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A TRAINING MANUAL ON MANGROVE 'RESTORATION' IN COASTAL COMMUNITIES OF THE NIGER DELTA, NIGERIA

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The views expressed in this report are those of the authors and CEHRD. They do not represent the views of any other person, organization or institution.

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FOREWORD

The term mangrove can be used in two ways; as a plant and as the habitat where the plant grows –the mangrove forest. Mangrove plants occupy the area between the terrestrial land and the sea in the tropics and sub-tropics. The land area where mangrove plants grow is called intertidal land because it is usually exposed at low tide and flooded at high tide. This is also home of numerous animal species that interact amongst themselves and with the plants as a community. In fact, mangroves are rated amongst the most species-rich and productive communities.

The Niger Delta mangroves, the largest expanse in Africa, are the last line of defense of coastal communities, providing numerous ecosystem goods and services to the dependent populations. These include different food species (e.g. crabs, oyster, periwinkles, mud skipper, etc.), wood for fuel and other household products (e.g. scaffolds, axe handles, paddles, etc.), shoreline protection, fish breeding/nursery grounds, and acting as carbon sink amongst others. Yet, mangroves in the Niger Delta are amongst the least studied, and ironically, the most exploited and degraded in the world. The major threats to mangroves in the region are oil spills and untreated industrial effluent discharges, uncontrolled cutting, dredging, reclamation, fragmentation, nipa palm invasion and plastics pollution.

There is urgent need to restore mangroves in the Niger Delta in order to restore the lost ecosystem goods and services. One way of achieving speedy mangrove restoration in the region is through community-led citizen planting action and conservation stewardship. This requires building capacity of residents of coastal communities, especially young persons, with basic mangrove planting and management skills, which is a strategic programme of the Centre for Environment, Human Rights and Development (CEHRD).

Building local capacity on how to plant and tender mangrove plants and habitats requires readily available, easy-to-understand guide-material on the subject area. However, to the best of my knowledge, there is no such user-friendly, region-specific and publicly accessible mangrove planting guidebooks for the Niger Delta. This mangrove manual produced by CEHRD is intended to fill, at least in part, the above resource gap. It is recommended as a reference material for anyone who is interested in restoring mangroves in the Niger Delta. Restoration in the title is in quote because mere planting of mangrove plants does not amount to successful mangrove restoration, rather it is one of the steps in the lengthy process that may take a minimum of 25 years to achieve. It requires discipline and devotion in monitoring, evaluation and enhancement. This is why it is important to conserve the remnant mangroves as we strive to 'restore' the degrade mangrove swamps.

Prof. Nenibarini Zabbey
Coordinator, CEHRD

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1.1 INTRODUCTION

Over the years, the earth has witnessed tremendous changes especially in ecosystem structure and dynamics. These changes caused by either natural (earthquake, hurricane, landslide) and man-made (urbanization, industrialization, pollution, agriculture, etc.) factors have led to serious alterations in the physico-chemical and biological components of the ecosystem with its resultant negative and/or positive impact. The mangrove ecosystem is also affected by this change. Given that the ecological resilience of mangrove species is low, mangrove plants are more vulnerable to environmental threats. This has caused dramatic decrease in mangrove community all over the world in the past decade. In the past, and even now some persons erroneously perceived wetlands as ecosystem of no value. Due to this perception, the scale of human impact on mangroves has increased dramatically in recent years, with many countries showing losses of 50-80% or more. Mangrove ecosystems have been degraded or converted into agriculture, aquaculture, industrial or urban development. Oil pollution has also contributed a greater percentage to this depletion especially in the Niger Delta part of Nigeria.

However, recently, many communities or societies have started appreciating the benefits of mangroves and there is a growing awareness of their economic and ecological values. There are also increasing efforts by governments at all levels, non-governmental organizations (NGOs) and local communities around the world to conserve, rehabilitate and manage mangroves sustainably, but the success story is still minimal. Preventive measures against mangrove destruction seem to be the best option of managing

mangrove sustainably, but where that is not possible due to high rate of loss, restoration is necessary.
The objective of any mangrove restoration programme should be tailored towards arresting the fast depletion and destruction of the mangrove ecosystem as to conserve the biodiversity of this fragile natural habitat.

