LIVING WITH THE LAND

Traditional Ecological Knowledge and
Resilient Communities

A catalogue of Rural Nature Based Solutions

This catalog presents a collection of nature-based solutions inspired by local and indigenous practices in rural areas to address environmental, social, and economic challenges. These solutions work with natural processes and systems, and to provide multiple benefits to local communities and ecosystems.

It provides a comprehensive overview of the potential of rural nature-based solutions, and is used as a tool for addressing the design challenges.

By exploring and understanding these rural nature-based solution, we can create more resilient and sustainable communities, protect and restore ecosystems, and enhance the well-being of both people and nature. These solutions can further be explored in urban environments. This catalog is a step towards achieving these goals.

What are **Nature-based solutions?**

"Nature-based Solutions are actions to protect, sustainably manage and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits."

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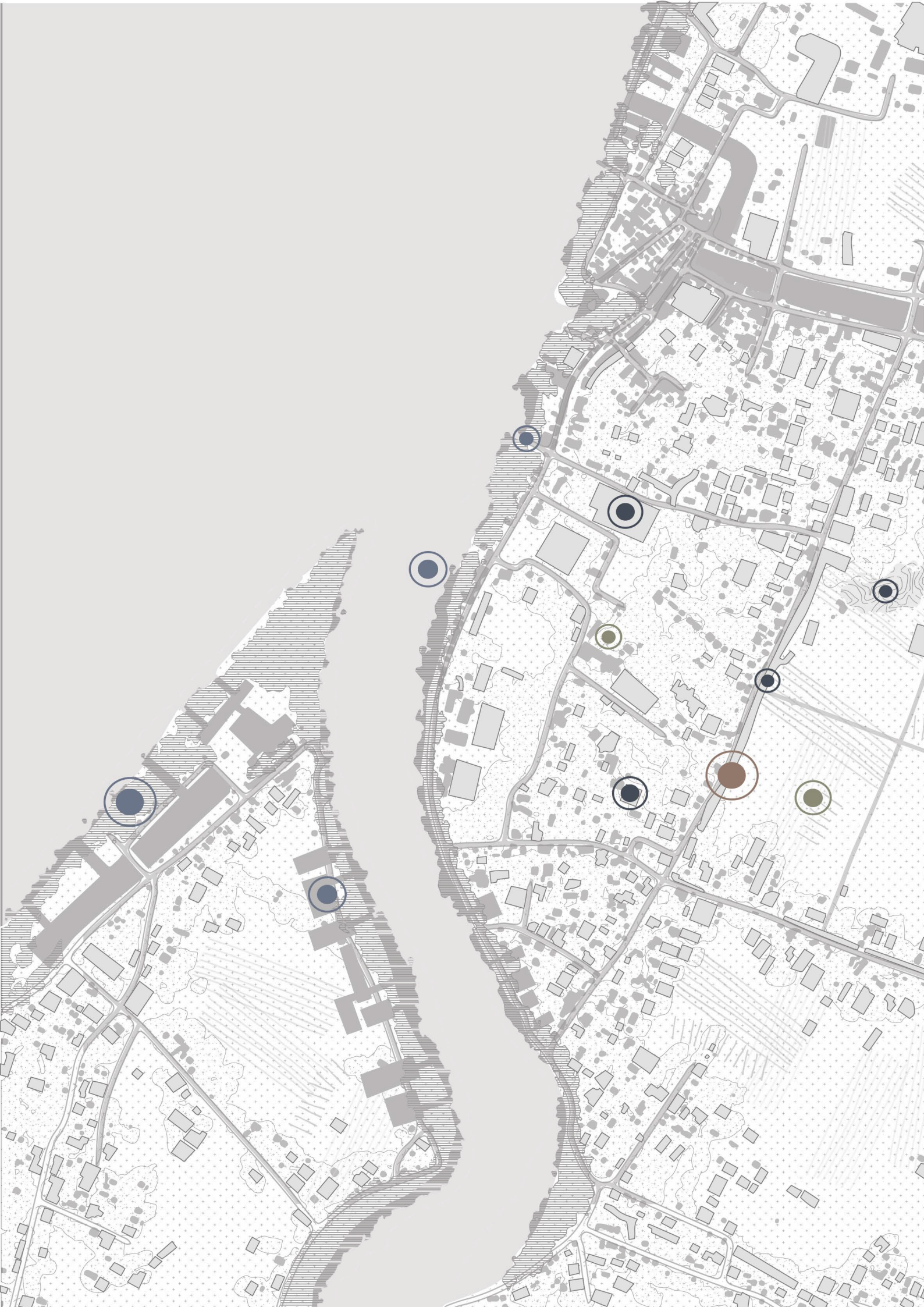
What are **"Rural" Nature-based solutions?**

The term "RURAL" associates to the local and indigenous nature of the practices. Therefore, Rural Nature based solutions are approaches that draw on traditional ecological knowledge and cultural practices of communities in rural areas to promote sustainable and equitable management of natural resources.

The Potential ?

These nature-based solutions are highly adaptive and resilient, and have been developed and refined over generations of trial and error. While some of them are new and have the potential to address the newer challenges. By recognizing and respecting indigenous knowledge and practices, and promoting their integration into modern conservation and development strategies, we can create more equitable, effective, and sustainable solutions for the challenges that our planet is facing.



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* All the above nature based solutions along with addressing the challenges, contribute to restoring biodiversity and creating habitats for all lifes.

A **Reader's Guide**

This guide explains the various criterias used to analyze different nature based solutions throughout this booklet.

Indeginous / Familiar / Novel

Indeginous NBS are based on traditional and local knowledge of the comminity.

Familar NBS are the actions being used currently to address the challenges.

Novel NBS are innovative and transformative potential solutions

Economical Aspect

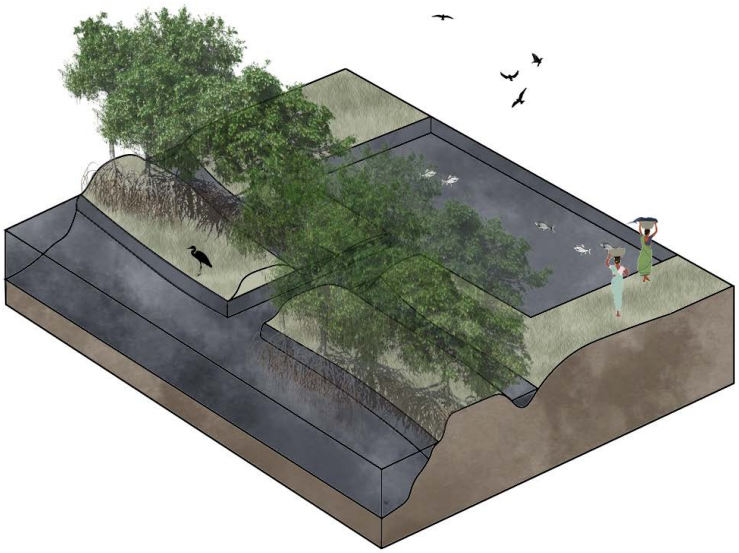
The economical aspect represents aggregate of the cost of implementation of NBS, maintainance and payback in terms of job generation for the community.

Participation of community

This aspect determines the level of participation of the community in the implementation and maintainance of the NBS.

Benefits / Impacts

This aspect determines the various ways in which the NBS contributes to benefits in terms blue and green, environmental, economical and social factors.



“Associated Mangrove Aquaculture”

A sustainable approach to aquaculture

Associated Mangrove Aquaculture, or AMA, is a concept for associating aquaculture with forestry by means of a greenbelt of mangrove along shorelines of waterways in the estuaries.

This nature-based solution restores the eroding tropical muddy coasts. The reduction of mangrove forests for aquaculture and fish breeding is so common in these areas, and is leading to large environmental impact. These AMA systems are a sustainable alternative where mangrove planting and restoration is used with aquaculture and shrimp breeding.

Novel

A Novel technique beginning to come to more use by farmers in south-east Asia, especially in Indonesia.

Participation of Community

Economy

Keeping the area of mangrove about 60% in AMA, the total economic value of the ecosystem services of the mangroves can be achieved. Hence, AMA the shrimp yield can be identical as for the normal intensive farms. Moreover, by shifting to AMA the environmental risks due to shrimp farming can be avoided.

About

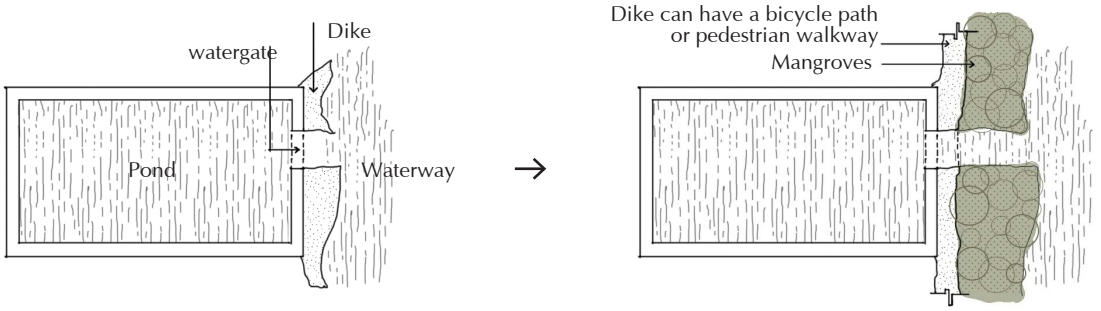
In this system, fishes or shrimps are grown in ponds that are built within or adjacent to mangrove forests. The mangrove trees provide a natural filtration system for the water, as well as a habitat for small fish and shrimp that serve as a source of food for the larger, commercially grown species.

Mangrove trees also help to absorb excess nutrients in the water, which can reduce the occurrence of harmful algal blooms and other water quality issues. Additionally, the trees act as a buffer against storm surges and other natural disasters, helping to protect the aquaculture ponds and the surrounding communities.

This method of aquaculture is considered to be more sustainable than traditional fish farming methods because it does not require the clearing of large areas of land or the use of large amounts of feed and chemicals. It also provides a source of income for local communities and helps to conserve and protect mangrove forests, which are critical ecosystems that provide a range of benefits to humans and wildlife alike.

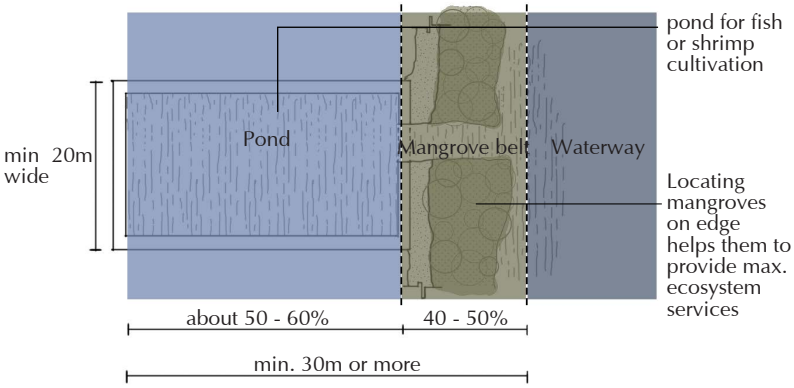
Benefits/Impacts

From common pond to AMA



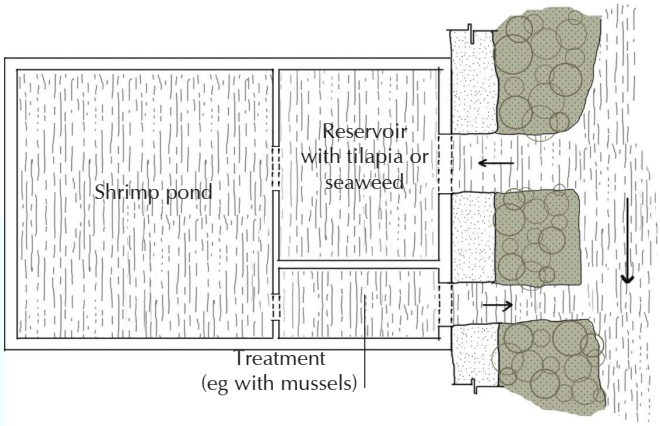
Common pond without mangroves (left), standard AMA single farm (right)

AMA pond design

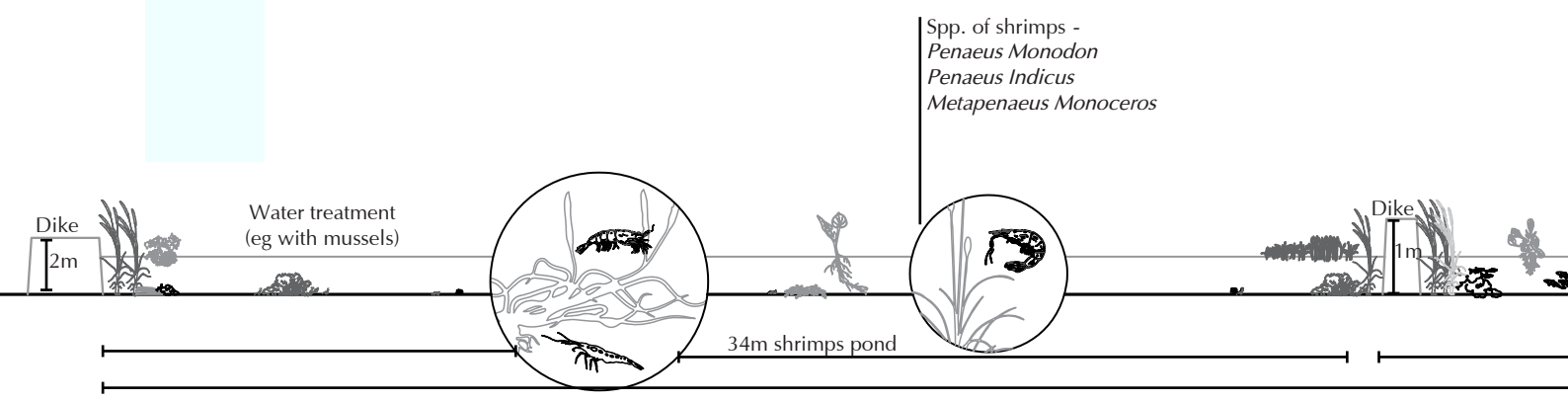


While converting an existing pond to AMA pond, the goal is to create an estuary with mangrove greenbelts of at least 20 m wide (ideally 50m). If there already are mangroves present, only a smaller part of the pond may need to be converted.

Complex AMA systems

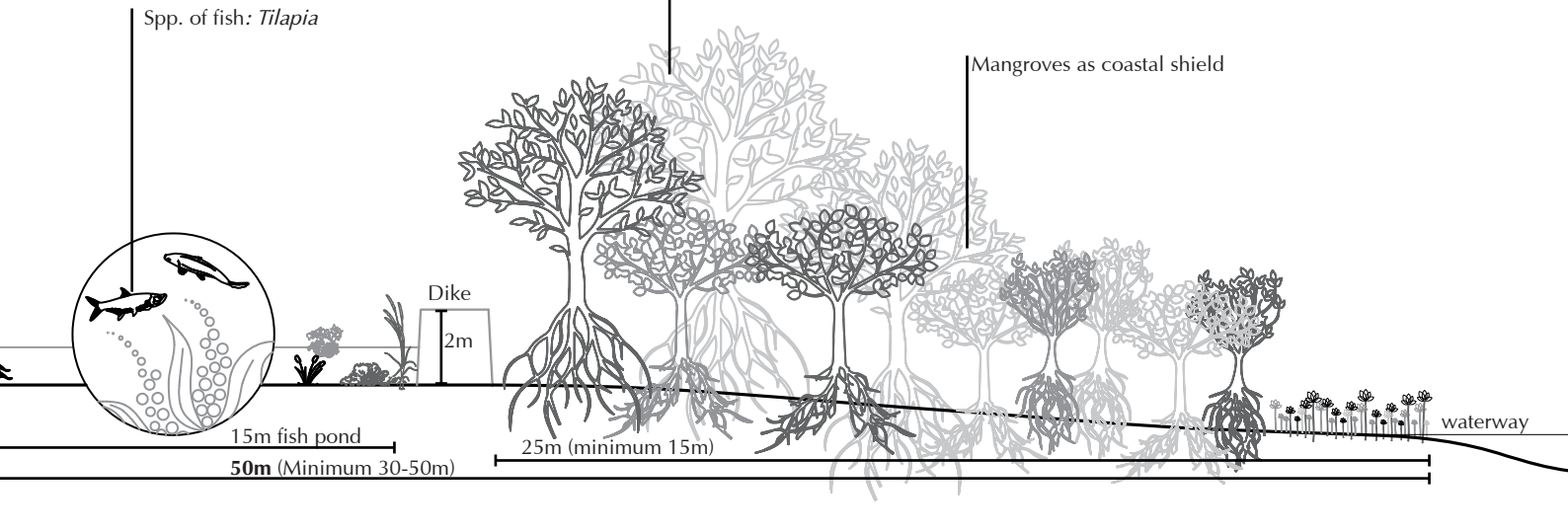


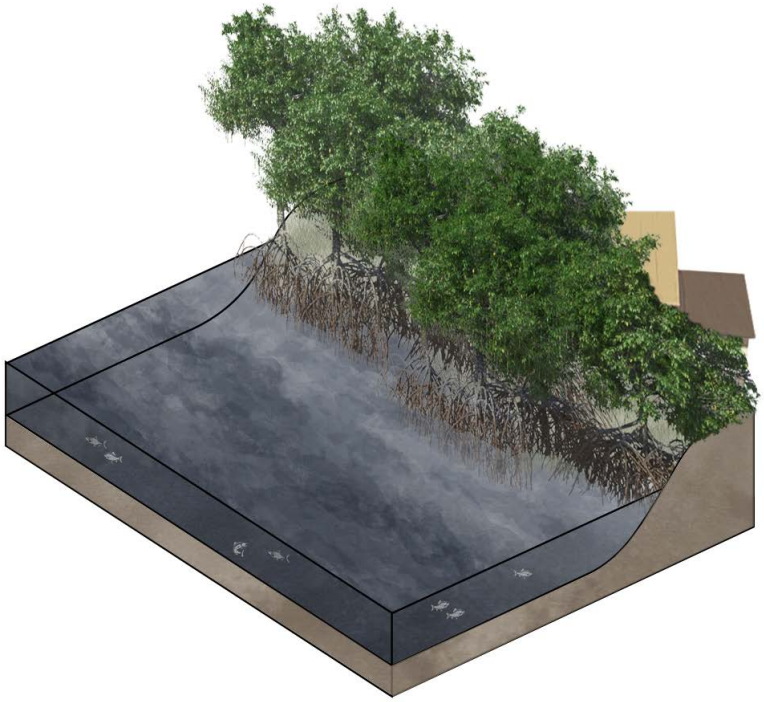
AMA farms have additional ponds for storage (water preparation) and sedimentation (for removal of excess water before discharging or returning water to storage pond) which allows for better water quality management. These systems have improved water quality in the shrimp farm and diversified system with more products and sources of income for farmers.



