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SUBJECT: GUIDELINES ON ENRICHMENT PLANTING OF MANGROVES AND BEACH FOREST FOR BIODIVERSITY CONSERVATION AND COASTAL RESILIENCY

1. Rationale

Mangrove and beach forests are important components of the coastal ecosystem that perform significant role in providing coastal defense and buffer against strong waves and storm surges brought about by typhoons and other similar climate-related phenomena. They also help prevent soil erosion during heavy rains, help minimize water pollution and serve as water catchment areas that reduce flooding. Mangroves also serve as habitat and nursery ground for marine fishes, crustaceans and other fauna thus, sustaining and improving fisheries productivity.

Mangroves, in particular provide the necessary conditions for nutrient recycling storage of vast amounts of carbon. Mangroves, sea grasses and tidal salt marshes are estimated to sequester carbon 10–50 times faster than terrestrial systems (McLeod 2011 and Da Silva 2011, as cited by Benson 2017). In addition, mangroves are among the most carbon-rich ecosystems, reportedly containing an average of 937C ha⁻¹ (Alongi 2012).

Beach forest cover is found above the high-tide mark of the sea on a sandy substrate and may emerge into neighboring agricultural land and upland forest (FAO, 2005). Together with the mangrove ecosystem, beach forests serve as a defense of coastal areas against storm surges and strong waves. Beach forest also aid in preventing coastal erosion by holding the coastal soils, this in turn prevents possible sedimentation of seagrasses and corals. These characteristics and functions of mangroves and beach forests explain the critical role of these ecosystems as a frontline of defense against the impacts of climate change. Although they have a related functions in the ecosystem, mangroves and beach forests differ significantly on their species composition. In the Philippines, human activities have altered much of the mangroves and beach forests over the past century.

There are numerous factors affecting the growth, distribution and development of mangroves such as: tidal elevation, sea level influence, hydrology, salinity, sedimentation rate, soil composition, rainfall and freshwater source (Jimenez and Lugo 1985 and Primavera et al. 2012). Moreover, environmental stressors such as climate (e.g. typhoons) are some of the risks which can adversely affect its growth and development. This contributes to high mortality rates in mangrove plantations and long period of succession before attaining the full canopy or climax stage.

In all circumstances of mangrove and beach forest degradation characterized by patchy or sparse vegetation, enrichment planting ensures that the density and diversity of mangrove and beach forest ecosystems can be restored at an accelerated rate including the other ecosystems services they provide. This Technical Bulletin hopes to serve as guide for this physical intervention.

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2. What is enrichment planting?

Montagnini et. al., (1997) applied enrichment planting in over-exploited subtropical forests of Argentina where it is defined as “the introduction of valuable species to degraded forests without the elimination of valuable individual which already existed at that particular site”.

In upland forestry, it is defined as the introduction of valuable tree species in forest areas where economical species are lacking (DENR Administrative Order 31, series of 1991 and highlighted in DAO 2016-20 or Implementing Rules and Regulations of Executive Order 193, Series of 2015: *Expanding the Coverage of the National Greening Program*).

It was also used in the DA-DENR Fishery Sector Program to mean “the direct planting of nursery-raised mangrove seedlings to sparsely vegetated or poorly stocked natural mangrove areas with the purpose of re-stocking and enriching the area” (DENR Administrative Order No. 2000 – 57, section 4).

In this Technical Bulletin, enrichment planting shall refer to inter-planting suitable mangrove or beach forest species in patchy or sparsely vegetated natural mangroves and beach forests including monoculture plantations with the goal of increasing density and species diversity without prejudice to the already existing vegetation for biodiversity conservation and coastal resiliency. Enrichment planting can be done using propagules, wildlings and potted seedlings.

3. Scope and Coverage

Natural mangrove and plantation and beach forest areas qualify for enrichment planting subject to the following conditions:

3.1 In natural mangrove areas with sparse vegetation characterized by presence of 625-1499 trees/hectare (FAO, 1996) beyond which the mangrove area is already considered dense.