This manual provides a step-by-step practical approach of how to successfully restore a devastated (degraded) mangrove ecosystem incorporating nursery raising to transplanting. The manual has been written in a very simplify manner in such a way that it can be easily understood by professional and non-professionals including primary and secondary schools students. It is hoped that users, especially the students will find this manual useful as to enable them to contribute their own quota towards environmental sustainability and mangrove restoration by putting into practice the steps therein.

2.1 Mangrove Ecosystem

Mangroves are salt-water wetland plants that have evolved to survive in the interface between land and ocean in the humid climate of the tropical and subtropical regions of the world. That is, they are intertidal trees (frequently inundated by the tides) found along shorelines. The environment has a wide range of salinity, moisture, temperature and other environmental factors. The predominant mangrove soil is “chikoko” (a combination of silty clay, acid sulphate, clay loam and peat) which is muddy-clay and with high organic matter that are partially decomposed. The soil pH range from 4.5 to 6.5. For instance,

Rhizophora racemosa grows very well in brackish water (mixture of freshwater and saltwater) and soft mud, whereas Rhizophora harrisonii and Rhizophora mangle favour higher salinity and hard mud.
Mangrove forests provide habitat to a variety of flora and fauna. The vegetation of mangrove ecosystem is mostly evergreen and very simple in structure and physiognomy.

2.2 Distribution of Mangrove Forest in Nigeria

Nigeria has the largest mangroves in Africa. The mangrove forest ecosystem in Nigeria lies between latitude 4o and 7.6o N and covers an estimated area of 10, 515km2 along the coastline and spreads from Badagry in the West to Calabar in the East. Majority of the mangrove forest in Nigeria is located in the Niger Delta; constituting about 35% of all West African mangroves. In the Niger Delta region, mangroves occur majorly in the coastal parts of Rivers, Bayelsa and Delta States but are also in Akwa Ibom and Cross-Rivers states.

2.3 Types of Mangroves in Nigeria

Mangroves are mainly divided into two major categories which are mangrove associates and true mangroves. There are several species of mangroves in the world but only 7 species are represented in Nigeria (Table 1). The distinct features of the Nigerian mangrove species are presented in Appendix 1.

Table 1: The following families and species are found in Nigeria:

Families	Common Names	Species
True mangroves*		
Rhizophoraceae	Red Mangrove	*Rhizophora racemosa* *Rhizophora mangle* *Rhizophora harrisonii*
Avicenniaceae	Black Mangrove	*Avicennia germinans*
Combretaceae	White Mangrove	*Laguncularia racemosa* *Conocarpus erectus*
Arecaceae	Nypa palm	*Nypa fruticans*
Associate mangrove**		
Pteridaceae	Mangrove Fern	*Acrostichum aureum*
Poaceae	Mangrove grass	*Paspalum vaginatum*

***True mangroves can only thrive naturally in tidal wetland**
****Mangrove associates grow both on terrestrial land and in the tidal wetland among true mangrove vegetation.**

Fig.1a: *Rhizophora* sp.
(Photo Credit: N. Zabbey)

Fig. 1b: *Conocarpus erectus*
(Photo Credit: N. Zabbey)

Fig. 1c: *Avicennia germinans* with hanging seeds and numerous breathing roots (pneumatophores) on the protruding from the sediment (Photo Credit: N. Zabbey)

Fig. 1d: *Laguncularia racemosa* (Photo Credit: N. Zabbey)

Fig. 1e: Nypa palm *(Nypa fruticans):* an invasive mangrove palm in the Niger Delta (Photo Credit: N. Zabbey)