Mangroves that provide provisioning ecosystem services are more suitable with AMA, so that the benefits of these can be directly be used by the community, for example the wood for construction purposes, roots, leaves or fruit or flowers for medical purposes etc.

Rhizophora Mucronata
Avicennia Marina
Sonneratia Apetala
Bruguiera Cylindrica
Heritiera Fomes
Ceriops Decandra





Mangrove Shield

The coastal protection

Mangroves are nature based defense systems for coastal protection, providing multiple ecosystem services.

Millions of people across the globe are at risk of coastal flooding, which is expected to increase with the Sea level rise and increasing frequency of cyclones. It is hence critical to recognize the importance of sustainable and cost effective nature based measures for coastal protection.

Familiar

Familiar NBS, for coastal protection all around the world

Participation of Community

Economy

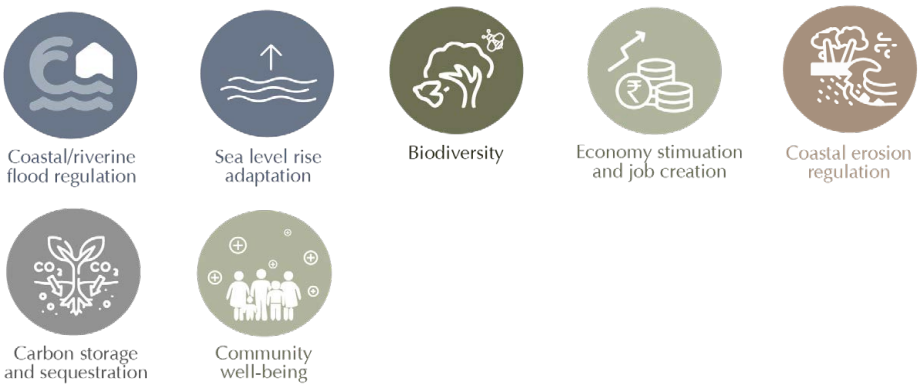
Keeping the area of mangrove about 60% in AMA, the total economic value of the ecosystem services of the mangroves can be achieved. Hence, AMA the shrimp yield can be identical as for the normal intensive farms. Moreover, by shifting to AMA the environmental risks due to shrimp farming can be avoided.

About

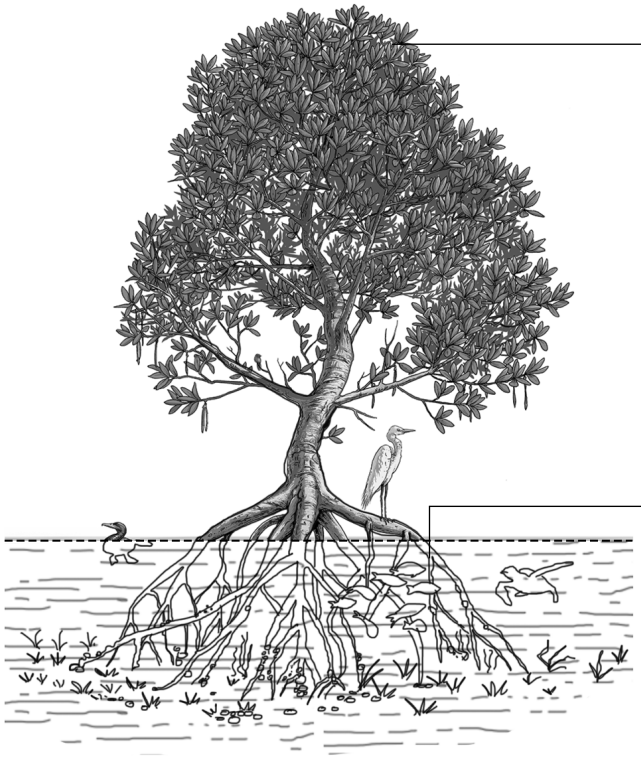
The mangrove trees have an intricate root system that helps to trap and stabilize sediment and reduce the impact of waves and storms. This root system holds the soil together and prevents erosion. Acting as buffer zones for the coastal communities, they provide a natural barrier against coastal erosion and storm surge. Mangroves dissipate wave energy and reduce the force of incoming waves, protecting the coast from erosion and flooding. They are highly effective at storing carbon, which helps to reduce greenhouse gas emissions and mitigate climate change. Mangroves can sequester up to four times more carbon per hectare than terrestrial forests.

Mangroves support a diverse array of marine and terrestrial species, including fish, crustaceans, birds, and mammals, making them important for biodiversity conservation. Additionally, mangroves provide important resources for coastal communities, including food, medicine, and timber. By protecting and managing mangrove forests sustainably, communities can ensure their own livelihoods and long-term well-being.

Benefits/Impacts



The mangroves structure



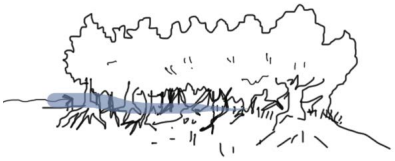
Leaves

The leaves of mangroves provides habitat for birds and food for various organisms. Mangrove leaves help to stabilize the soil and prevent erosion by trapping sediment and reducing the force of waves and tides.

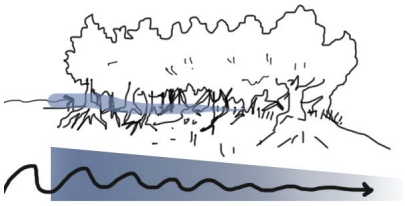
Roots

Mangrove roots stabilize the soil and prevent erosion by trapping sediment and reducing the force of waves and tides. They are adapted to have high salt tolerance and provide important habitat and food sources for a variety of organisms

Role of mangroves in coastal risk reduction

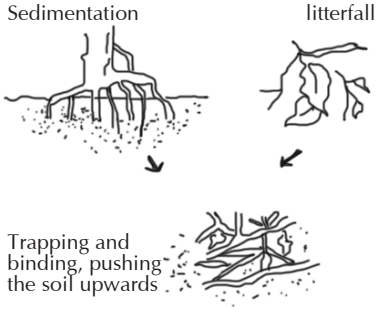


Reduce wave damage - Wind and swell waves are rapidly reduced as they pass through mangroves, lessening wave damage during storms.



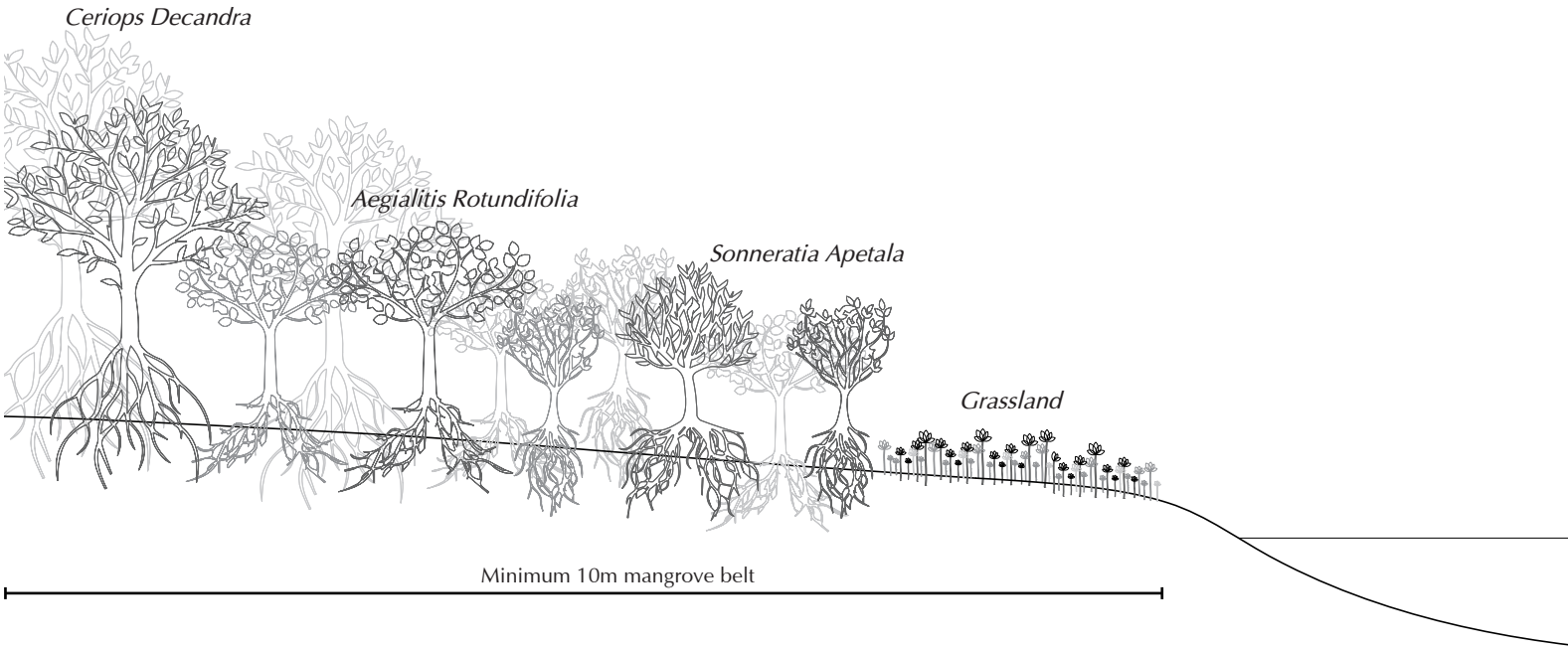
Reduced damage from large storms - Wide areas of mangroves can reduce storm surge flood levels, while narrower belts can still reduce the impacts of large waves and high wind speeds occurring during major storms (also called cyclones, typhoons or hurricanes).

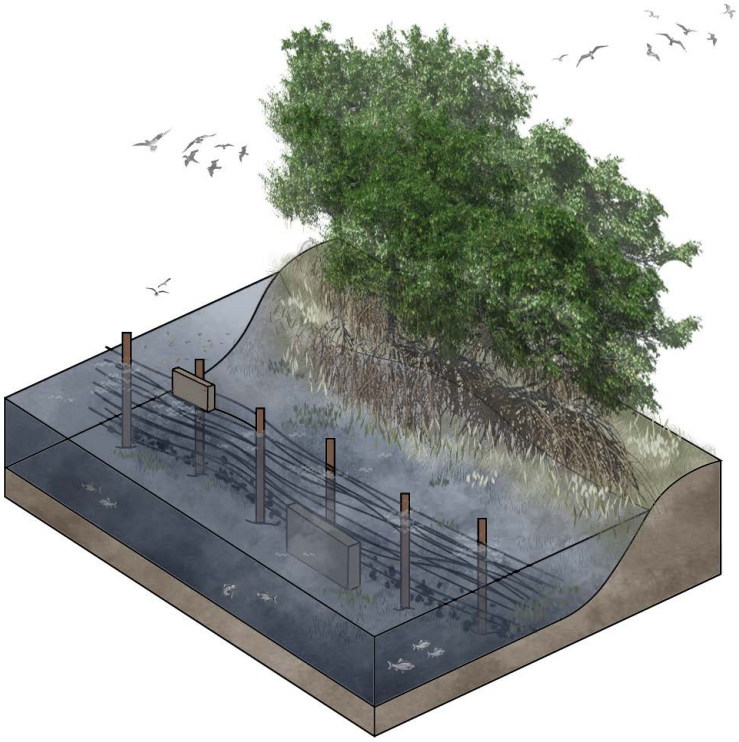
Reduced Tsunami damage - Wide areas of mangroves can reduce tsunami heights, helping to reduce loss of life and damage to property in areas behind mangroves.



Reduces erosion and binds soil together - The dense roots of mangroves help to bind and build soils. The above-ground roots slow down water flows, encourage deposition of sediments and reduce erosion.

Keeps up with sea level rise - Over time mangroves can actively build up soils, increasing the height of the mangrove soil surface, which may be critical as sea level rise accelerates.


Ceriops Decandra
Aegialitis Rotundifolia
Sonneratia Apetala
Grassland
Minimum 10m mangrove belt



Sustainable Dams

Weaving a defense for the mangroves

This innovative nature-based dam helps defending the mangroves from wave surges creating a more stable coastline for the villages of Sundarbans. This approach is inspired from the communities in northern Java in the district of Demak.

These dams are basically a network of permeable structures which trap the mud sediments for mangroves to recover and restore. This system unlike dams and dykes work with the forces of nature instead of fighting against it.

Indigenous

An indigenous practice from Dutch Wadden Sea, now being used all across Indonesia to protect the coastal communities.

Participation of Community

Economy

This system involves high community participation while creating job opportunities for local communities for the weaving of this infrastructure. These dams provide long term benefits for these communities as well. Economically this system is cheaper that concrete sea walls in terms of both material cost and labor costs.

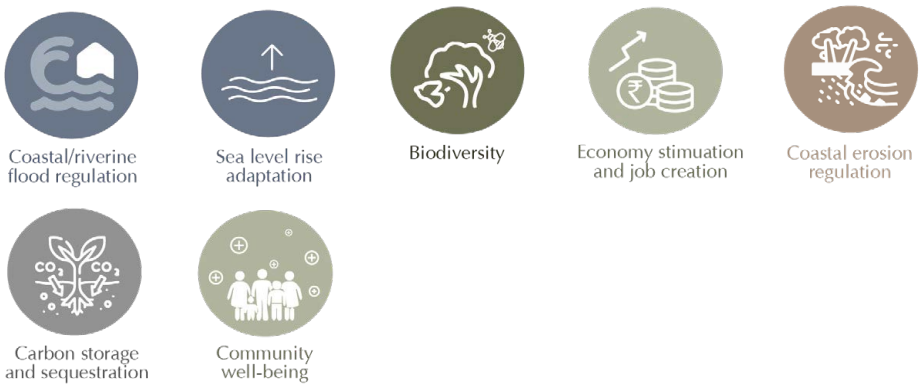
About

This system addresses the challenge of the eroding coastlines due to the loss of mangroves, more frequent cyclone surges in the past years, shift to intensive aquaculture monetary benefits by communities etc.

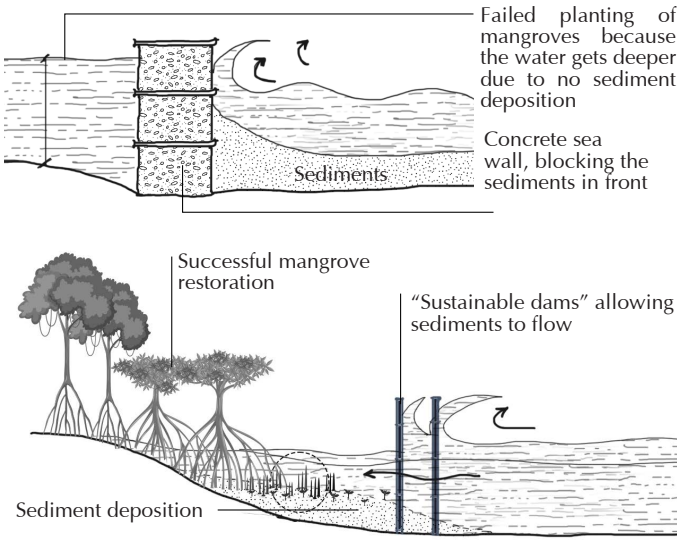
In the past years concrete embankments have failed to defend these islands from floods induced by cyclones. Instead they only worsened the matters leading to loss of mangroves and biodiversity in the edges.

Hence, to restore coastal ecosystems and create a double line defense system for the villages of Sundarbans, sustainable dams are introduced. This system has been extremely successful in Indonesia and can be replicated elsewhere around the world. Building with nature can answer the question of coastal protection not just for rural communities but also in cities.

Benefits/Impacts

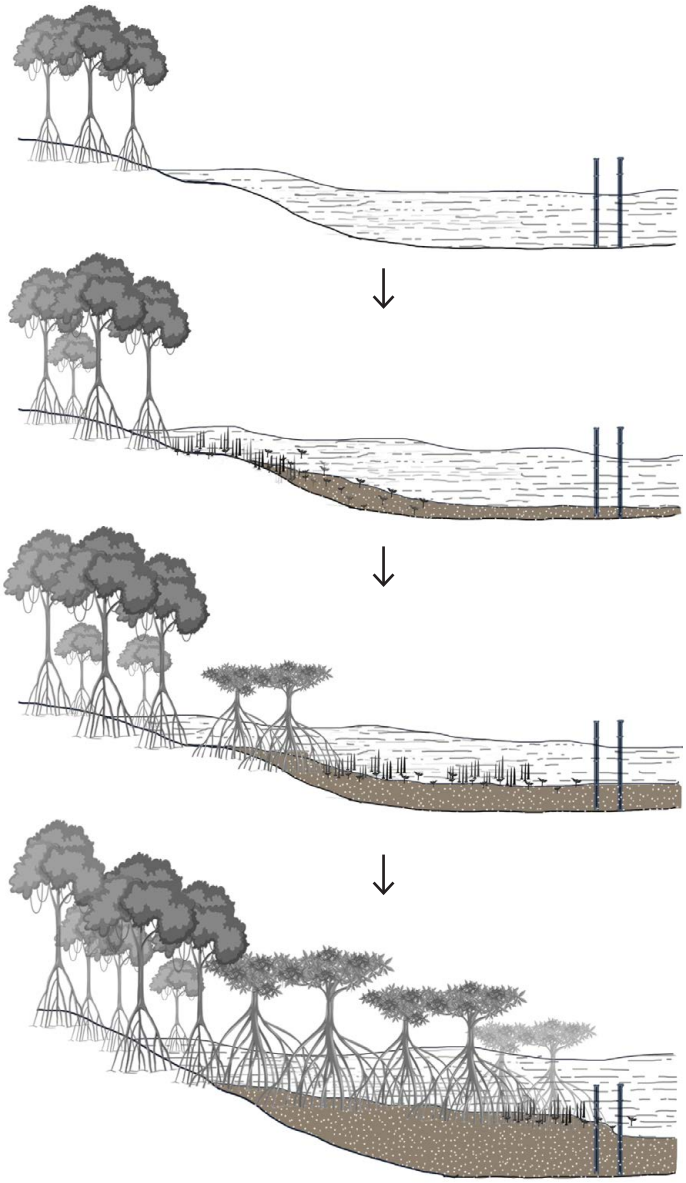


From concrete sea walls to sustainable dams



Concrete sea walls (top), sustainable dams (down)

Mangrove restoration over the years with "Sustainable dams"

