.gov.ng @HYPREPNigeria
Hydrocarbon Pollution Remediation Project (@HYPREPNigeria)
hyprep_nigeria Hydrocarbon Pollution Remediation Project
www.hyprep.gov.ng