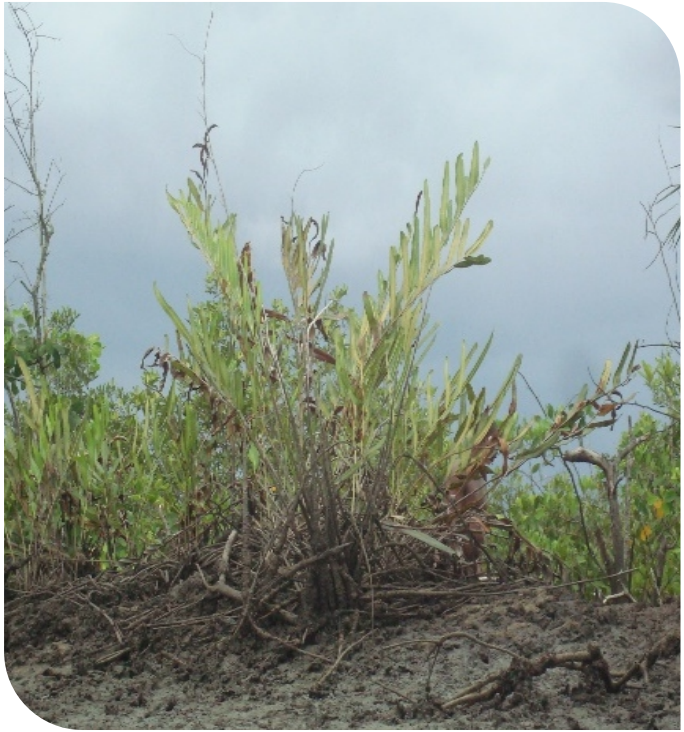

Fig.1f: *Achrostichum aureum* (mangrove fern) (Photo Credit: N. Zabbey)

2.4 Mangrove Adaptations

Mangrove plants are halophytic (salt tolerant) plants ("halo" means salt, "phyte" means plant). They are able to survive in the salt environment by adopting some strategies. Some of these adaptation strategies include:

I. Ability to deal with excess salt (salinity) condition by special mechanism of salt excretion, exclusion and accumulation by the root systems.

ii. Presence of prop and stilt roots that guarantee them support in the mud. This root system that prop them above the water level can absorb air through small pores on the bark called lenticel. Some also have pneumatophores (breathing roots) that also project above the water surface for gaseous exchange.

iii. They limit water loss from their system by some physiological adaptations like increasing their internal osmotic pressure and reducing stomatal openings.

iv. They exhibited viviparous mode of reproduction to increase the survival chances of their offspring. Viviparity means that the seeds germinate and grow to produce propagules while still attached to the parent tree before detaching to a suitable site to continue growth.

3. 1. Importance (benefits) of Mangroves

Mangroves have been known in years past to provide many valuable functions to man. These functions are both socio-economic and ecological. About 24 functions of mangroves have been identified. Some of these functions include but not limited to the following:

a. Timber and wood production

b. Firewood and charcoal production

c. Yam stake and other poles
d. Scald-fold
e. Materials for Construction work
f. Dye and tannins production
g. Breeding ground for most seafood
h. Protection against floods and storm
i. Reduction in river banks and coastal erosion
j. Water quality maintenance
k. Nature recreation and ecotourism activities
l. Habitat for fishes, crustaceans, mollusks, amphibians, reptiles and birds.
m. Traditional medicines
n. Honey production
o. carbon sequestration
p. aquaculture (eg fish and prawn culture)
q. salt production
r. Agriculture (eg rice cultivation)
s. Nutrient cycling
t. Waste and poisons absorptions
u. Education and research

4.1. Threat to Mangroves

Mangroves continue to face serious threats. Mangrove wetlands are one of the most threatened natural communities worldwide, with about 50% of the global area lost since

1900, and 35% of the global area lost in the past two decades. Human activities remain a major cause of destruction and loss of mangrove ecosystems in every part of the world.

Major causes of mangroves loss are:

a. Urban and industrial developments
b. over-harvesting for timbers, firewood and other mangrove products
c. diversion of water flow resulting from road construction
d. Clearing mangroves for commercial shrimp farms, fish ponds, rice production and coconut plantation
e. Deforestation for construction of sea ports, airports, tourist resorts & centres
f. Invasion and colonization by alien (exotic) species e.g. *Nypa fruticans.*
g. dam impacts
h. Environmental pollution arising from oil exploitation and exploration (such as crude oil spillage, artisanal refining (kpo-fire) and mining), industrial and heavy metals pollutions.
i. Climate change
j. Natural factors such as cyclones, hurricane, tsunamis.

Fig. 7: Exploitation of mangrove for woods and other products

Fig. 8a: Artisanal refining (kpo-fire) operation and its effects in the Niger Delta mangroves (Photo Credit: N. Zabbey).