3.1.1 Logged-over areas

3.1.2 Areas damaged by typhoons and other climate related phenomenon;

3.1.3 Areas with sparse vegetation near mouths of rivers

3.2 In plantation mangrove

3.2.1 Plantations heavily damaged due to natural causes like typhoons and other climate- related phenomenon

3.2.2 Plantations damaged by pest and diseases;

3.2.3 Monoculture plantations in seaward zone planted with *Rhizophora* sp.

3.3 Abandoned, Unutilized and Underdeveloped (AUU) Fishponds that have been properly turned over by BFAR to the DENR

3.4 For beach forests

Selection of site for the beach forests depends mainly on the location of the easement zone. Easement zones are land along beach and riverbank indicated by dotted lines in the land title and allows the title holder to use the area if the government is not yet using the said area. In establishing the plantation for beach forests, sites that will be selected must be:

- Within the 20 m of the easement zone

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3.5 The following are not recommended for enrichment planting:

- 3.5.1 Seagrass beds
- 3.5.2 Areas damaged by algal blooms
- 3.5.3 Areas with high garbage deposition
- 3.5.4 Areas with unstable and unsuitable substrates (e.g. sand shifting areas, rocky-coraline substrates)
- 3.5.5 Mudflats/tidal flats

3 Activities involved in Enrichment Planting

4.1. Choice of species and requirements for mangroves.

4.1.1 Enrichment planting can make use of propagules, wildlings and potted seedlings depending on location and substrate. Zonation pattern must be observed. Priority species for enrichment planting is shown in Table 1.

Table 1. Suggested mangrove species per zonation

Zonation	Species
Seaward to Landward	<i>Sonneratia alba</i> Sm. (Pagatpat) <i>Avicennia marina</i> Forssk. Vierh. (Bungalon) <i>Rhizophora stylosa</i> Griff. (Bakawan bato- seaward at the back of <i>S. alba</i> and <i>A. marina</i>) <i>Aegiceras floridum</i> Roem. And Schult. (Tinduk-tindukan - rocky to s substrate)
Middleward to Landward	<i>Ceriops tagal</i> Perr. C.B. Robb. (Tangal-most preferred) <i>Ceriops zippeliana</i> Blume (Malatangal) <i>Avicennia marina</i> var. <i>rhumpiana</i> Forssk. Vierh. (Piapi) <i>Avicennia officinalis</i> L. K.D. Koenig (Api-api) <i>Aegiceras corniculatum</i> Lour. Poir. (Saging-saging) <i>Bruguiera sexangula</i> (L.) Lam (Pototan) <i>Bruguiera gymnorhiza</i> (J.F. Gmel.) Blume (Busain) <i>Bruguiera cylindrica</i> (L.) Blume. (Pototan lalaki) <i>Bruguiera parviflora</i> Roxb. With. & Arn. Ex. Griff (Langarai) <i>Heritiera littoralis</i> Aiton (Dungon-late) <i>Xylocarpus granatum</i> J. Koenig (Tabigi) <i>Xylocarpus moluccensis</i> (Lam.) M. Ruem (Piagau) <i>Rhizophora apiculata</i> Blume (Bakawan lalake)
Riverine-upstream	<i>Sonneratia caseolaris</i> (L.) Engl. (Pedada) <i>Nypa fruticans</i> Wumb. (Nipa) <i>Rhizophora mucronata</i> Lam. (Bakawan babae)

4.1.2 For seafront planting, bigger sizes (minimum 50 cm to 1-1.5 m for *A. marina*, *S. alba*, *R. stylosa*)

4.1.3 Inner areas can make use of smaller sizes (minimum 30 cm *A. marina* and *S. alba* to 40-60 cm *R. apiculata* and *R. mucronata*)

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4.2 Choice of species and requirements for beach forest. Priority species are listed on Table 2.

Table 2. List of recommended mangrove associated and traditional beach forest species.

Mangrove Associated Species	Traditional Beach Forest Species
<i>Pandanus tectorius</i> Parkinson (Pandan Dag)	<i>Casuarina equisetifolia</i> L. (Agoho)
<i>Millettia pinnata</i> L. (Bani)	<i>Albizia procera</i> (Roxb.) Benth. (Akleng-parang)
<i>Cordia subcordata</i> Blanco (Balu)	<i>Artocarpus blancoi</i> (Elmer.) Merr. (Antipolo)
<i>Thespesia populnea</i> Sol. Ex Corea (Banalo)	<i>Alstonia macrophylla</i> Wall ex. G. Don (Batino)
<i>Morinda citifolia</i> L. (Bangkoro)	<i>Buchanania arborescens</i> (Blume) Blume (Balinghasay)
<i>Calophyllum inophyllum</i> L. (Bitao)	<i>Cynometra ramiflora</i> L. (Balitbitan)
<i>Barringtonia asiatica</i> (L.) Kurz. (Botong)	<i>Pandanus dubius</i> Spreng (Bakong)
<i>Heritiera littoralis</i> Aiton (Dungon-late)	<i>Garuga floribunda</i> Decne (Bogo)
<i>Instia bijuga</i> (Colebr.) Kuntze (Ipil)	<i>Pithecellobium dulce</i> (Roxb.) Benth. (Camachile)
<i>Xylocarpus rumphii</i> (Kostel.) Mabb. (Malapiagau)	<i>Syzygium cumini</i> (L.) Skeels. (Duhat)
<i>Talipariti tiliaceum</i> (L.) Fryxell (Malubago)	<i>Sterculia foetida</i> L. (Kalumpang)
<i>Terminalia catappa</i> L. (Talisay)	<i>Dillenia philippinensis</i> Rolfe (Katmon)
	<i>Parishia malabog</i> Merr. (Malabog)
	<i>Broussonetia luzonica</i> var. <i>glabra</i> (Blanco) Bureau (Malambingan)
	<i>Vitex parviflora</i> A. Juss (Molave)
	<i>Atuna racemosa</i> Raff. (Tabon-tabon)