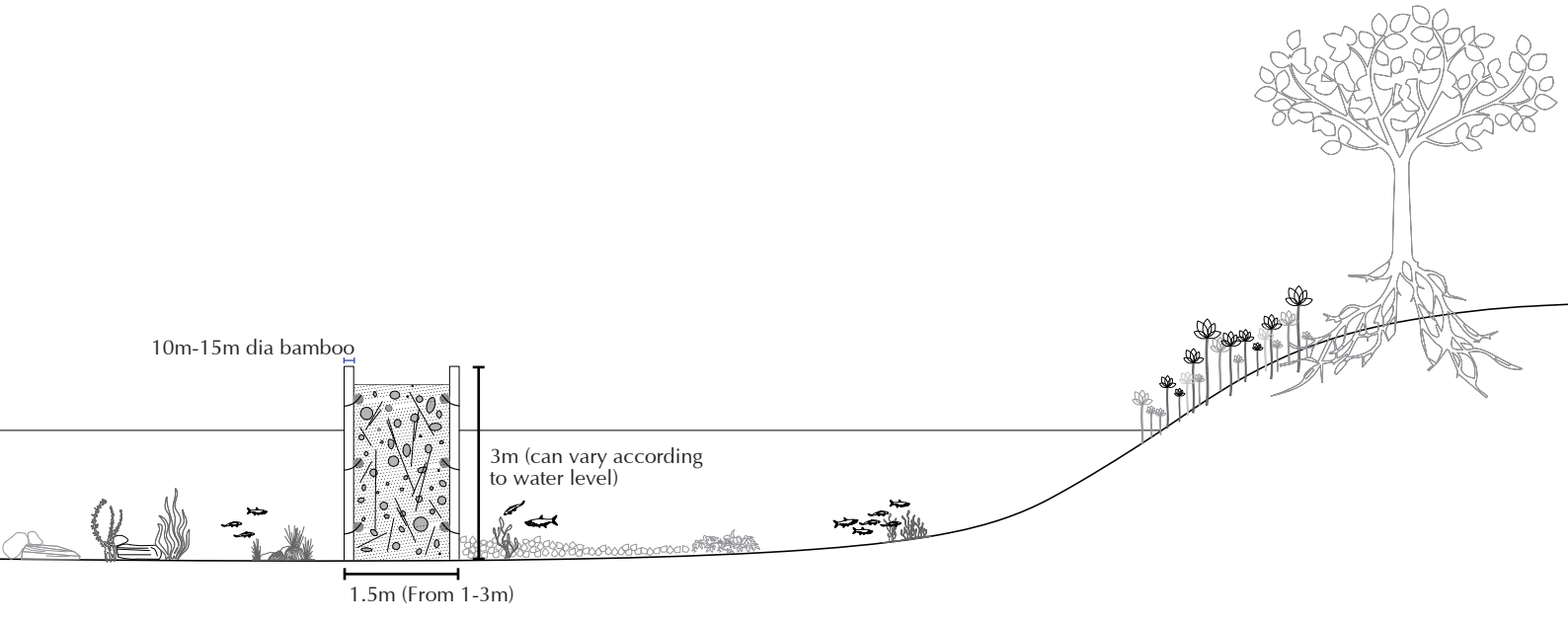


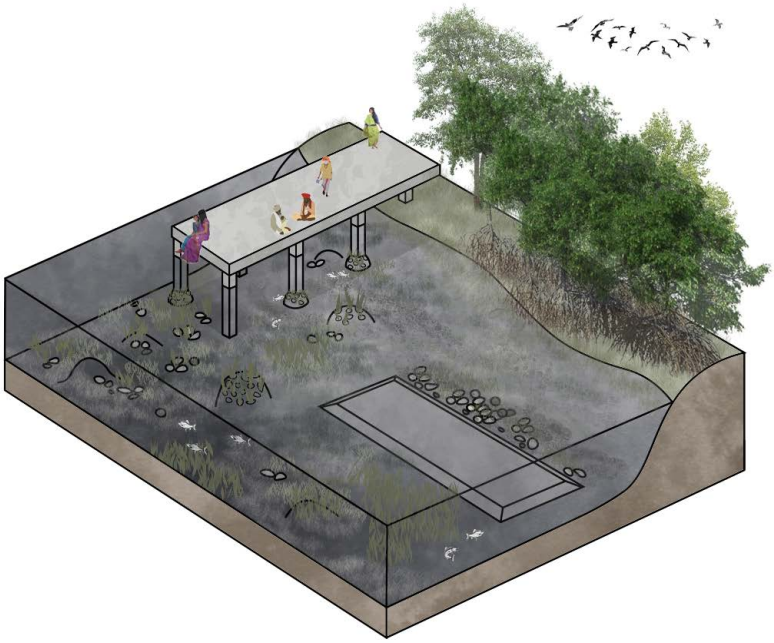
Concrete sea walls are expensive impermeable infrastructures that does not allow sediment to flow through leading to decrease in sediments on the coastal side increasing the water depth and not allowing mangrove belts to grow and expand.

Whereas the permeable structure allow sediment flow and the mesh allows the sediment to get trapped on the coastal side, allowing the mangroves to grow naturally and restore from the seeds for the present mangrove belts. The mangrove belts extend over the years naturally combining with these structures and acting as coastal defense.

These small, water-permeable dams filter sediments from the seawater, creating a fertile environment for mangrove trees. These semi-permeable dams are built from wooden poles packed with branches or mesh to dampen wave action and allow fine sediment to settle and build up and consolidate behind the dams.

Over the years, the sediment deposition allows the regain of land. Once the land is back, mangroves can regrow in the area and making the mangrove belt expand and strengthen, helping to protect the coastline against erosion and storms.


10m-15m dia bamboo
3m (can vary according to water level)
1.5m (From 1-3m)



Coastal Micro habitat Systems

An ecological waterfront infrastructure

Waterfront infrastructure in both rural and urban areas is rarely built to support biodiversity and provide ecosystem services, but has the potential to do so. The coastal Micro habitat systems are ecological systems to replace the ordinary coastal infrastructure to support biodiversity and other ecosystem services. It can help mitigate the environmental impacts and recover ecosystem functions in waterfronts. These systems are designed to support diverse range of micro habitats for aquatic organisms. They can provide important refuge and feeding areas for fish, as well as habitat for other aquatic organisms such as insects, mollusks, and algae.

Novel

It is a novel way to designing the coastal infrastructure by incorporating space for micro habitats to improve biodiversity and create a positive environmental impact

Participation of Community

Economy

This NBS can be incorporated in the existing coastal infrastructure or can be an addition to it, hence it is relatively inexpensive when compared to larger-scale habitat restoration projects. Despite a few costs, these micro habitat systems can provide important benefits to aquatic ecosystems. Therefore, the costs of constructing and maintaining may be outweighed by their ecological benefits.

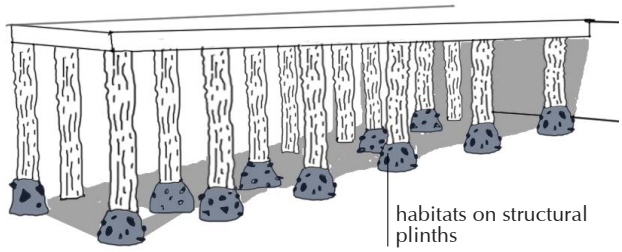
About

Docks and Piers introduce shade to areas of waterfront. Shading results in reduced plant density by inhibiting photosynthesis and increasing plant mortality, damaging communities of aquatic vegetation valued as nursery habitat . This often results in the elimination of upland, inter-tidal, and near shore vegetation.

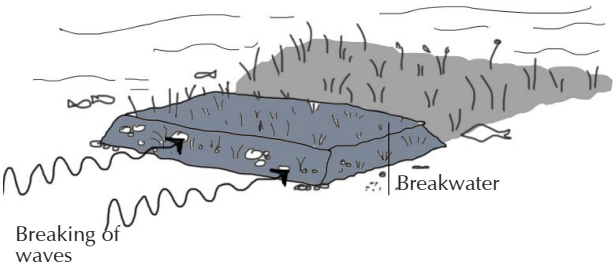
There are various ways to improve this. Firstly while designing, the orientation of the dock and spacing of pilings can be engineered to promote light penetration under the doc. Secondly, ecological designs that address habitat structure needs to be considered during the design phase. Third option is to incorporate textured pilings into dock design to create more surface area for algae, barnacles, and other marine organisms to grow. Benthic habitats, possibly in the form of artificial reefs, could potentially be incorporated into the base of pilings to provide shelter for fish and other organisms feedingon algae and invertebrates inhabiting the pilings .

For the existing infrastructure, these could be built in conjugation or independently of seawall and dock development

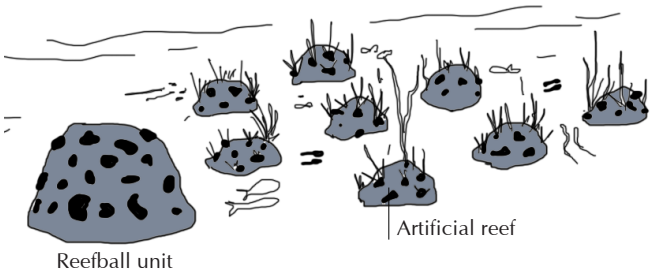
Benefits/Impacts



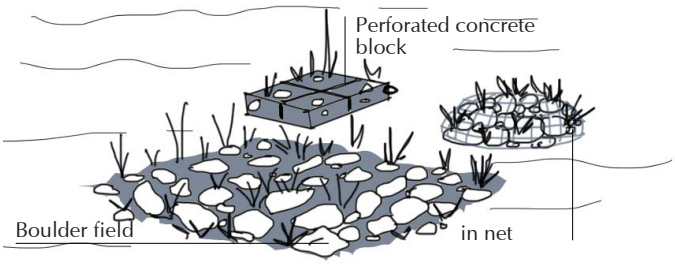
PILING HABITATS
Reconstructs rocky habitats for fishes, marine organisms, plants etc, hence increasing the inter tidal habitat area.



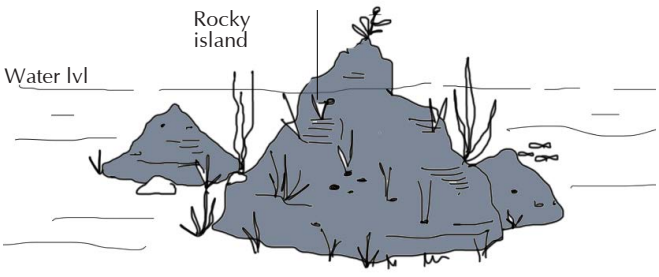
SUBMERGED BREAKWATERS
Submerged breakwaters built in front of seawalls can mitigate wave energy and create protected soft substrate habitat suitable for algae, small invertebrates, and juvenile fish



REEF BALLS (ARTIFICIAL REEFS)
ReefballS are hollow, textured, perforated concrete domes that have been used to replicate rocky benthic habitat They are built to Provide/ reconstruct rocky habitats for fish/marine organisms.

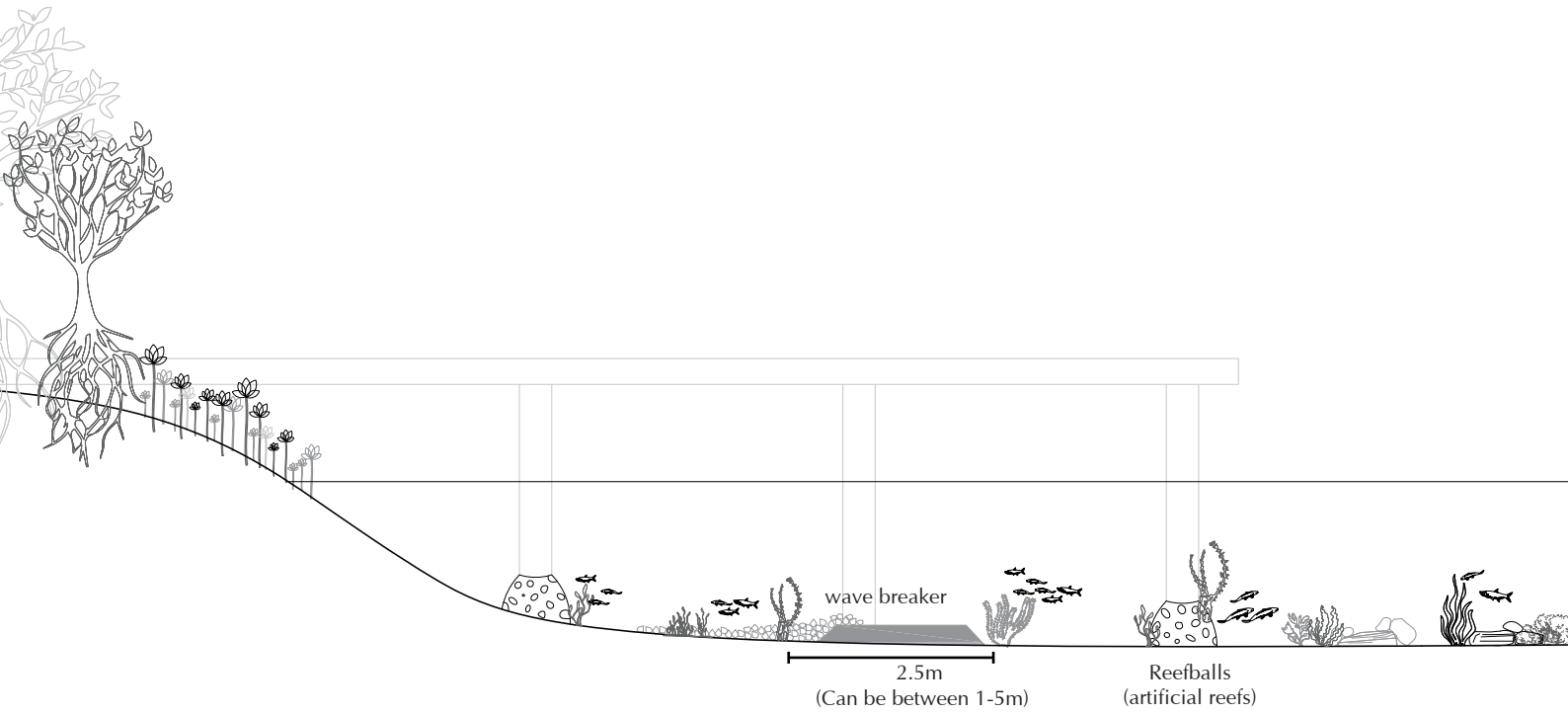


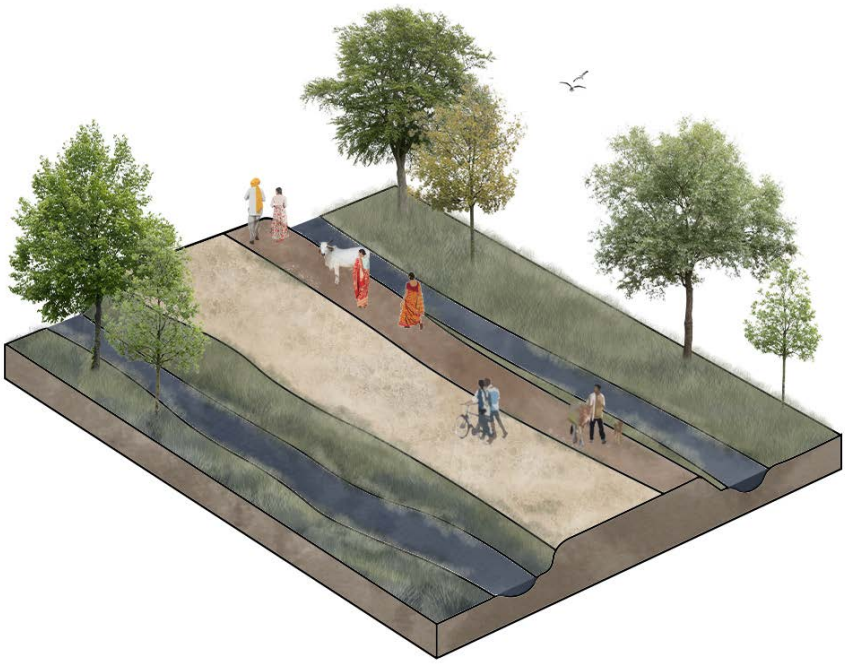
ARTIFICIAL REEFS FOR ALGAE
Low profile structures made of local rock or concrete to accommodate algae holdfasts Provide/reconstruct rocky habitat as basis for algae and supports ecosystem reliant on algae (fish, invertebrates,etc)



ROCKY OUTCROPPINGS
Rock outcroppings provide shallow water habitat area, micro habitat, and places for water birds to nest. They provide an unique waterfront aesthetic experience.

Reference: dyson, karen (no date) (PDF) ecological design for urban waterfronts - researchgate


wave breaker
2.5m
(Can be between 1-5m)
Reefballs
(artificial reefs)



Rural Streets

The pathway to sustainable streets

The rural street is a model of a "Sustainable street" for rural landscapes. They are designed keeping environmental and social sustainability in mind. These streets prioritize pedestrians, cyclists, and fauna over vehicles, encouraging sustainable modes of transportation. They increase the safety for the users and are and more adaptable to both the users and the animals of the villages. Some of them can also be designed to act as physical barriers in the events of flooding due to cyclones or storms.

Novel

A Novel approach to street design in areas where the streets can act as physical barriers for flooding related issues and also help in stormwater management.

Participation of Community

Economy

The construction and labor cost of these streets are comparable to the ordinary street. But, Rural streets can provide economic benefits by reducing flood damage to surrounding properties and infrastructure. They help maintain access to rural areas during flood events, which can support local economic activities such as agriculture, forestry, and tourism

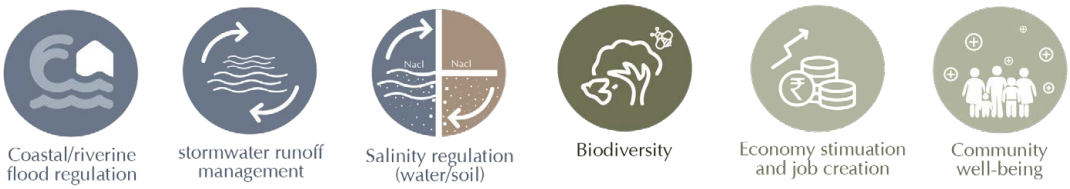
About

Rural streets are basically elevated streets with a part of street for slow mobility like bicycles and tuk tuk's while the other part of street dedicated for pedestrian use by the community and the village animals. The streets have canals on both sides to manage stormwater runoff and also collect freshwater that can be used to irrigate the agricultural fields. Hence, these streets incorporate green and blue infrastructure like the canals alongside and trees.

The streets act as a protective barrier and can be a nature-based solution in rural areas for managing flood risk and preserving natural habitats.