Fig.8b: Destruction of a restored mangrove ecosystem by oil spillage at Bodo Creek in 2008 (Photo Credit: F. B. Tanee).

5.1 Mangrove Restoration

Restoration as defined by society for Ecological Restoration is the process of assisting the recovering of an environment that has been degraded, damaged, or destroyed. Every restoration project should follow the principle of ecological mimicry; that is, to ensure that the structural, functional diversity and dynamics of the specified ecosystem is maintained even if in a modified form. So mangrove restoration in a simple term, could be seen as any process that returns a mangrove ecosystem to an earlier condition (whether or not this was pristine), either through natural means or recovery following basic secondary succession principles.

5.2 Factors that can Prevent Successful Mangrove Restoration

1. Failure to involve the local community in the restoration programme can make them to go against the project or even destroy it.
2. Carrying out restoration in areas where the real cause of loss has not been ascertained and corrected.
3. Hasty planting in an area where there is the possibility of natural recruitment, causing damage to the naturally regenerating mangroves and thus disturbing and slowing down natural recovery.
4. Planting the right species in the wrong place because of no good knowledge of the autecology (the study of the relationship of a species to its environment) of that particular species. This will result to mortality or slow growth.
5. Planting in places where the restored mangroves would block sediment and water flows.

5.3 Principles of Successful Mangrove Restoration

To successfully restore a mangrove forest, there are two very important ecological restoration principles that should be put into consideration. These are:

1. **One must ensure that the biological and physico-chemical conditions of the environment are appropriate for mangrove restoration:** Mangroves may have been lost or degraded due to alteration in the physical, chemical or biological components of the ecosystem. For instance, oil pollution (as it is common in the Niger Delta), conversion for other land uses, or changes in the supply of freshwater or loss of sediments or other causes may have severe negative impacts on the affected mangrove ecosystem. Such activities may degrade the environment such that mangroves could no longer survive where they had existed. Restoration of a healthy mangrove forest can only happen if these biological and physico-chemical conditions for mangrove growth and development are corrected/restored.

2. **One must ensure that both social and economic conditions permit mangrove recovery:** If mangroves lost or degradations were caused by some socio-economic activities such as tree felling by local communities for commercial or other purposes, there is likelihood that such could reoccur if it is not addressed before the restoration project. Streamlining the land ownership and use rights, and a possibility for management after restoration should be taken into consideration. In this case, there is need to involve the local communities and local government so that policies and planning that will strengthen local actions are taken care of.

6.1 STEPS FOR SUCCESSFUL MANGROVE RESTORATION

For successful mangrove restoration, the following steps as adopted from Lewis and Marshall (1997) are considered, having met the two principles stated above with some modifications to suit our local peculiarities.

Step One:
Adequate Preparation

The first thing to do if you want to carry out a mangrove restoration work is to make adequate preparation Although before commencement of the process, the local communities should be consulted and engaged, and their views considered in the decision making. . This is very important for the following reasons:

i. They are the primary beneficiary of the restoration project
ii. They are the owners of the land or have the right to use such land.
iii. They are the ones that will look after (manage) the project to ensure its success
iv. They are the ones to enforce all the laws guiding the sustainable use of the mangrove resources.

Such preparations include:

1. Identifying the causes of mangrove restoration failures in the past. Has there been any restoration exercise in the area in the past? If yes, was it successful or failed. If it failed, what were the cause(s) of the failure? Addressing this issue will go a long way of guaranteeing success in your restoration exercise.

Two types of failure have been identified in every mangrove restoration exercise; viz;

a. Technical failure. This occurs when one does not understand the ecological condition for the successful growth and establishment of the mangrove in the area. For instance, what makes mangroves in the area died or does not exist? Why have there been restoration failures in the area in the past, if such has been carried out? Addressing such issues will go a long way in determining the success of the restoration project.

B. Social failure. This occurs when stakeholders in the restoration project failed in their different responsibilities. For instance, in 2003, the attempted restoration of mangrove forest at Iwokiri Creek in Ogu-Bolo Local Government area in Rivers State failed because the Federal Government who promised to fund the project did not release funds for the project. As a result, the seedlings that were raised in nursery were abandoned at a point and the restoration project failed.