4.3 Nursery Establishment and Management

Nurseries are necessary in enrichment planting to ensure the availability of seedlings of the required species, numbers and sizes at a given time. Otherwise, planting will be highly dependent on the availability of propagules, seeds or wildlings. Choosing the species to propagate will vary among regions and must be suited to the target sites. This means that prior information on the correct species to plant must be satisfied first before nurseries are established. Before conducting enrichment planting, several in-situ small-scale mangrove nurseries and beach forest shall be established to lessen hauling stress and acclimatize the seedlings to the prevailing microclimatic conditions. The ERDB - MBFDP Technical Bulletin No. 3 (2015) provides technical guidance in nursery establishment and management.

The benefits of nurseries are as follows:

- Nurseries provide temporary storage for excess seeds and propagules produced during the fruiting season which otherwise would be lost.
- Nurseries work best with small seeds which are not suitable for direct planting as they are easily washed away by currents.
- In seafront areas, survival of nursery raised seedlings is higher than direct planting of propagules because their stems and roots, and bigger sizes can better withstand barnacle infestation and wave action.

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4.3.1 Site Selection

4.3.1.1 For Mangrove Nursery

- Relatively flat and firm substrate
- Close to river or freshwater sources
- Good drainage (not water logged)
- Within or close to planting site
- Protected from wave action
- With gaps and opening with mother trees for shade
- Flooded during spring tide (high tide)

4.3.1.2 For Beach forest

- Site must be flat and has a firm substrate
- Must have an accessible source of freshwater
- Must have a good drainage
- Partially-shaded by mother trees
- Easily accessible for hauling and transport

4.3.2 In-situ Nursery Operation

- Site Preparation- removal of debris, trimming of branches that may hinder to the growth and development of seedlings to be raised.
- Fencing- bamboo poles and fish net can be used to prevent stray animals and debris to destroy the seedlings.
- Construction of nursery facilities (Potting shed, seed box, seed beds, pot beds, hardening beds and storage room)
- Plastic lining – put plastic lining on seed beds to prevent the primary roots to penetrate in the soil.
- Potting- mangrove soil is the best potting media to be used due to the rich in organic matter and nutrient no need for fertilization. For beach forest, garden soil plus saw dust is the best media

4.3.3 Collection

The right timing in collecting plantable materials is very crucial in nursery activities for both mangrove and beach forest.

4.3.3.1 For Mangrove

4.3.3.1.a Propagules/fruits – being viviparous matured propagules poses ring like abscission at least 1 cm. in length between the fruit and the pericarp. Collect the matured propagules/fruits in the standing mother trees to lessen stress and damage cause by natural factors.

4.3.3.1.b. Wildlings - numerous species of mangrove can be propagated using wildlings except for *Rhizophora spp.* Wildlings can be collected under the mother trees, abandoned fishpond, and swash zone. Maximum size of wildlings to be collected is 1 foot in height and it can be condition in the nursery at least 3 months before out planting. It can be collected thru carefully earthballed and place in polyethylene plastic bag.

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4.3.3.2. For Beach Forests

4.3.3.2.a Seeds - Collect mature and healthy seeds that will be germinated from the standing mother trees with superior qualities.

4.3.3.2.b Wildlings - In case of limited seedlings, wildlings may be used provided quality standards are followed. Ready pots before collection; observe extra care in uprooting, packaging and transport; leaf/root pruning; and immediate planting in the nursery

4.3.4 Handling and transport

After collection, propagules/wildlings must not be exposed to direct sunlight. Sunburns which appear like brownish to blackish spots on the hypocotyls can cause low viability. Propagules should be placed inside moistened sacks which should be kept cool and open at all times. Propagules must be kept under cover/shade to prevent excessive loss of moisture especially during the dry season.