The rural street is designed keeping in mind the communities, reflecting local values and priorities.

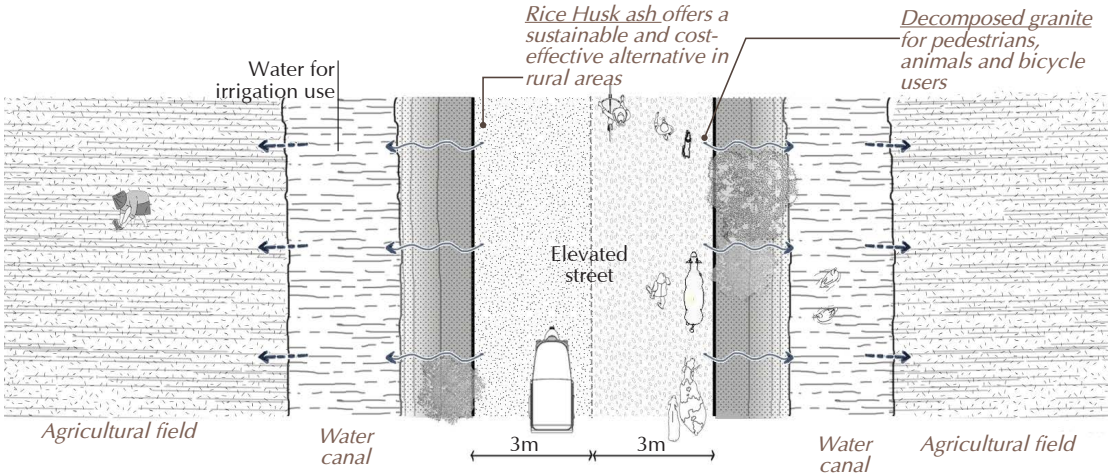
Benefits/Impacts



Different rural street possibilities

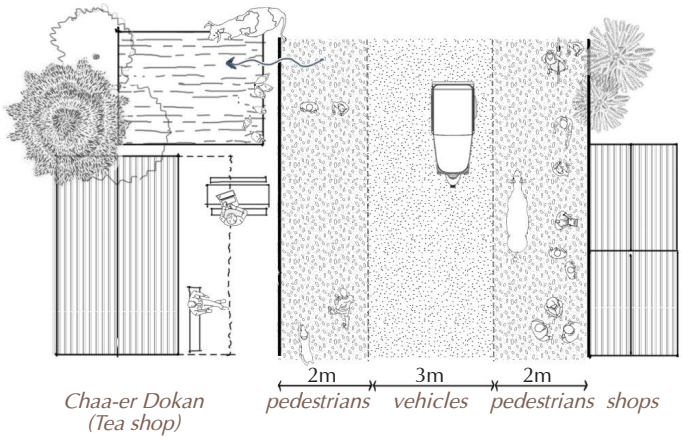
The idea of rural street can be applied in different ways depending on the existing street section, whether it is in agricultural setting, commercial area, along the coast , built areas or a hybrid setting of above. Below are some possible street designs for these cases-

Agricultural fields on both sides



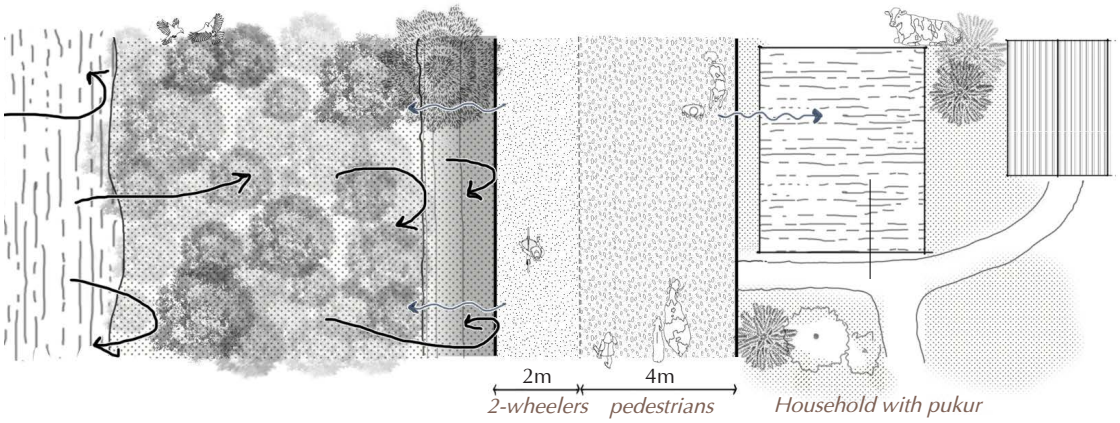
In the areas with agricultural fields on both sides, the street is elevated with water canals on both sides, which are used to irrigate the fields. The elevation allows to collect the stormwater runoff into the canals.

In commercial areas



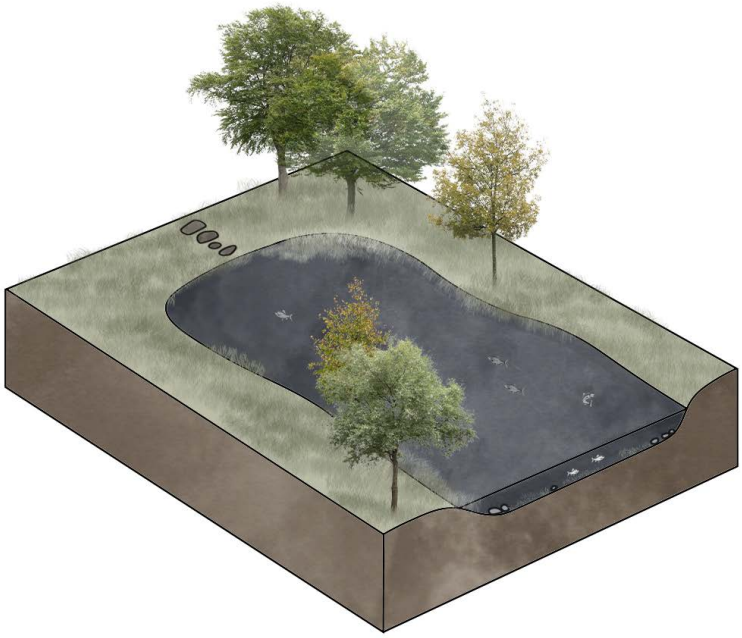
The street in commercial areas have pedestrian access on both sides prioritizing the accessibility of community and animals.

Along the coast



In coastal areas the street is elevated on the coast side acting as a second line of defense in case of storms. These streets are only for 2-wheelers and pedestrians, keeping it free of motor vehicles.


Rural street
Irrigation pukur
Decomposed granite
Rice husk ash



Pukur

Lifeline for Local Agriculture and Livelihoods

The rural landscape of the Indian Sundarbans is composed of an extensive pond system known as “PUKURS”. These are man-made ponds or reservoirs used to harvest freshwater from monsoon season and use it all year round. These water systems are freshwater sources for the inhabitants of the villages. The majority are manually-dug with rainwater during the monsoon, groundwater, or tidal exchange. The presence of these “PUKURS” allows this zone of Sundarbans to be inhabited by people. Traditionally these water bodies were used for domestic needs, but with blue revolution they were used also for aquaculture. Aquaculture being a source of high economic value for the villagers, the number of these ponds have been increasing in the last years. These threats are putting the livelihoods of the local people at risk, as well as the fragile ecosystem of the Sundarbans.

Indigenous

The Indigenous technique used by the people of Sundarbans to store and use freshwater from the rain.

Participation of Community

Economy

Pukurs are extremely cost effective. The construction cost of Pukurs is relatively low compared to other forms of water management infrastructure such as dams or reservoirs. They can be constructed locally by every household. And the long-term economic benefits of Pukurs are significant, as they can provide a reliable source of water for agriculture and other household activities, such as fish farming and tourism, for many years.

About

Pukurs play a crucial role in the economy of the Indian Sundarbans, providing livelihoods for thousands of people and contributing to the region's agricultural productivity and food security.

The water from the Pukurs is used for **domestic purposes** such as bathing, washing clothes, and cooking, which reduces the dependence on expensive bottled water or other sources of freshwater. They are also used for **fish farming,**Various fish species are cultivated in Pukurs, such as Rohu, Catla, Mrigal, and Tilapia. Pukurs are used for **irrigation purposes** and provide a reliable source of water for paddy fields, which is essential for rice cultivation, the main crop of the region. The water from the Pukurs is diverted to the fields through a system of canals or channels. Moreover, the Pukurs have **cultural and religious significance**, and some are even considered sacred by the local people. This has led to the development of tourism around some of the Pukurs, providing an additional source of income for the local communities. They are often associated with local myths and legends, and some are believed to have healing properties.

Benefits/Impacts

The Pukur system of Indian Sundarbans

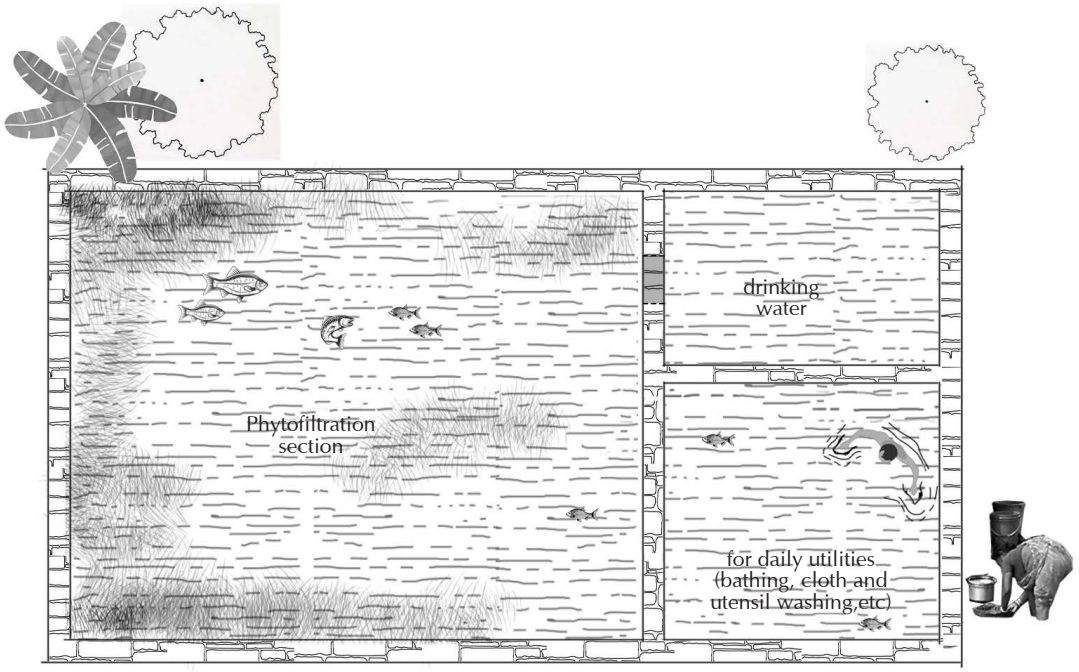
The Sundarbans in Indian region

One of the islands from Indian Sundarbans

The diagram shows the Pukurs dominating the landscape system of the Indian Sundarbans.

Pukur 2.0

The Pukur 2.0 is a 3-part pukur system with the biggest section for phytofiltration of water from fishes and plants. The water is then filtered to a smaller part that can serve the drinking water needs. A separate part is proposed for daily utilities, to keep the rest of pukur water clean.



Fish species

- *Oreochromis Niloticus*
- *Labeo Rohita*

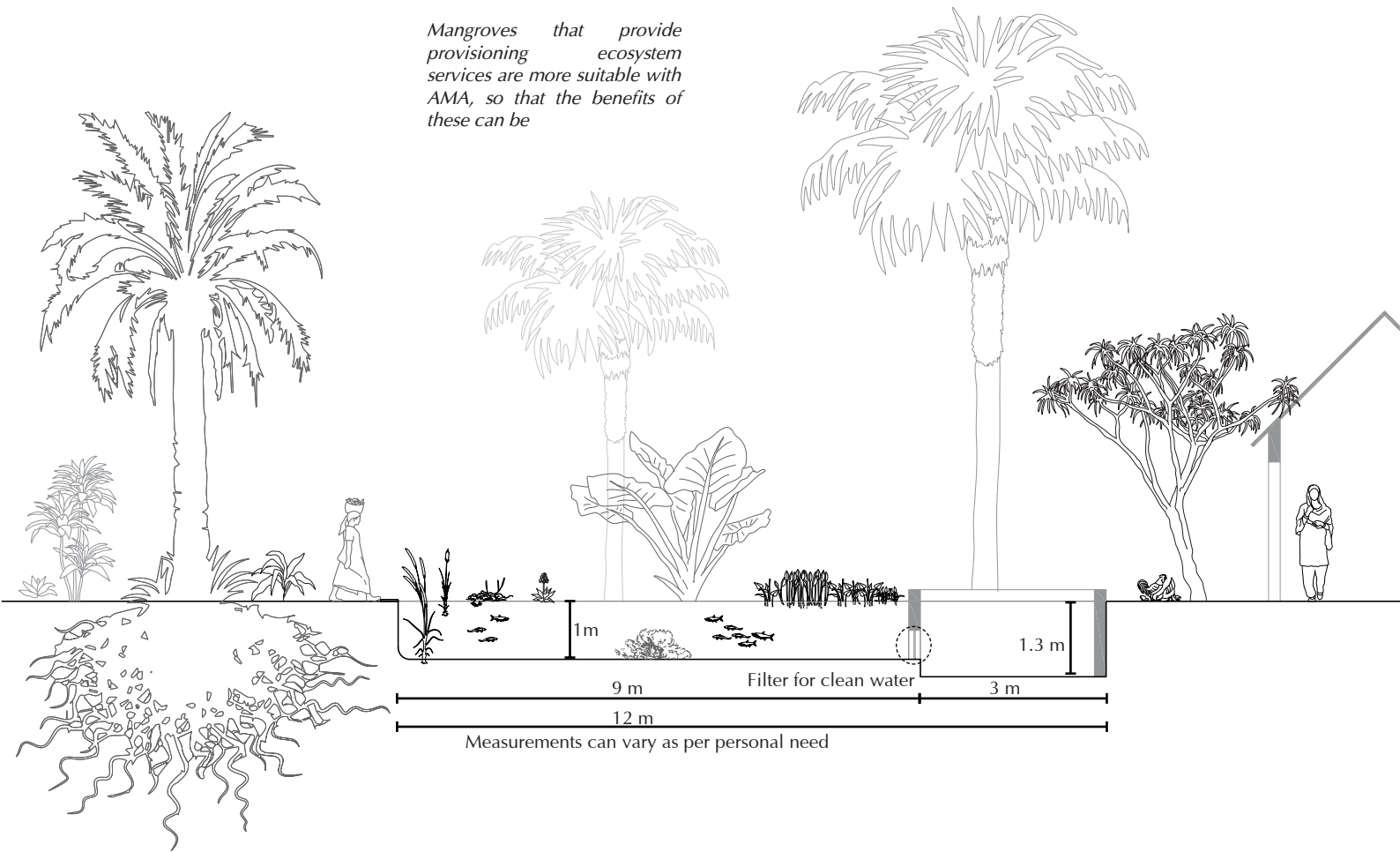
Tree species

- *Areca Catechu*
- *Shorea Robusta*

Plant species for phytofiltration

- *Hydrilla Verticillata*
- *Pistia Stratiotes*

Mangroves that provide provisioning ecosystem services are more suitable with AMA, so that the benefits of these can be



Communal Pukur

Pond Ecosystem for the community

Communal Pukurs are Pukurs that are collectively owned and managed by a group of people in a community. In the context of the Indian Sundarbans, communal Pukurs are an important aspect of the local community's social and economic life. They play an important role in fostering social cohesion and community development.

These pukurs can be used for irrigation, fish farming, additional freshwater storages and are social spaces for the community on day to day basis.

Indigenous

The Indigenous technique used by the people of Sundarbans to store and use freshwater from the rain.

Participation of Community

●●●●●

The space is for community use and the maintenance of these water bodies requires active participation and coordination among the members of the community.

Economy

●●●●●

Communal pukurs are cost-effective in terms of their contribution to the livelihoods of the local people and their ecological benefits.

- **Low maintenance cost**, as it is maintained by the members of the community
- **Multiple benefits** such as irrigation, fish farming, and water resource management
-**Ecological benefits**, providing habitat for aquatic species and reducing the dependence on other freshwater sources.
- **Social benefits**, strengthen community ties and promote local governance

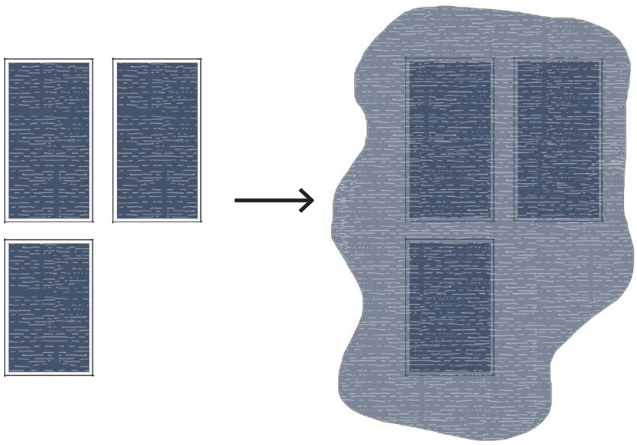
About

Pukurs play a crucial role in the economy of the Indian Sundarbans, providing livelihoods for thousands of people and contributing to the region's agricultural productivity and food security.

Communal pukurs can be a great tool for **water resource management**, as they can collect large amounts of freshwater, hence improving groundwater recharge, and reduce the risk of water scarcity. They can help in **biodiversity conservation** by providing habitat for aquatic species and help to maintain the ecological health of the region. They build **climate resilience** in the region by storing rainwater, reducing the dependence on freshwater sources, and providing irrigation for agriculture. They have a potential to be a good **social** space in the villages. These systems are based on **traditional ecological knowledge** of the region, hence promoting them can provide valuable insights into sustainable ways of managing natural resources.