2. Do some desktop work and literature review. One needs to understand the concept and practical approach of restoration exercise. You must understand certain things about the environment where the restoration is to be done. You must do some literature searches to have background knowledge of the mangrove (especially in terms of the species diversity) and ecology of the area. In addition, you must also know the:

i. Tidal cycle of the area. Tide table from the nearest port will assist in this direction.
ii. The mangrove species that is common and likely to survive in the area
iii. The successes and failures of possible restoration attempts in the area in the past and the lesson learnt
iv. The community interest in the mangrove

v. Some local laws and cultures guiding mangrove forest in the area.

Step Two:

Have A Good Knowledge of the Autecology of the Mangrove

Autecology is the study of a species relationship with the biotic and abiotic factors of that environment. Autecology of the mangrove species is a very critical step for a successful restoration of the mangrove forest. Understanding the autecology of the mangrove species at the site with particular reference to the pattern of reproduction, seed distribution/dispersal, and seedling establishment and growth will greatly assist in the restoration work.

Therefore, the establishment and subsequent growth of a particular species of mangrove depends on the tidal cycle and coverage of the zone, the salinity of the soil and the amount of fresh water available.

Step Three:

Getting the right Hydrology for Mangrove Restoration

Hydrology (water characteristics such as water physico-chemistry, movement and depth) of a wetland ecosystem determines the success and/or failure in growth and establishment of any species one wants to restore in an ecosystem. So understanding the local hydrology of the area that controls the establishment of such species will play a critical role for a successful restoration exercise. This is because mangrove species occur in a wide variety of hydrologic and climatic conditions.

Each mangrove species thrives at a different substrate level, which in some part dictates the amount of tidal waters the mangrove will be exposed to. Thus, it is imperative to

ascertain the critical periods of inundation and dryness that governs the health of a particular species. For instance, most species of red mangrove thrive best in condition of inundation by normal high tide. So, ensure that the normal hydrology (depth, duration and frequency, and of tidal flooding) are in place before planting of the mangroves.
Use the hydrology of an existing natural mangrove forest as a reference point to determine the hydrology of your plan restoration site.

Step Four:
Removal of Stress that Prevent Secondary Succession

Critical parameters to consider at this stage are:

1. What was the area you want to restore used for in the past?
2. Was the habitat you are about to restore as a mangrove forest was actually a mangrove forest in the past?
3. If mangrove plants have not grown there before, what do you think could be responsible for the non-growth?
4. If mangrove was there before and it is no more there again, what might have caused their death?
5. Has there been attempt to restore such forest site before and it failed? What do you think could be responsible for the failure?

All these obstructions to mangrove establishment may be due to stress in that ecosystem. Finding possible answers to these questions will enable you to look for potential stress that could hinder growth and establishment of the mangrove species in the area. These

potential stresses caused changes to the original mangrove habitat thereby preventing natural regeneration. Plan on ways to remove such stress before attempting restoration.

There are several possible stresses that have been identified that can prevent secondary succession (regrowth) in a mangrove restoration exercise.

Examples of such stress include

1. Soil pollution e.g. crude oil
2. Lack of ground water
3. Blockage of tidal exchange
4. High salinity and sulphate
5. Soil nutrient deficit
6. Soil compaction
7. Presence of Pests e.g. crabs etc.

It is important to evaluate the type of stress and proffer solution to it. For instance, a dike from a previously used fishpond can obstruct the inundation of tides. In such a situation, one has to device means of amending or removing the stress. For example, if it is an obstruction like dike, removal can be done through excavation or creating channels for free flow of tidal waters, so as to create same general slope, and the exact tidal elevations relative to a benchmark as a reference site, thus ensuring that the hydrology is correct. In case it is a pollution stress especially oil pollution, remediating (removing the oil physically, mechanically or biologically) the site will assist in removing such pollution stress.

A case scenario:

Effects of stress on the success and failure of mangrove restoration in Bodo and Kono Creeks in Ogoni, Rivers State, Nigeria.