In transporting, keep them in a horizontal position and protected from heat. Banca, or the use of any other kind of boat is the most practical means of transporting mangrove propagules to the nursery site. Otherwise, they may be transported manually.

4.3.5 Sowing and germination

4.3.5.1. For Mangroves

Germinate the fine/small seeded mangrove (*Sonneratia spp.*) in the seed boxes before transplanting in the plastic bag if the germinant has 2 pair of leaves. For small seed of *Avicennia spp.*, it can be germinated in the seed bed before transplanting or direct planted in the plastic bag.

Potted seedlings are those mature propagules/seeds/wildlings sown in plastic bags and grown in nursery. *Avicennia spp* and *Sonneratia spp.* could be propagated from seeds and wildlings.

Non-viviparous small to medium sized seeds of *Xylocarpus spp.*, *Aegiceras spp.*, *Lumnitzera spp.*, *Excoecaria agallocha*, *Nypa fruticans*, etc. and small/short-sized viviparous propagules of *Ceriops spp.* and *Bruguiera spp.*, should be directly grown/ raised in the 5cm x 7cm size biodegradable plastic bags.

4.3.5.2. For Beach Forests

Tiny, winged seeds like agoho, should be germinated on seed box with extra fine sand, sterilized, if possible, with seed box protection from ants. Big seeds (banalo, bani, bitaog, butong, kalumpang) may be sown on plastic bags or on a seed bed.

4.3.6 Sorting and Grading

Group the seedlings with the same species and homogenous sizes to avoid over top or domination of one seedling to other. Select the viable and healthy seedlings free from pest and diseases to be prepared for out planting.

4.3.7 Hardening

The selected plantable seedlings will be gradually exposed to full sunlight to prepare the seedlings to the harsh and adverse climatic conditions in the planting site such as strong wind

and intense heat to ensure high survival rate. To withstand these conditions, it is recommended that the mangrove and beach forest seedlings must be well-hardened for around 2-6 weeks before out-planting.

The prescribed plantable size of hardened potted seedlings is 1.5 - 2 feet which is measured from the base/root collar.

4.4. Plantation Establishment through Enrichment Planting

Enrichment planting can be done to "enrich" established plantations especially in monoculture plantations and secondary mangrove and beach forest with gaps/openings or sparse vegetation through planting of desirable species (potted seedlings) suitable in the area (Species-Site Matching).

4.4.1. Natural mangrove forest

- Site preparation – removal of debris and undesirable materials before out planting.
- Staking – use bamboo stake as tree guard with 2m X 2m spacing.
- Hole digging – dig a hole at least 1 foot in diameter and 1 foot in length to have enough space for root development.
- Hauling – use plastic crates or sacks in transporting the plantable seedlings in the planting site carefully.
- Tying – tie the seedlings into the bamboo stake to hasten the root development and help the seedling to stand still against wave and wind action
- Planting – place the seedling in the hole and cover with soil up to root collar only and do not compact the soil. If propagules are used as planting materials, direct planting is required and a maximum depth of 1/3 of the length of the propagules should be burrowed beneath the soil.


4.4.2. Established mangrove plantation

- Site preparation – removal of debris and undesirable materials before out planting
- Fencing – use bamboo poles in protecting the plantation from outside factors such as garbage and stray animals.
- Establish navigational lane – provide free access for small boat to pass thru so that newly established mangrove plantation will not be an obstruction to their fishing activities.
- Staking – use bamboo stake as tree guard with 2m X 2m spacing
- Hole digging – make a hole at least 1 foot in diameter and 1 foot in length to have enough space for root development.
- Hauling – use plastic crates or sacks in transporting the plantable seedlings in the planting site carefully.
- Tying – tie the seedlings into the bamboo stake to hasten the root development and help the seedling to stand still against wave and wind action
- Planting – place the seedling in the hole and cover with soil up to root collar only and do not compact the soil. If propagules are used as planting materials, direct planting is required and a maximum depth of 1/3 of the length of the propagules should be burrowed beneath the soil.

4.5. Plantation Care and Maintenance

The success and sustainability of any plantation mainly relies on the different activities to be done after planting. Plantation care and maintenance in mangrove and beach forests is needed to ensure that sustainability is at least 3 years. These are the regular activities to be done:

- Regular removal of debris and garbage in the plantation
- Regular patrolling and repair of fences
- Replant dead planted seedlings during low tide of planting season
- Monitor the plantation against pest and diseases
- Monitor the growth and development of the plantation.


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