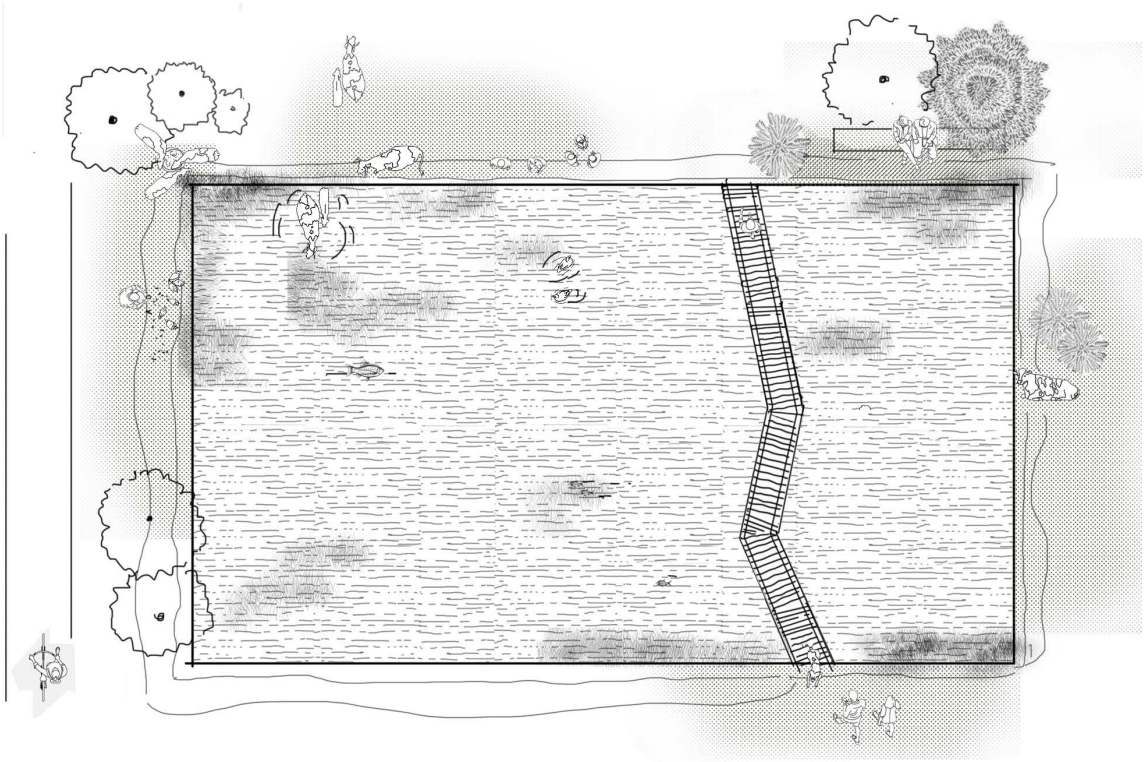
Benefits/Impacts

Communal Pukur Typologies



TYPOLOGY 1

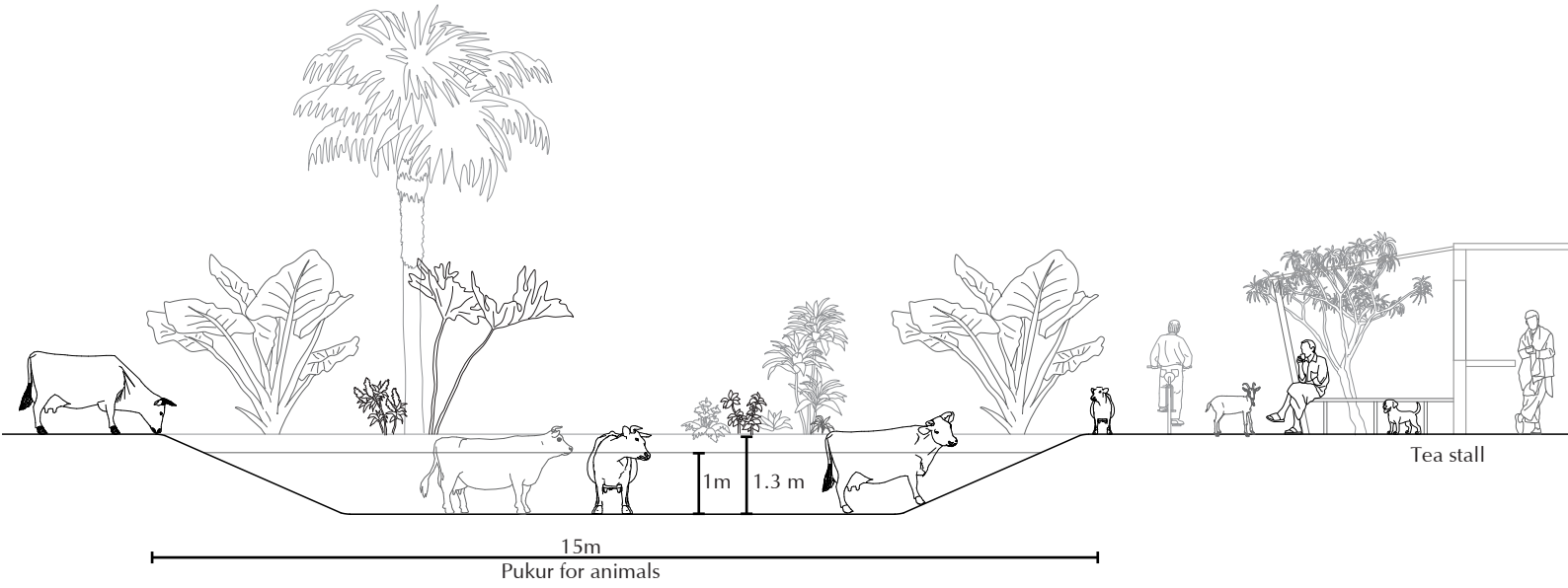
The first scenario is, a collection of small pukurs when flooded can form a bigger system. This could be a case during heavy rainfall in monsoon or floods induced by cyclones.

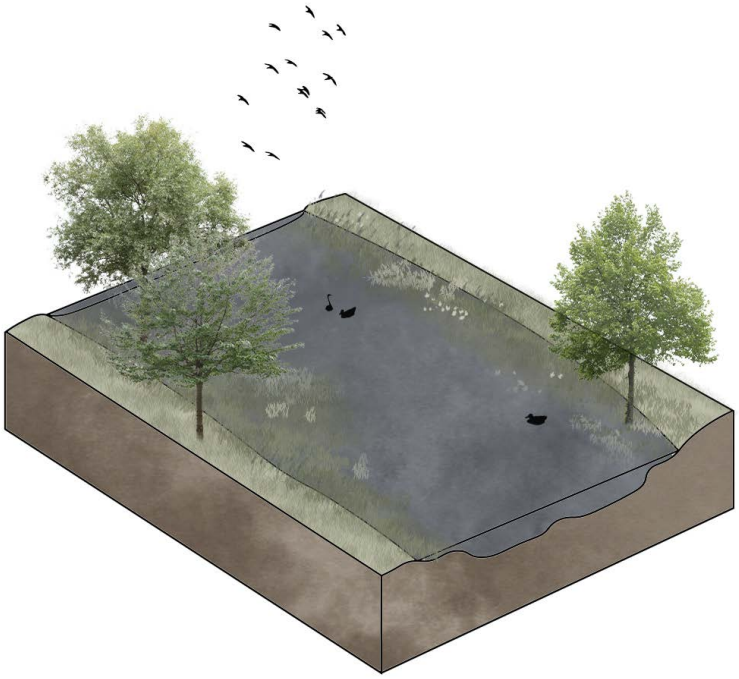


TYPOLOGY 2

The second case is a big Pukur, acing as a social point where the members of the community meet on day to day basis, can be a recreational space, a sacred waterbody in the village, can be a place for animals to bath and graze.


POINT
AKHIRALA.
9474399069.


1m
1.3 m
Tea stall
15m
Pukur for animals



Naturalized Retention basins

The Natural sponge

A Conventional Retention basin, also known as detention basins, are stormwater management systems designed to control and treat the flow of stormwater runoff.

Naturalized detention is intended to serve multiple functions, in addition to flood prevention, including pollutant removal and creation of wildlife habitat (where appropriate).These basins are formed in low lying areas in flooding or heavy rainfall events.

Familiar

This practice of managing stormwater runoff is well known

Participation of Community

Economy

Retention basins are economical as they require less infrastructure and maintenance. However, the cost-effectiveness of retention basins can be reduced if the basin requires extensive grading or excavation, if there are land acquisition costs, or if the basin requires ongoing maintenance.

About

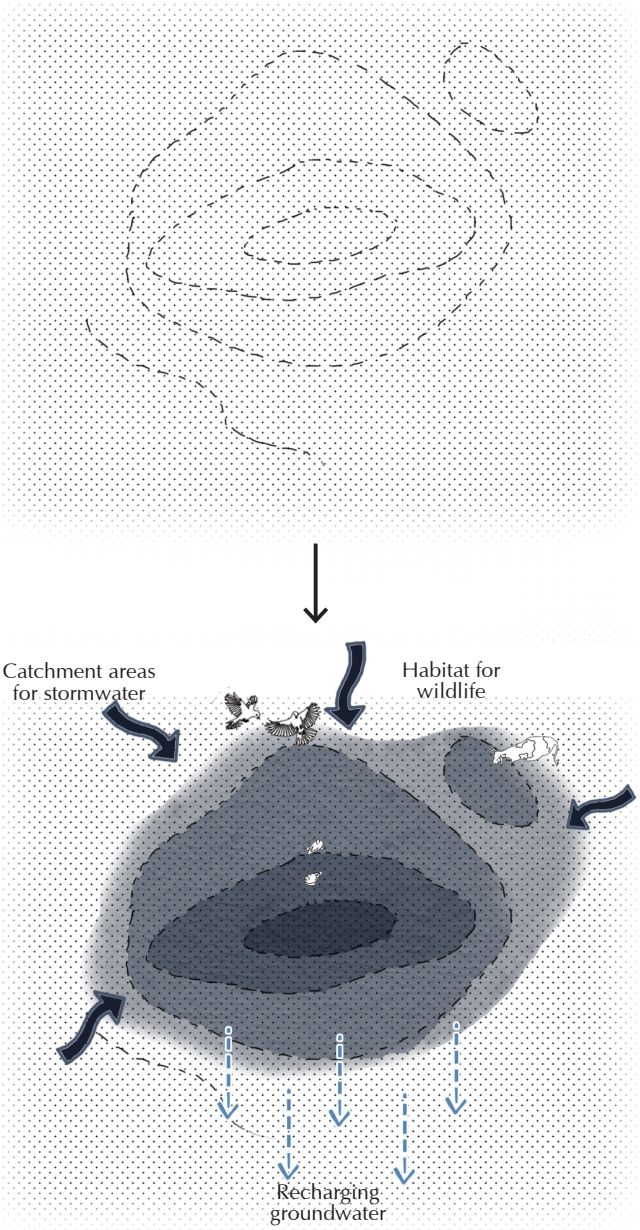
Water management in areas of lack of freshwater or high seasonal demand of water coupled with low supply, requires a solution to manage and restore the natural systems. These retention basins are **dry ponds**,**stormwater management facilities** designed to temporarily store and slow down stormwater runoff. They also act as **carbon sink, biodiversity refuge** and **place for relaxation** and contact with nature.

The stormwater runoff is directed into a shallow depression or depression-like area that has been designed with a permeable surface such as gravel, sand, or vegetation. The stormwater is then allowed to infiltrate into the soil, where it can recharge groundwater supplies and provide additional water for plant growth.

Retention basins are **green infrastructures** that uses nature to slow down, absorb and filter rainwater where it falls.

Benefits/Impacts

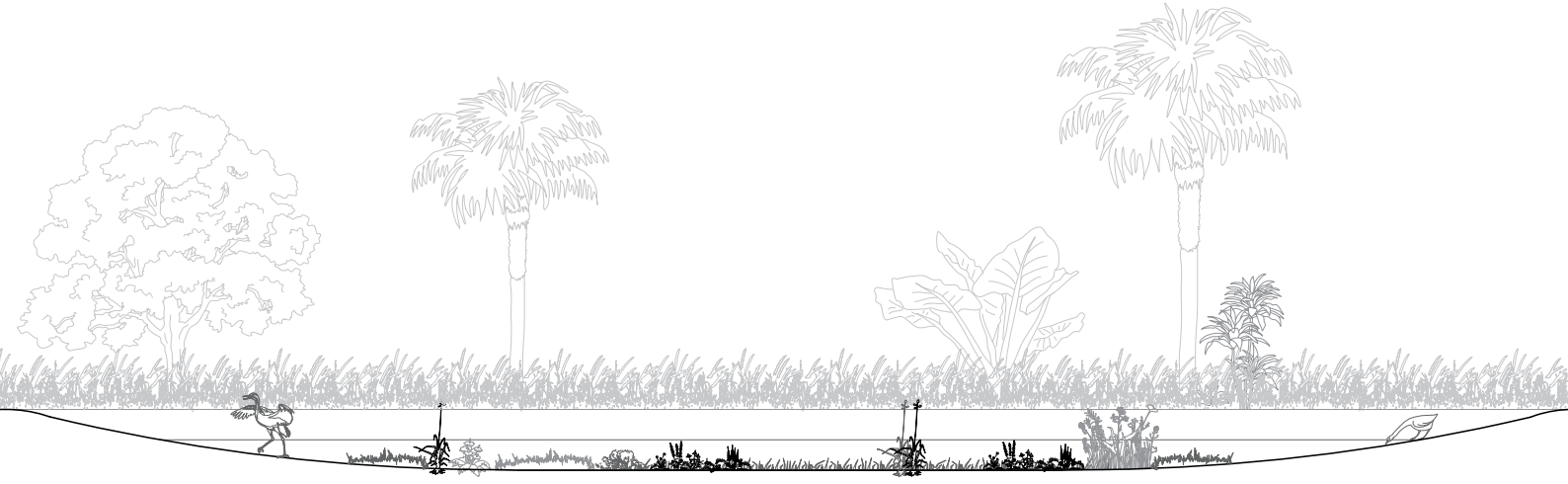
RETENTION BASINS AS FLOOD MITIGATION MEASURES



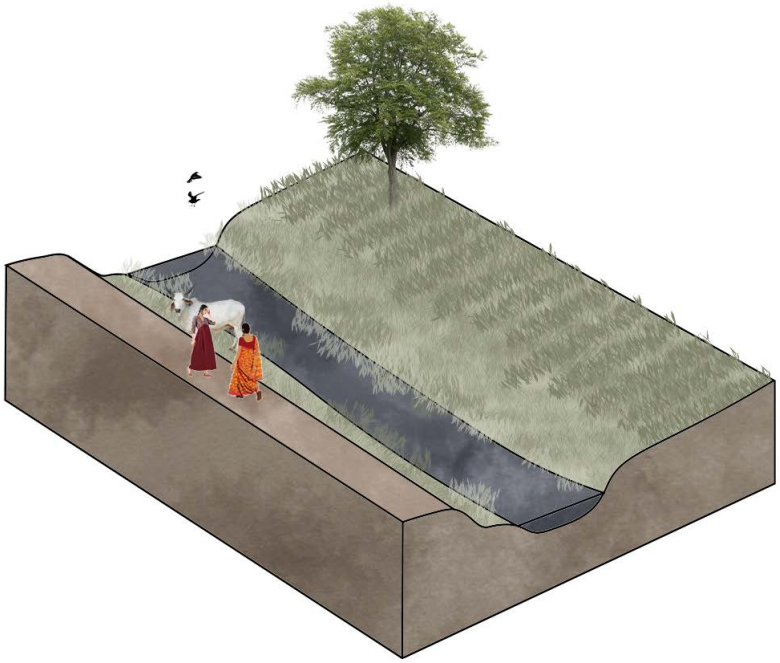
During floods, naturalized retention basins can be formed as a result of natural features and topography in the landscape. When there is a storm induced flooding or a large amount of rain, water flows over the land and follows the path of least resistance. If the land has features such as depressions or low areas, water can collect in these areas and form a retention basin.

They can be temporary areas that can hold huge quantities of water during storms — saving the agricultural land and the communities from flooding.

In the case of Sundarbans, Rice paddies (for eq - Oryza sativa)can function as naturalized retention basins, holding and filtering stormwater runoff while also providing food and habitat for wildlife.



Measurements varies as per the existing topography of the area



IRRIGATION SYSTEMS WITH PUKURS

On-farm water reservoir

This system uses irrigation ditches, which are a kind of linear pukurs. The systems are naturally replenished through precipitation. Utilizing this local water supply helps offset water that may otherwise be transported from far-off reservoirs, making this a sustainable irrigation method.

Familiar

Canals for irrigation are a familiar method of managing water resources and supporting agriculture in many parts of the world.

Participation of Community

Economy

Sustainable and cost-effective alternative for managing water resources and supporting agriculture. They can also help to reduce pressure on groundwater resources, which can be depleted through excessive pumping.

About

This system consists of man-made channel along the agricultural fields, used to catch the stormwater runoff and using it for irrigation. It is typically a shallow channel or trench, excavated from the ground and lined with materials such as earthen embankments, to reduce seepage and erosion. They are a really good supplement with additional water to support crop growth, especially for crops like paddy having a high water requirement. This ditch can also store the excess water from paddy, helping it maintain the correct ponding depth. Once in the ditch, the water can be directed to individual fields or crops using a system of gates or turnouts.

Irrigation canal systems can provide a range of benefits beyond simply supplying water to crops. These canals can be a source of water for animals and can also be a thriving ecosystem featuring fish, aquatic plants, alga, etc. They can also provide additional ecosystem services, such as carbon sequestration, flood control, and biodiversity conservation.