A 'small' area of mangrove in the the Bodo Creek was killed by crude oil spill, while the Kono Creek experienced displacement of native mangroves by the invasive nypa palm. The Centre for Environment, Human Rights and Development (CEHRD) undertook mangrove restoration (planting) of both sites in 2005 and 2010, respectively. The aim of the mangrove planting was to teach the local people that they can contribute to maintaining mangroves through planting of areas that had suffered losses (see details in Zabbey and Tanee, 2016). The Bodo mangrove-planting project was successful (72%) because the stress (crude oil) was reduced to a tolerable level by remediation before mangrove seedlings were planted. In contrast, the Kono Creek mangrove-planting project failed (only 12% success) because after removing the nypa palm, stressors (e.g. soil compaction and lack of essential growth nutrients) were not addressed before the mangrove planting (Fig. 10).

Fig 10. Restoration sites (A) Bodo (successful) and (B) Kono (failed) (Zabbey and Tanee, 2016)

Step Five:
Design the Restoration to Ensure Appropriate Hydrology

The final graded topography of the site needs to be designed in such a way as to match with a nearby mangrove forest site. Create well-designed tidal channel because if the normal tidal stream are not maintained, a mangrove may dry out and die over time. You might not need to re-grade the entire area; strategically breaching the dikes or obstructions to enhance tidal exchange and filling deep channels may solve the problem.

Step Six:
Mangrove Planting

After undergoing steps 1-5 above and confident that natural recruitment will not provide the quantity of successful established seedlings or the rate of growth required for the success of the restoration exercise, then actual planting of propagules, or collected seedlings can now be utilized. Propagules or seedlings suitable for planting are usually found within the vicinity of the area, especially along high tide lines. If an area lacks natural seed sources, seeds or propagules may be collected from another area that has a lot of seeds or seedlings and transported to the restoration site. Seedlings can also be raised in a nursery from local seed sources and later transplanted to the restoration site.

7.1 Mangrove Nursery

Mangrove nursery is a place where mangrove seedlings are raised for the purpose of planting. In a typical nursery, many young mangrove seedlings are tendered from sowing to developing in such a way that they will be able to endure the hard conditions on the field. Mangrove seedlings raised in nursery are found to have greater survival chances

than mangrove propagules sown directly in the field or through natural regeneration. Therefore, a well-nursed mangrove seedling is the best planting material and recognized as one of the best practices for mangrove restoration.

7.2. Is Mangrove Nursery Necessary?

Given that several options exist for mangrove restoration, many people might think that there is no need going through the labourious mangrove nursery processes, since mangrove propagules can be sown directly. The following are the reasons for mangrove nurseries:

1. The nursery will help the propagule to develop stronger and healthier root system, which may increase their survival rate.
2. Help for proper timing for mangrove restoration, since mangrove planting goes with timing.
3. It enables the mangrove seeds/seedlings to withstand and surmount the unfavourable condition usually experienced in the environment at the early stage of growth.
4. Pests mostly crab that usually devour the seedling stage of mangrove plants are easily controlled.

7.3 Types of Mangrove Nursery

There are two types of nursery; namely: permanent and temporal nurseries. These two types can be subdivided into 2 subtypes based on tidal location. These are floating and flooded nurseries. In other words we can have permanent (floating or flooded) and temporal (floating or flooded).

1. **Permanent (Fixed) Mangrove Nursery:** this is constructed for a long-term supply of seedlings/propagules. Although it is very expensive to construct, but ensure good quality seedlings production.

Fig. 12: Permanent mangrove nursery
Source: www.wikipedia.org

2. **Temporal (Flying) Mangrove Nursery:** this kind of nursery is temporally constructed for the purpose of one restoration project. It is usually constructed closed to the restoration site. Immediately after completion of the project, the nursery is discarded.

Fig. 13: Temporal mangrove nursery
Source: www.wikipedia.org

3. **Floating Mangrove Nursery:** It is a mangrove nursery constructed in upland areas (beyond the level of the highest tide).

Fig. 14: Floating mangrove nursery
Source: www.wikipedia.org

4. **Flooded Mangrove Nursery:** It is a type of mangrove nursery constructed in low intertidal zones and is regularly flooded by tidal waters. It requires minimal effort in terms of setup and upkeep.

Fig.15: Floating mangrove nursery
Source: www.wikipedia.org

7.4. Major Factors to be considered before Siting a Mangrove Nursery

Nursery location has a significant impact on the survival of the seedlings/propagules. Some factors to consider when siting a mangrove nursery are:

i. The site should be prone to periodic flooding.
ii. Availability of good quality fresh and salt water.
iii. Accessibility to good quality and mature propagules/seeds.
iv. The nursery site should not be waterlogged (that is, it requires good drainage)
v. Pumps for pumping saltwater from the creeks to the nursery especially if it is a floating mangrove nursery.
vi. Good access road(s) for transportation of equipment and labour to sites.
vii. The land should be relatively flat.

7.5 Soil Preparation for Mangrove Nursery

The best soil for nursery is the soft clayey muddy soil found in the intertidal areas. The soil should be collected during low tide and put into the nursery container. Any hard material in the soil should be removed before putting it into the bags.

Black or white polythene bags of 5"x8" should be used for the nursery. Fill the polythene bags with soil up to 3 cm from the top (i.e. the soil content should start from 3cm below the brim of the bag). There should be perforations at the base and sides of the bag for proper drainage and aeration. The filled bags should be kept in the shade to harden.

7.6 Mangrove Propagule/Seed collection

Note that mangrove propagules (seeds) are living entities and are very delicate. So care should be taken during their collection so that they remain alive and healthy before and after collection. Propagules (seeds) can either be collected from the mother plant or picked afloat on the water surface.

The following procedures should be adhered to when collecting propagules/seed :

1. Collect only mature and healthy propagules/seeds devoid of rot or insect damage.
2. Collect propagules/seeds from healthy and mature trees. Mature trees should be at least 7 m tall
3. Collect only propagules/seeds that are big in size; as big sized seeds tend to grow more actively than small seeds.
4. Collect propagules/seeds in the morning and keep them under shade as heat from the sun may likely kill them.
5. Propagules and seeds should be placed appropriately when transporting them.
6. Propagules/seeds should not be left in the rain or wet area for a long period as this condition may result to rot and death.
7. Never collect seeds/propagules in plastic bags as this may generate heat that can kill the seeds/propagule. Instead use basket.
8. Propagules/seeds should be planted within 48 hours of collection as any delay may reduce the viability of the seeds
9. Propagules are produced year round but January and February are the peak months in this region.

Fig. 17: Propagules of Rhizophora sp
Source: www.wikipedia.org

7.7 Propagule/Seed planting in Nursery

The following procedures should be followed for propagule/seed planting in the nursery

a. The soil in the containers should be watered before planting the propagule/seed.

b. Propagules/seeds should not be planted too deep or too shallow in the soil.

c. Propagules (e.g. *Rhizophora* spp.) should be planted straight in the center of the container up to one third (1/3) of the propagule length.

d. Planting should be done either in the early morning or later in the evening to avoid the scotching effect of the sun.

e. The root part (swollen part) of the *Rhizophora* spp. propagule should be pushed to a depth of about 7 - 8 cm into the soil in the containers. Small sticks can be tied to the uncovered part of the propagule for support.

f. Plant one seed/propagule per container.

7.8 Nursery Management

1. Shading at the early stage of the nursery is important as it serves to protect the seedlings from direct contact to heavy rains and sunlight. Always use transparent shade.

2. Seedlings should be watered with freshwater and brackish water. Brackish water is recommended over seawater as salinity (above 34) causes stunting and wilting of the seedlings. Watering should be done twice daily (early morning and late evening). Before watering, always check soil moisture on a daily basis. This is

because if the soil is too dry, the roots will die and plants may appear wilted or burnt, whereas too much water can cause poor growth, damping off disease and root rot of seedlings. Watering can be done with a watering-can or perforated jerrycan.

3. Fertilizer should be applied if the soil nutrient is found to be low. About 3 - 4 g of N:P:K (15:15:15) dissolved in 1 litre of water can be used to irrigate seedlings.
4. Regular weeding should be done when the need arises
5. Pest Control: The use of chemical control method should be the last option when other methods have proved abortive.

7.9 Hardening-off

Hardening-off is a process of making the seedlings to experience the typical weather conditions on the field. Seedling must be tough to survive. Hardening off is done two (2) months before planting. It is done by:

a) Decreasing water one month before seedlings are transplanted. This is necessary to prepare the plants for the harsh environment at planting.
b) Seedlings should be watered half the amount it was previously watered with every other day.
c) Seedlings should be wet thoroughly one day followed by being moist the next day. The soil should not be allowed to dry-out or let the leaves of the plant to dry up (appear burnt).