Benefits/Impacts

stormwater runoff management

Biodiversity

Carbon storage and sequestration

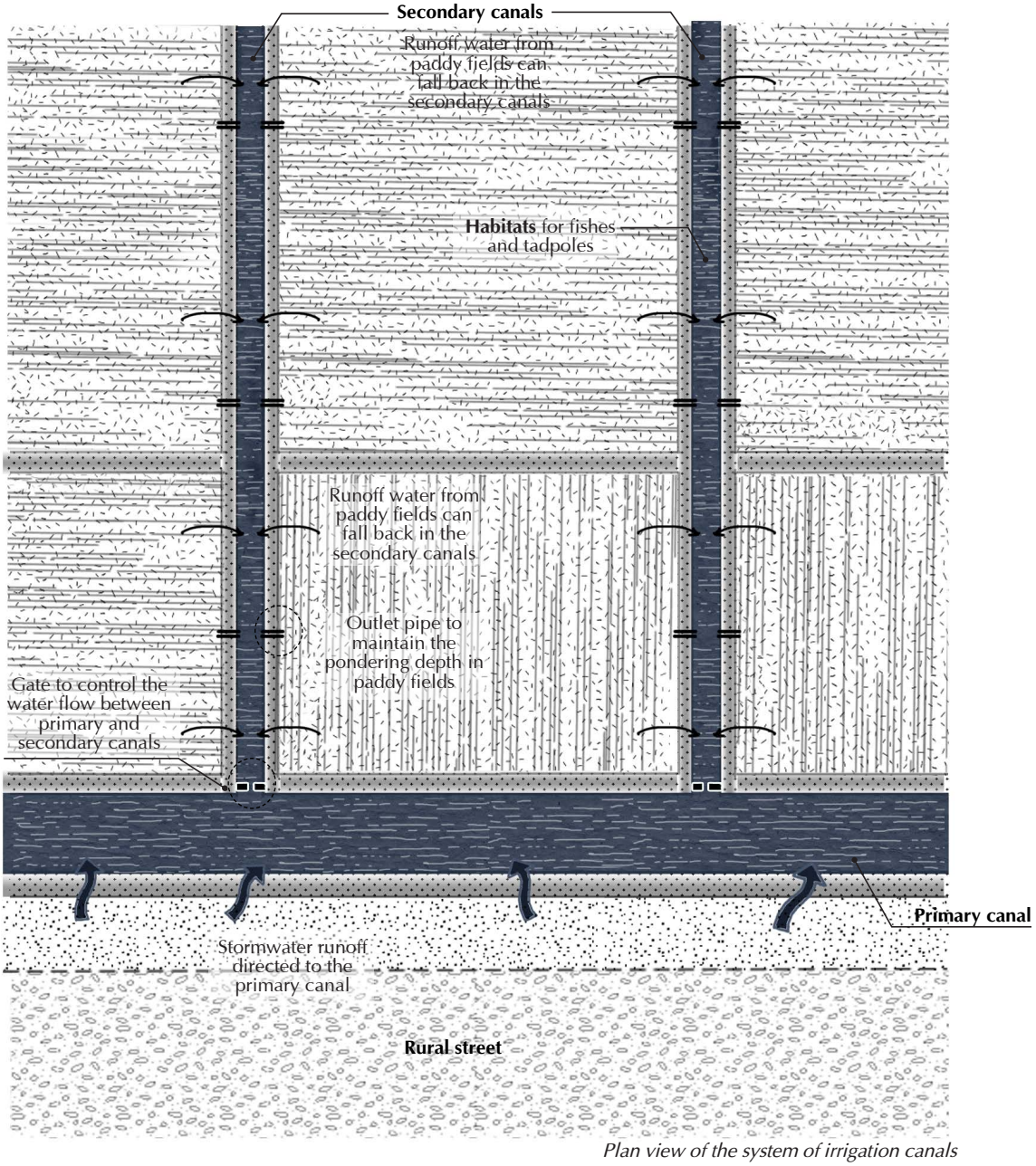
Community well-being

The irrigation canal system

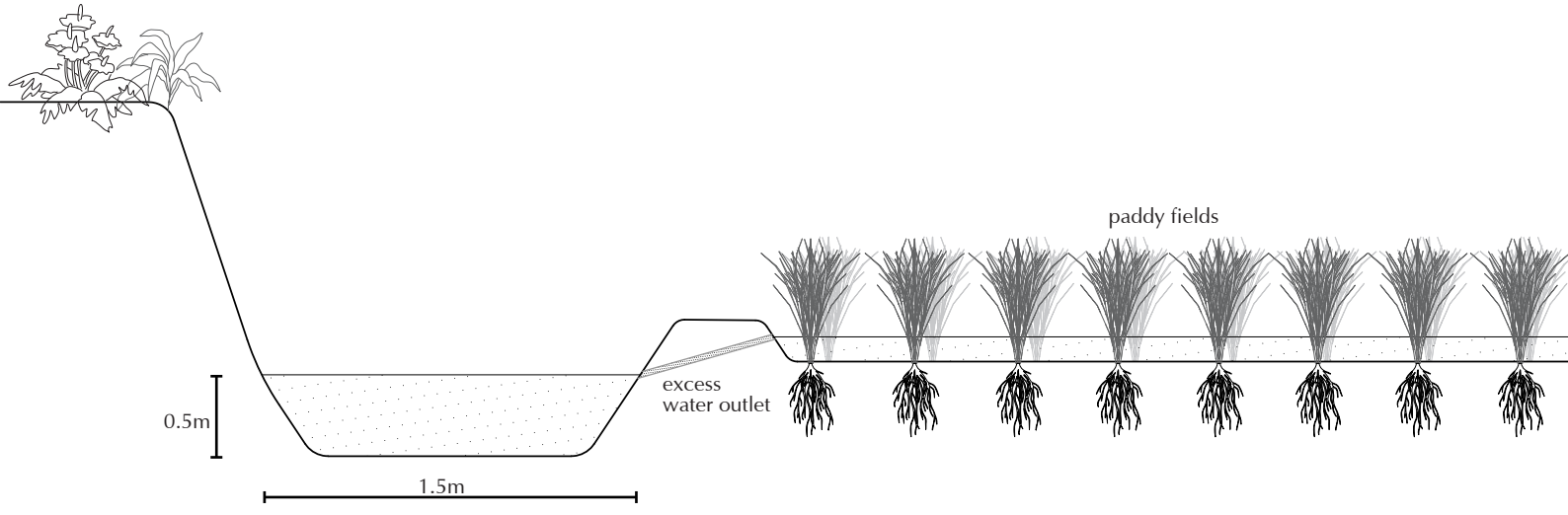
The system of linear pukurs, is a essential part for sustainable agriculture. In the case of Sundarbans, where paddy agriculture is the most dominant that relies on flooded field, this system is very important.

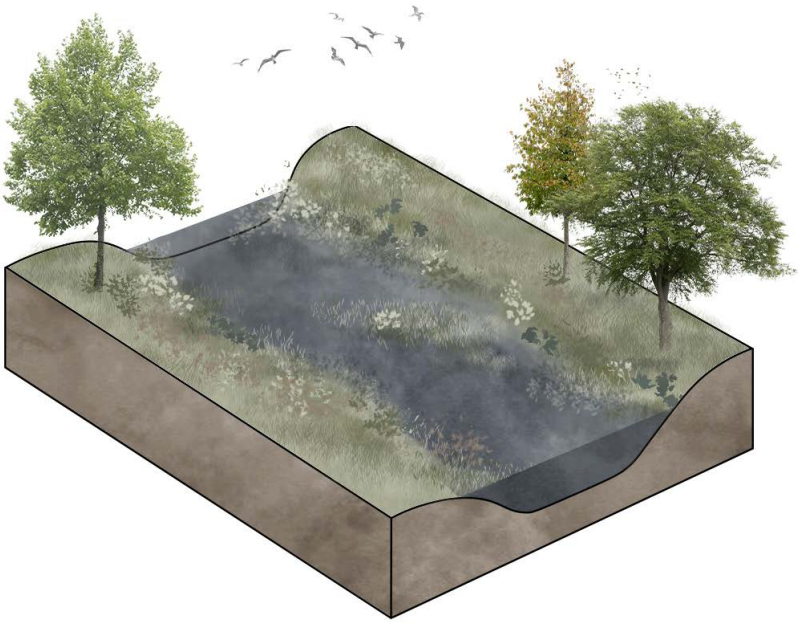
The Irrigation canals are divided in 2 categories. One being the primary canal, which is bigger and runs along the roads collecting stormwater runoff in monsoon. These canals are reservoirs for the secondary canals that are much smaller in comparison and runs along the agricultural fields distributing the water from primary canal and helping maintain the pondering levels in paddy fields. During periods of heavy rainfall or high river flows, the canals can divert excess water away from the fields to prevent damage to crops and infrastructure. The canals are usually designed with a series of gates and pipes to regulate the water flow and manage the timing and volume of water supplied to each field.

By supplying water to the fields and managing excess water, irrigation canals help to improve the productivity and resilience of rice farming systems.



Plan view of the system of irrigation canals


paddy fields
excess
water outlet
0.5m
1.5m



PHYTOFILTRATION

Cleaning the water to make it fit for use

Phytofiltration is a process of using plants to remove pollutants from contaminated water or soil.

The traditional way to clean the Pukur includes the use of potassium permanganate and lime put into the water once in a couple of months. But, phytofiltration can replace this method as it is a sustainable and environmentally friendly approach to remediation that uses natural processes to restore ecosystems and protect human health.

Familiar

Phytofiltration has been used for many years as an eco-friendly and cost-effective method of removing contaminants from soil, water, and air.

Participation of Community

Economy

Phytofiltration is a low-cost and sustainable method of remediation, particularly when compared to traditional methods such as excavation or chemical treatment.

About

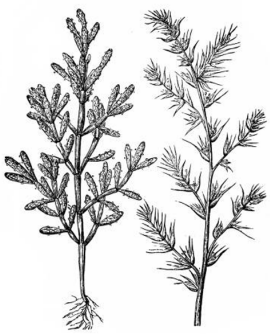
In phytofiltration, the plants are grown in the contaminated water or soil, and they absorb the pollutants through their roots. As the pollutants are taken up by the plant, they are broken down into less harmful substances, stored in the plant tissues, or released back into the environment.

Phytofiltration also has the potential to provide additional environmental benefits beyond pollution removal, such as carbon sequestration, habitat creation, and improved water quality. Furthermore, because it is a nature-based solution, it can be implemented at different scales and in different contexts, from small-scale community projects to large-scale restoration efforts. For instance it can be used in pukurs, communal pukurs, inland wetlands or any other water system. The plant species not only remove **pollutants**, like **heavy metals**, but can also **desalinate** the water. In case of Sundarbans, where salinity is a big threat to groundwater due to increase saline levels and saline water intrusions from floods induced by cyclones, the species can be helpful in **phytodesalination.**

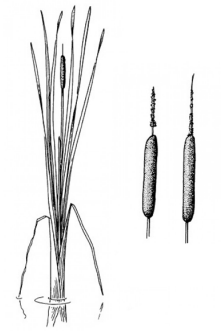
Benefits/Impacts

Plant species for phytofiltration

Suaeda Maritima
Has the ability to absorb and accumulate heavy metals, such as cadmium, lead, and nickel, from contaminated soil and water. It can also help in desalination as it is particularly effective in coastal regions and salt-affected areas

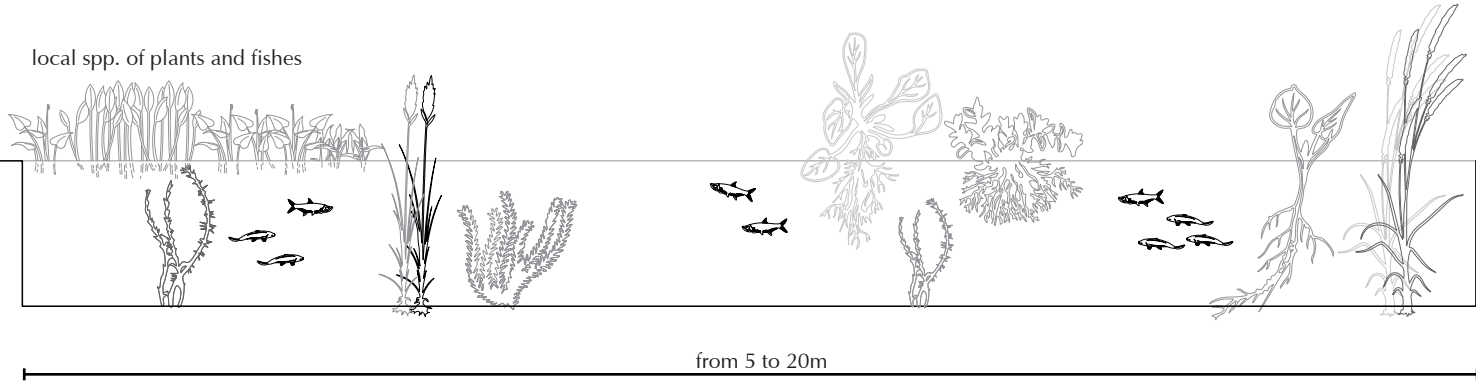


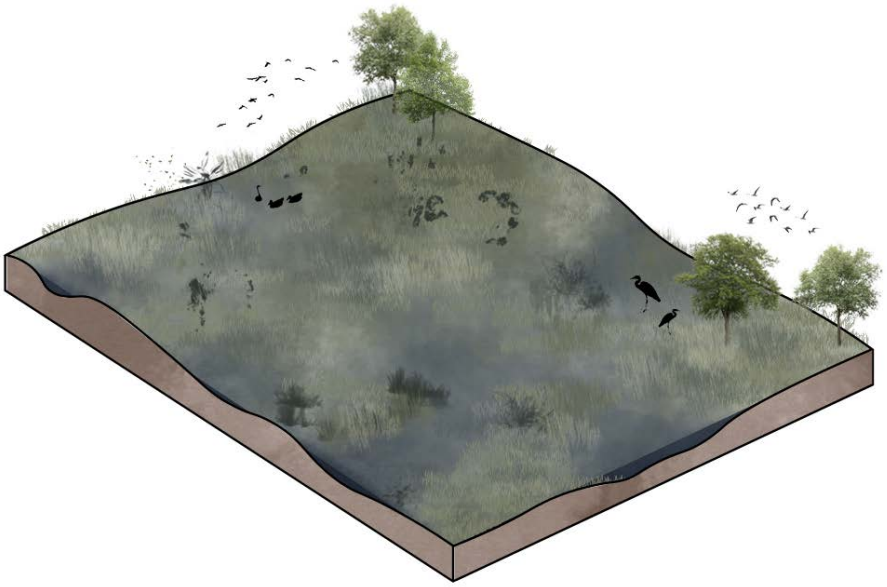
Salicornia Europaea
Have the ability to accumulate heavy metals, such as cadmium and copper, from contaminated soil and water. Salicornia europaea has been found to have the ability to accumulate salt in its tissues, which can then be harvested and removed to desalinate saline soil or water.



Typha Spp
These are wetland species and have the ability to absorb and accumulate pollutants from water through their roots. They can be used in constructed wetlands for wastewater treatment, providing a natural and cost-effective solution for removing pollutants from wastewater. They can also help to control erosion and provide habitat for wildlife.

Ipomoea Aquatica
Aquatic plant species for phytofiltration. It can be grown in floating treatment wetlands or constructed wetlands for wastewater treatment. Also known as water spinach, it is a vegetable crop, hence it has the potential to provide both environmental and economic benefits.


local spp. of plants and fishes
from 5 to 20m



Natural Inland Wetlands

An ecological treasure

Natural inland wetlands are a subset of natural wetlands that are not in the coastal marine area. This includes both freshwater and inland saline wetlands.

These are important ecosystems that provide a variety of benefits, including water storage, flood control, nutrient cycling, acts as carbon sinks and habitat for wildlife all year round. These are the ecosystems hosting the most biodiversity.

Familiar

Natural inland wetlands have been recognized as important ecosystems for a long period and have been valued for their ecological, social, and cultural benefits

Participation of Community

Economy

Natural inland wetlands can provide a range of long term economic benefits such as flood control, water purification, carbon storage, recreation, biodiversity conservation etc., although these benefits can be difficult to quantify.

About

Wetlands play a crucial role in promoting sustainable development and addressing a variety of environmental challenges. By functioning as nature-based solutions, they provide a range of ecological services that are essential for the health and well-being of both people and the planet. Here are some examples:

Water purification: Wetlands naturally filter and clean water. As water flows through the plants and soil in a wetland, pollutants and sediment are removed, resulting in cleaner water.

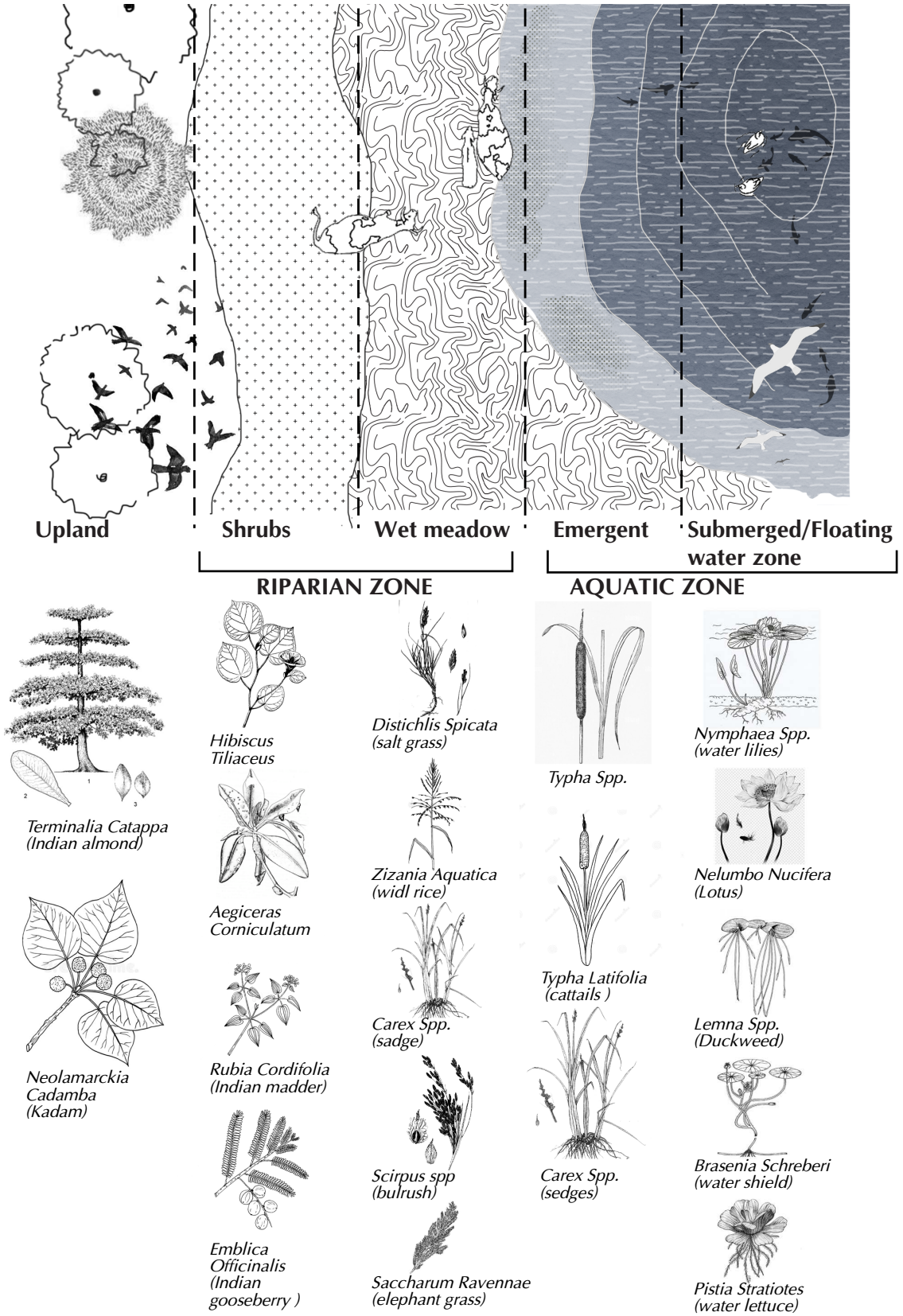
Flood control: They can absorb and store large amounts of water, helping to reduce the risk of flooding downstream. By slowing down the flow of water during storms, wetlands also help to prevent erosion and reduce the damage caused by flooding.

Carbon sequestration: Wetlands are important carbon sinks, meaning they absorb and store carbon dioxide from the atmosphere. This helps to mitigate climate change by reducing the amount of greenhouse gases in the atmosphere.

Biodiversity Hosts: Wetlands are home to a wide variety of plant and animal species, making them important centers of biodiversity. By conserving and restoring wetlands, we can help to protect and preserve these important habitats.

Benefits/Impacts

Plant species for different wetland zones



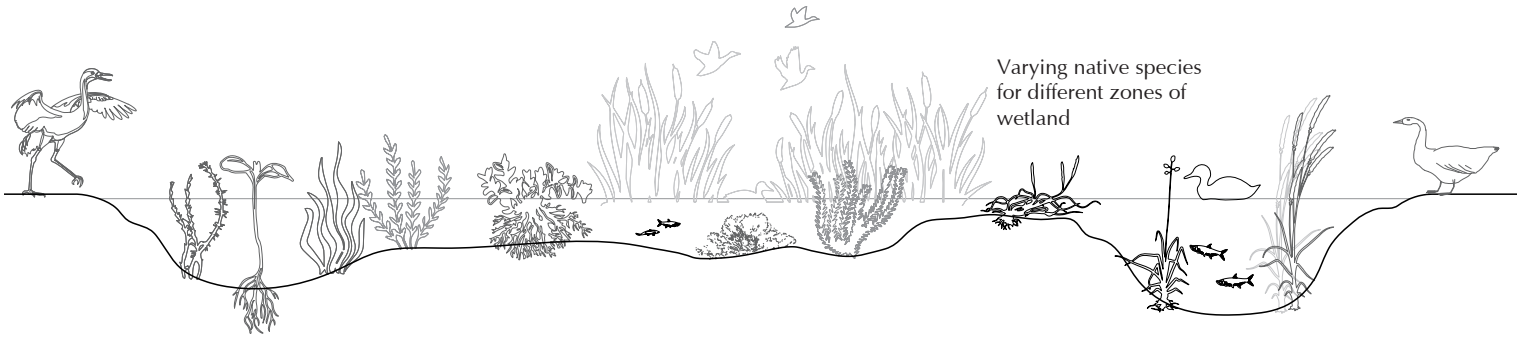
SUBEMERGED / FLOATING WATER ZONE - Characterized by submerged plants and plants with floating leaves

EMERGENT ZONE - The emergent zone is the area of the wetland that is shallow and frequently flooded.

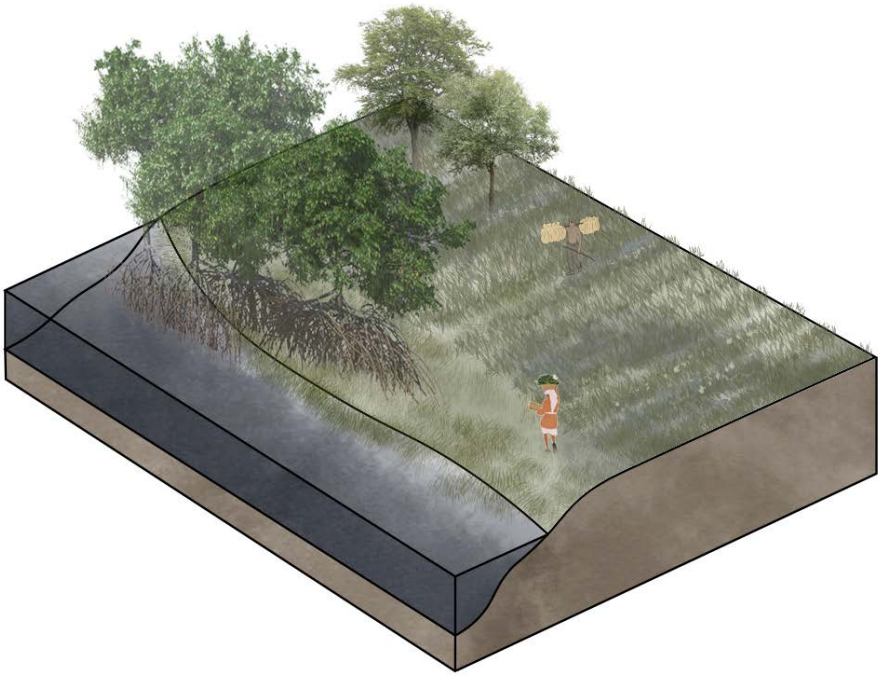
WET MEADOW- Characterized with plants such as sedges, grasses, rushes and herbs.

SHRUB - Characterized with shrubs, wines and sedges

RIPARIAN ZONE- Area adjacent to a the waterbody consisting of woody shrubs, trees and forest vegetation.



Measurements vary as per the existing landscape conditions



“SALT TOLERANT AGRICULTURE”

Tool for Climate Change Adaptation in Sundarbans

Salt-tolerant agriculture, refers to the cultivation of crops that can tolerate and grow in soils with high levels of salt. This type of agriculture is particularly important in regions where irrigation water is saline or where the soil is naturally saline, or in case of Sundarbans where the salinity of water and soil is always an issue to increasing cyclones.

Indigenous

Salt-tolerant agriculture has been practiced by indigenous communities in certain regions for centuries. For eg, in parts of Mexico, the indigenous Zapotec people have been cultivating salt-tolerant crops such as quinoa and amaranth Similarly, in Iran, the use of halophyte plants for food and medicinal purposes.

Participation of Community

Economy

The economic viability of salt-tolerant agriculture depends on several factors. The low yields from salt tolerant crops, can also affect their economic viability. But, salt tolerant crops has the potential to provide a sustainable and viable option for agriculture in saline environments, and its economic viability can be improved through supportive policies and infrastructure.

About

In general, salt-tolerant crops tend to have lower yields than traditional crops grown in non-saline soils. This is because high levels of salt in the soil and water can interfere with plant growth and development, resulting in reduced yields. However, through selective breeding and genetic modification, some salt-tolerant crop varieties have been developed that can produce yields comparable to traditional crops.

Most of the salt tolerant paddy varieties fetch a lower yields and lower market rates. The grains are thicker than usual and hence don't sell well. Indigenous salt tolerant varieties used to grow in the Sundarbans before the green revolution of the 1960s, after which the high yielding varieties gradually replaced them.

In the case of Sunderbans, various attempts have been made to grow different species of salt tolerant paddy,but **Dudhersar** was the only existing variety that could **tolerate low levels of salinity** and also fetch a price in the market to act as a remunerative crop. However, **highly salt-tolerant varieties like Darsal, Nona Bokra and Talmugur**, even though found to be cultivated in patches of the Sundarbans, are not popular because they cannot fetch a good price in the market.

Benefits/Impacts

Salt tolerant crops

Paddy varieties

Swarna Sub 1 (left) , Oryza sativa (middle), Dudheshwar rice (right)

Swarna Sub 1
- Flood-tolerant rice variety
- High yielding even during floods

Oryza sativa (Kerela Sundari)
- Flood-tolerant
- High-yielding rice variety

Dudheshwar Rice
- Salt resistant paddy variety

Wheat varieties

KRL 210 wheat cultivation

KRL 210
- Durum wheat variety for suitable for cultivation in moderately saline soils.

KRL 19
- Bread wheat variety, suitable for cultivation in highly saline soils.

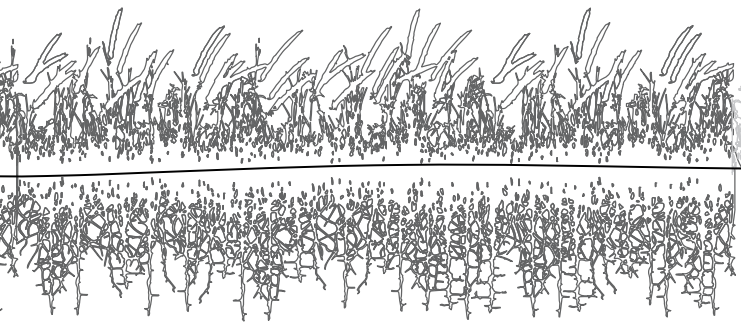
Other crops

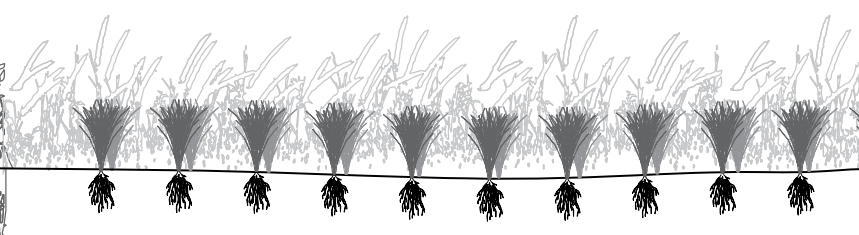
Indian spinach (left), bitter gourd (middle), sponge gourd (right)

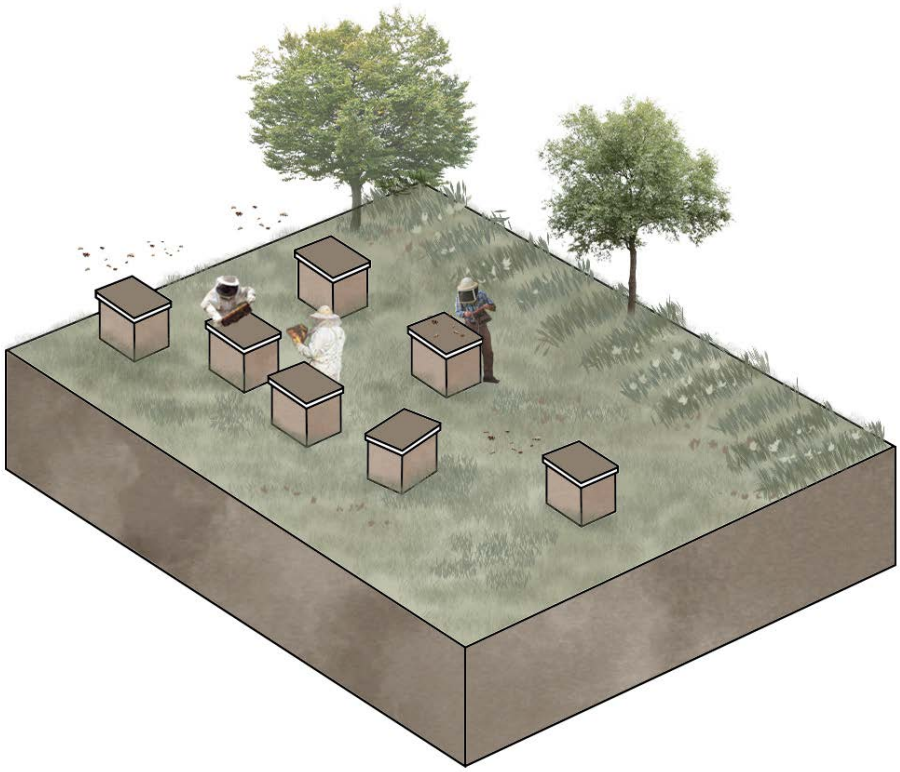
Basella alba (Indian spinach)
- Can grow in saline soils irrigated with low salinity water

H-88 (Tomato)
- Salt tolerant tomato

Momordica charantia(Bitter gourd) and Luffa cylindrica (sponge gourd)
- Salt-tolerant and can be grown in saline soils







NATURE BASED BEEKEEPING

Making life better with bees

Nature-based beekeeping, also known as natural beekeeping or holistic beekeeping, is an approach to beekeeping that prioritizes the health and well-being of bees and their natural environment. It emphasizes working with the natural behaviors and needs of bees, rather than manipulating them for human purposes.

Nature-based beekeeping involves practices such as providing bees with natural hives, keeping the cost of beehives as low as possible. Because with low-cost hives the barrier to becoming a beekeeper is removed, making beekeeping accessible to more people. This means more people can keep more bees.

This approach aims to create a more sustainable and resilient beekeeping system that supports the health and well-being of bee populations, as well as the pollination services they provide.

Indigenous

Nature-based beekeeping has been practiced by many cultures around the world for thousands of years, eg in Africa, traditional beekeeping practices have involved the use of natural hives, the Mayans of Central America practiced stingless beekeeping

Participation of Community

Economy

Nature based beekeeping is a sustainable and low-cost beekeeping system. It reduces or eliminate the need for expensive inputs, such as pesticides, antibiotics, and modern beekeeping equipment. It is a source of income for local farmers and yields additional benefit s like pollination services to agricultural crops.

Working of Nature based Beekeeping

The Nature Based Beekeeping approach requires a good understanding of the local context and skills and knowledge from local community. It is not an equipment-centric approach, rather a knowledge based approach. Communities tap into the potential of their natural resources – namely honey bees, floral resources and hive-making materials. Here are some key practices involved in nature-based beekeeping:

-**Natural hives**: Nature-based beekeepers use natural hive designs that mimic the structure and features of natural bee habitats, such as hollow trees or rock crevices. These hives are typically made from natural materials, such as wood or straw, and allow bees to build their own comb and manage their own hive environment.

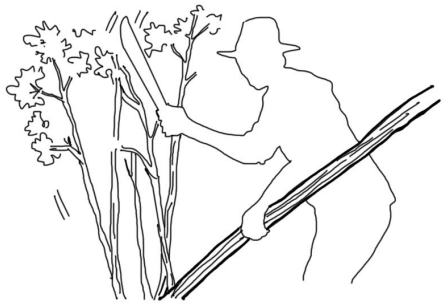
-**Avoiding chemicals**: No use of chemical treatment,instead the focus is on maintaining healthy bee populations through practices such as providing adequate nutrition, reducing stress on the colony, and allowing bees to build resistance to pests and diseases naturally.

-**Minimal intervention**: The aim to minimize human intervention in the bees' natural behaviors.

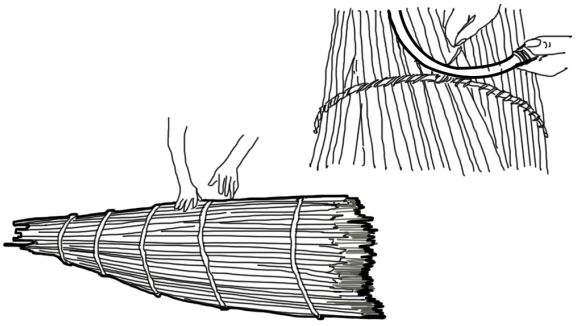
-**Supporting biodiversity**: Providing diverse range of flora and fauna in the local ecosystem, to provides bees with a diverse range of food sources and supports overall ecosystem health.

Benefits/Impacts

Local hive making process

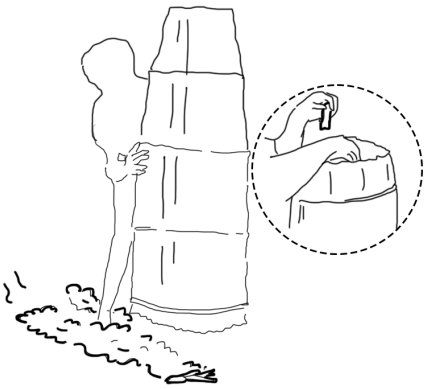


STEP 1 - Local hives can be made from materials like papyrus reeds, bamboo, logs, bark, climbers, sticks and clay.

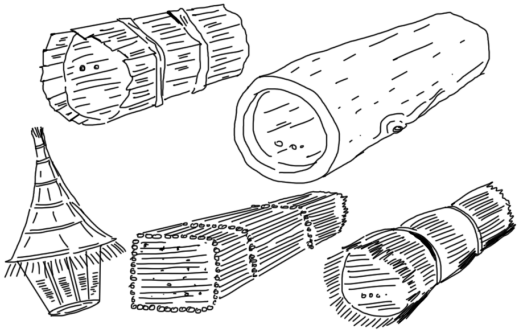


STEP 2 - The bark strips are split and knitted into rings that is knotted together to the long strips. The hive is constructed narrower on top.

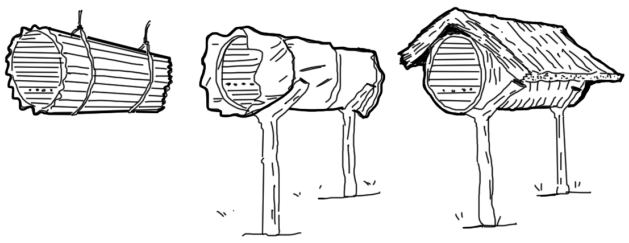
STEP 3 - A mixture of cow dung and water is used for plastering the hives to protect them from pests and predators. They are dried in the sun after.



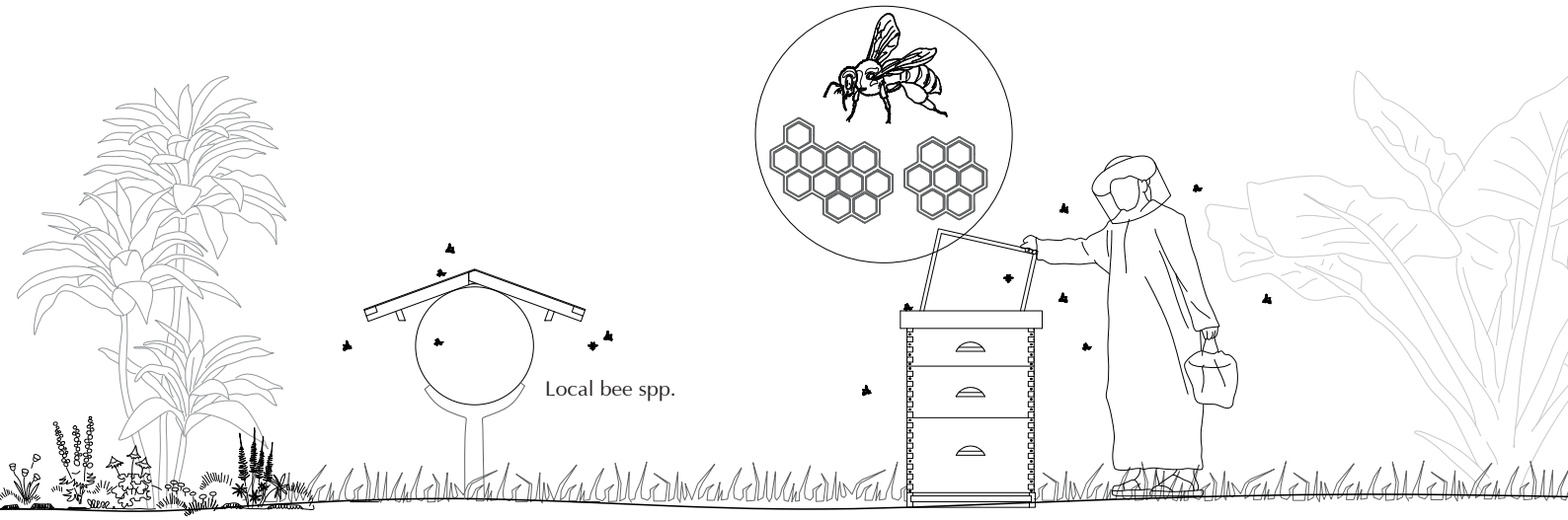
STEP 4 - The hive is repeatedly smoked with a closed top for a 2-3 days.