All seedlings/propagules that have undergone these processes are ready for planting and should now be carefully transplanted to restoration site.

7.10 Seedling Planting Techniques at Restoration Site

i. Ensure that the holes dug are wide enough to accommodate the roots of the seedling or propagules. The depth of the hole depends on the length of the root of the mangrove seedling to be planted.

ii. Place the seedling straight (vertical) in the hole and ensure that the roots do not curl upward. Curl roots can lead to stunted growth and possibly death of the seedlings. Allow the roots to dangle freely in the hole. If the seedlings are from nursery bags, then only tear off the bag and plant the seedling with the nursery soil attached to the root.

iii. Cover the hole containing the seedling with loose soil to ensure proper aeration.

iv. Planting spaces should be between 1-2 metres apart (between 5000 – 10000 propagules per hectare.

v. Planting should mimic the natural mangrove environment. Mangroves do not occur in straight lines. Therefore, planting should not be done in a straight row. It should be planted in zigzag row.

Note: ***Do not attempt to introduce or plant a non-native mangrove species in an area.***

Fig. 19: Mangrove planting
(Photocredit: FBG Tanee)

9.1. Monitoring and Evaluation

This is necessary in order to determine the success or failure of the restoration exercise. Proper monitoring of the restoration site should be done at regular interval. It is very important to document with photographs every aspect of the restoration activities, including the monitoring phase. The field photographs would be useful in evaluating the success rate or otherwise of the project.

The following parameters should be assessed during monitoring.

1. The species that develop
2. Growth rate
3. Other growth characteristics
4. Survival rate
5. Changes in the rehabilitated ecosystem
6. Presence of associated flora and fauna

8.2 Bibliography

Clarke, A. and L. Johns. 2002. Mangrove Nurseries: Construction, Propagation and Planting. Fish Habitat Guideline FHG 004, Department of Primary Industries, Queensland Fisheries Services.

Lewis, R.R. and M.J. Marshall 1997. Principles of successful resto¬ration of shrimp Aquaculture pond back to mangrove forest. Page 126 in Programa/Resumes de Marcuba. La Habana, Cuba.

Jackson and Lewis, 2000, A Field Guide for Identifying Mangroves in Nigeria.

Moberg, F. and P. Ronnback. 2003. Ecosystem services in the trop¬ical seascape: Ecosystem interactions, substituting technolo¬gies, and ecosystem restoration. Ocean and Coastal Management 46:27–46.

Society for Ecological Restoration (SER). 2002. SER International Science and Policy Working Group. The SER Primer on Eco¬logical Restoration **www.ser.org/content/ecological_restoration_ primer.asp.**
UNEP (2007). Mangroves of Western and Central Africa. UNEP-Regional Seas Programme/UNEP-WCMC.

www.wikipedia.org. Accessed 6th August, 2020
Zabbey, N. and Tanee, F.B.G. 2016. An assessment of asymmetric mangrove restoration trials in Ogoniland, Niger Delta, Nigeria: lessons for future intervention. Ecological Restoration 34(3): 245 - 257.

8.3 Appendix 1

A Field Guide for Identifying Mangroves in Nigeria					Jackson & Lewis, 2000
	Rhizophora			*Avicennia*	*Laguncularia*
Leaves	Dark green in clusters			Pointed tips	Rounded tips pair of glands at leaf base
Roots	prop roots drop roots			pneumatophores	no prop roots no pneumatophores occasional pneumathodes
Fruit	elongated propagules			lima-bean shaped fruits	small almond shaped
Flowers	small, white			small, white	small, white
Location	fringe waterfront			landward from *Rhizophora*	landward from *Rhizophora*
Species	*R. racemosa*	*R. harrisonii*	*R. mangle*	*A. germinans*	*L. racemosa*
leaves	elongate	broader	broader		
flower buds per stem	multiple with blunt tips	multiple with pointed tips	two to four		

CEHRD's Mission is "to forge a common link with the rural Niger Delta communities primarily through research, participatory trainings, campaigns and advocacy on the problems confronting them. Equipping them with the basic knowledge of their situation and encouraging them to address the issues nonviolently themselves".

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