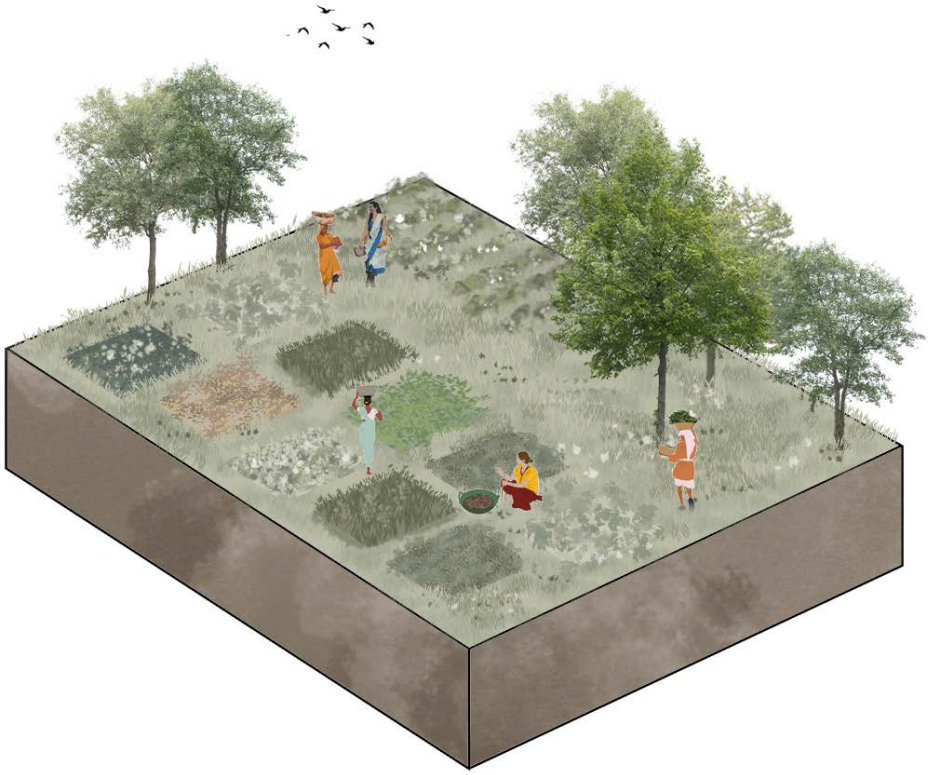


There are many ways of making local hives with different materials and techniques.



STEP 5 - The hives are protected from rain and wind using polythene wrap,iron sheets or thatched roof. They are also shaded with different materials like banana leaves to avoid direct heat from the sun


Local bee spp.



Local Farms

Building Resilient Food Systems

Local farms refer to farms that produce food or other agricultural products for local communities or markets. They are typically smaller in scale and are usually owned by a community. Local farms often focus on sustainable and organic farming practices.

These farms are important because they provide fresh, healthy, and locally grown food to consumers, creating circular economy.

Indigenous

Indigenous communities have often practiced sustainable agriculture for centuries, using traditional knowledge and practices that are adapted to their local environments

Participation of Community

Economy

On a community level,local farming has the potential to provide economic, social, and environmental benefits to and promote a more sustainable and equitable food system.

Preserving the future of agriculture

One of the big issues in agriculture sector is the loss of **native seeds**. Regularly, hybrid seeds companies push farmers to cultivate hybrid seeds. But, with these seeds comes the usage of chemical fertilizers and pesticides. The continuity of this practice will lead to loss of soil productivity- it will not produce any crop anymore.

Local farms make use of native seeds that are adapted to local environments and have evolved to thrive in specific climates and soil conditions. Native seeds are often well-suited to local growing conditions, requiring less water and fertilizer than non-native species, which can help to conserve water resources and reduce the use of harmful chemicals.

Using native seeds also promotes biodiversity and genetic diversity, as local farmers can grow a wider variety of crops that are adapted to specific micro climates and soil conditions. Moreover, native seeds can help to preserve traditional agricultural knowledge and support local food systems, as they are often tied to cultural practices and culinary traditions.

Benefits/Impacts

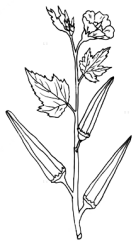
Species for Local farms

Here are some specific species that can be grown in local farms in Sundarbans:

Vegetables

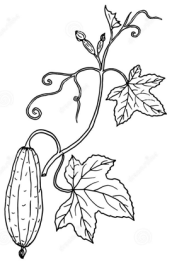
Solanum lycopersicum
(Tomato)

Solanum melongena
(Brinjal or eggplant)



Abelmoschus esculentus
(Okara)

Cucurbita spp.
(Pumpkin)



Luffa cylindrica
(Sponge gourd)

Vigna unguiculata subsp. sesquipedalis
(yard-long bean)

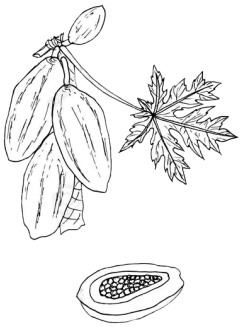
Spinacia oleracea
(Spinach)

Amaranthus spp.
(amaranth)

Fruits

Mangifera indica
(Mango)

Musa spp.
(Banana)



Carica papaya
(Papaya)

Psidium guajava
(Guava)

Spices

Curcuma longa
(Turmeric)

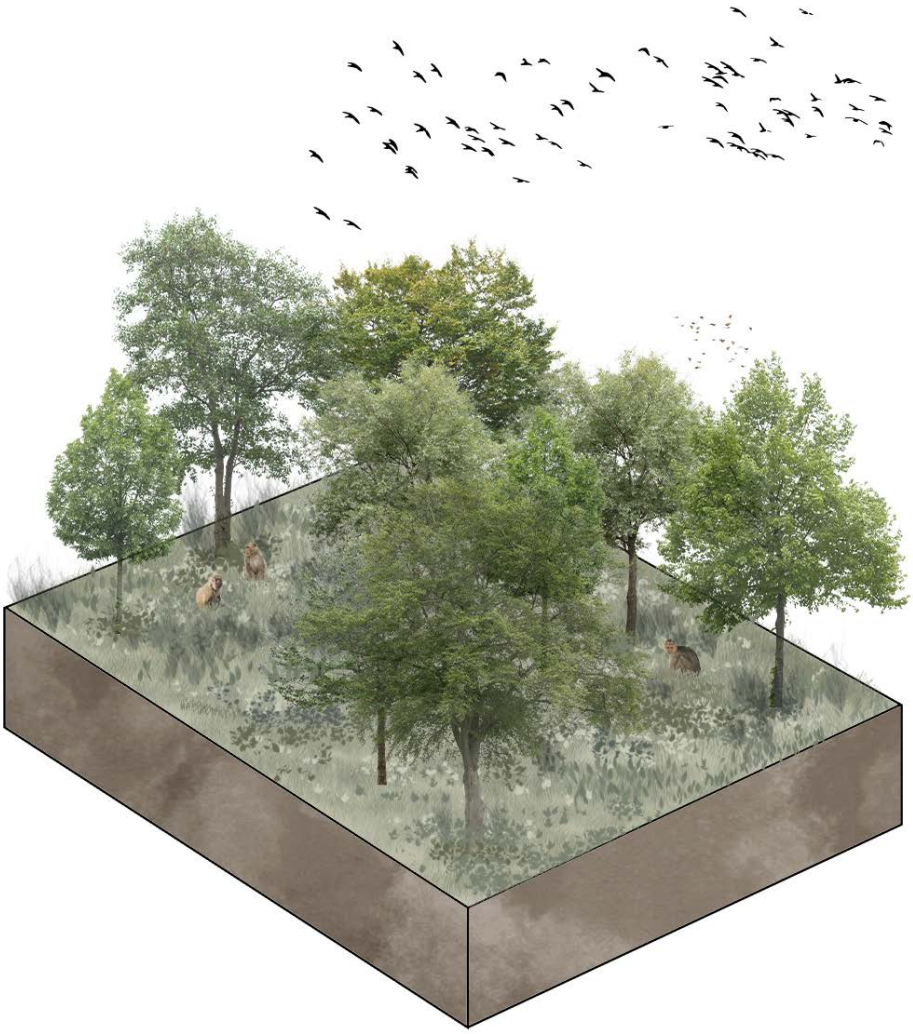
Zingiber officinale
(Ginger)

Elettaria cardamomum
(Cardamom)

Piper nigrum
(Black pepper)


পালং শাক
Spinach
BEDS
দেশীয় জাতের বীজ নার্সারি
Native Seed Nursery
SATOYAMA Agriculture Conservation Activity through Establishing Community Based Seed Bank in the Sundarbans Coastal Region of Bangladesh


Native spp. for farm



Inland Rural Forest

Forest Ecosystems for Biodiversity Conservation and Climate Regulation

Rural inland forests refer to forested areas that are located in rural, non-urban areas away from coastal regions. Rural inland forests can be a vital natural resource for the local communities, providing various ecosystem services such as climate regulation, water conservation, soil protection, and biodiversity conservation. These forests can also be a source of wood, non-timber forest products, and other forest-based livelihoods for the local people.

Indigenous

Forests have long been known for contributing to climate change mitigation and adaptation efforts, as well as promoting sustainable development and improving the resilience of local communities.

Participation of Community

Economy

Rural inland forests can be both economical and valuable in terms of the services and benefits they provide. They provide numerous products for local communities acting a source of income for them and also providing valuable ecosystem services.

About

Forests are home to the majority of terrestrial biodiversity, and they provide clean air and water, protect against erosion and landslides, and help to regulate the climate by removing carbon from the atmosphere.

Rural Inland forest consist of a mix of native tree species that are well adapted to the local environment. They may also include shrubs, grasses, and other vegetation, as well as a variety of wildlife and other biodiversity.

Benefits/Impacts

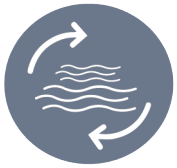
Biodiversity

Economy stimuation and job creation

Community well-being

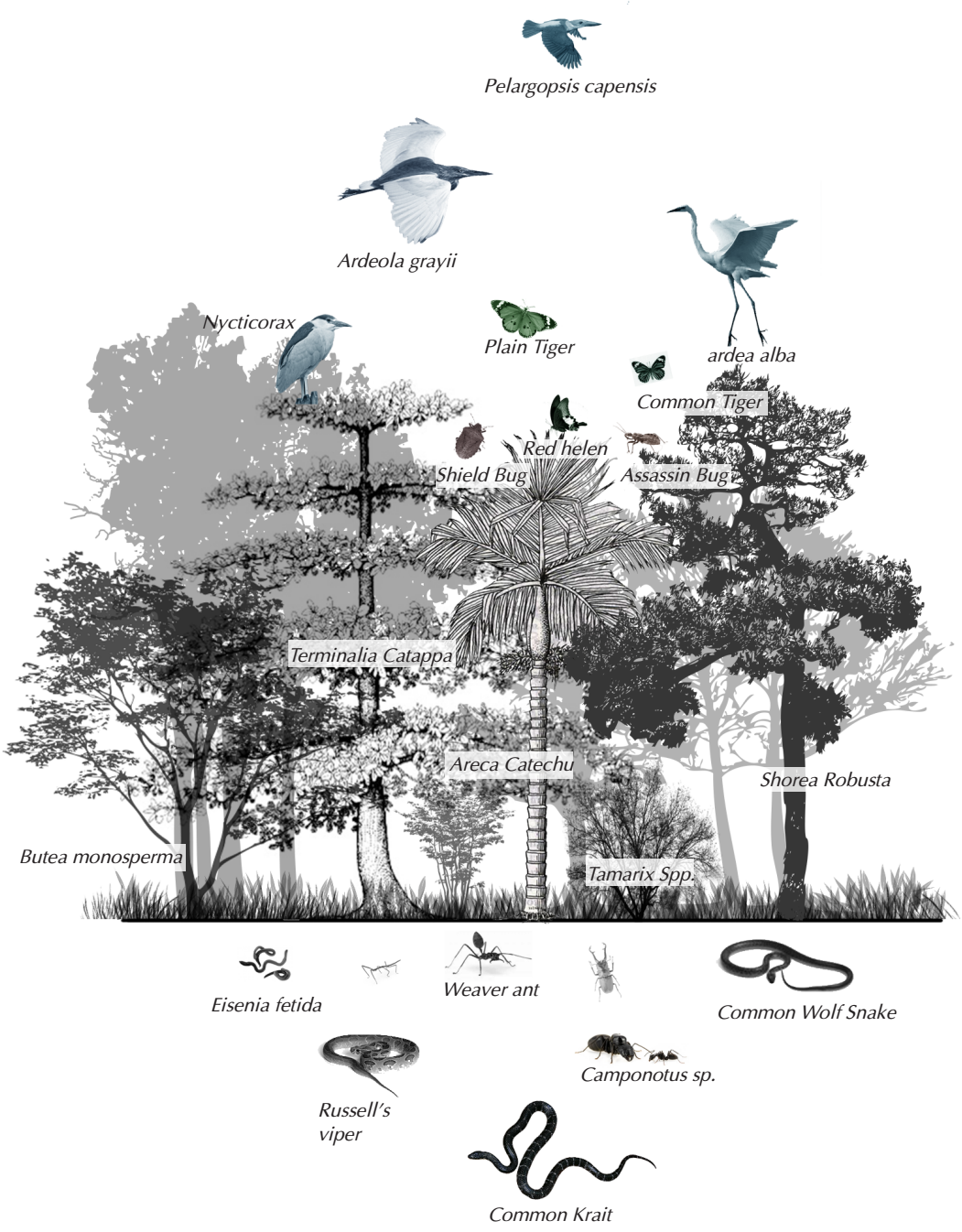
Air pollution regulation

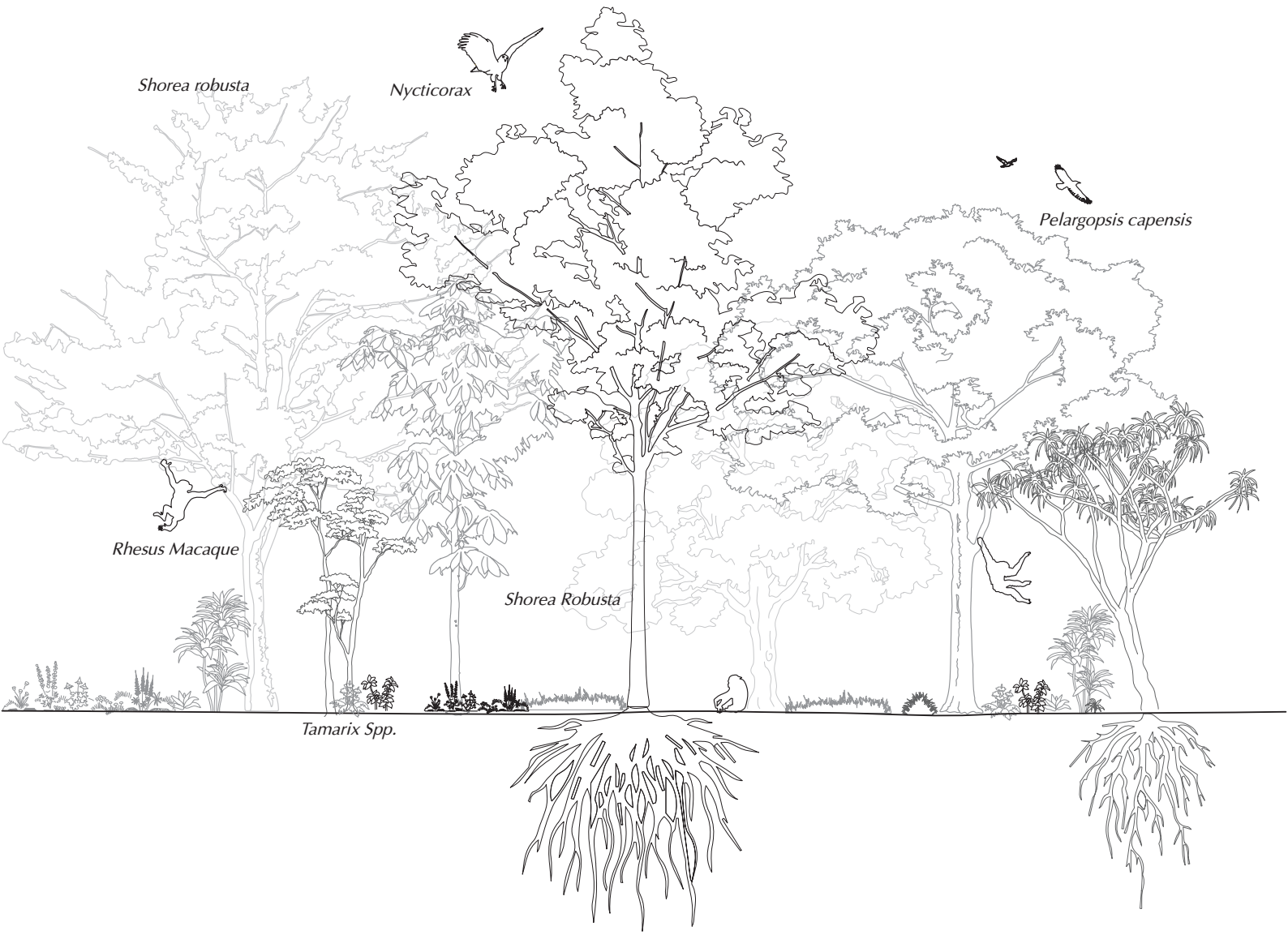
Carbon storage and sequestration



stormwater runoff management

Water pollution regulation


Pelargopsis capensis
Ardeola grayii
Nycticorax
Plain Tiger
ardea alba
Common Tiger
Red helen
Shield Bug
Assassin Bug
Terminalia Catappa
Areca Catechu
Shorea Robusta
Butea monosperma
Tamarix Spp.
Eisenia fetida
Weaver ant
Common Wolf Snake
Camponotus sp.
Russell's viper
Common Krait


Shorea robusta
Nycticorax
Pelargopsis capensis
Rhesus Macaque
Shorea Robusta
Tamarix Spp.

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