The Living Estuary

A Study of Developing Landscape Spatial Adaptive Strategies to Integrate the Water, Ecosystem and Anthropo-Dynamics in the Estuary of Volta Delta, Ghana

Ayu Prestasia

Landscape Architecture MSc Thesis – July 2018

TU Delft

Rotterdam - NL
www.nytimes.com

Ada Foah - Ghana
EFIE NANFO
www.flyingfourchette.com

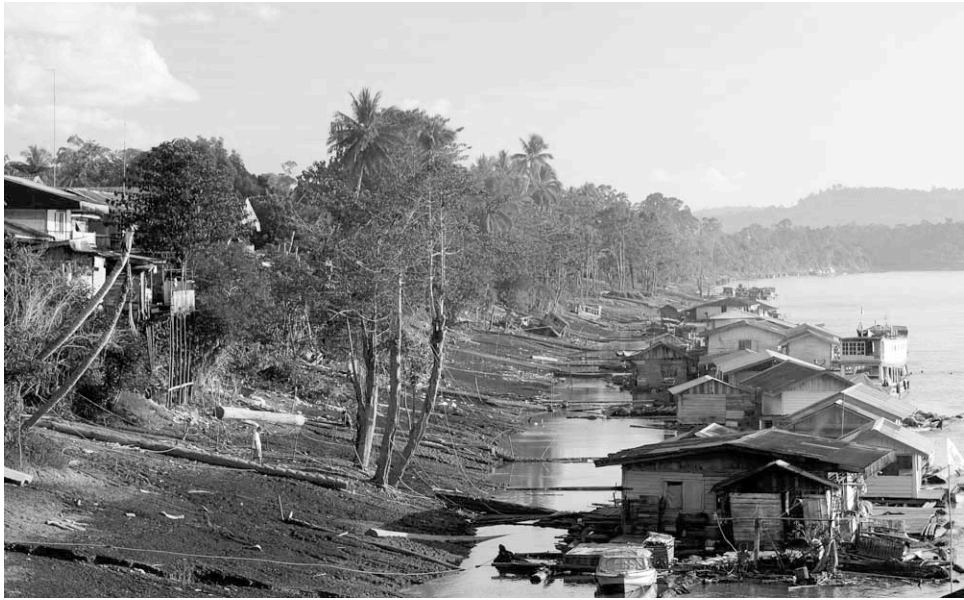
Map showing the 48 deltas included in a study by Tessler et al., 2015. (in Meyer et al.,2016)

RMS Delta, The Netherlands

Mississippi River Delta, USA

Volta Delta, Ghana

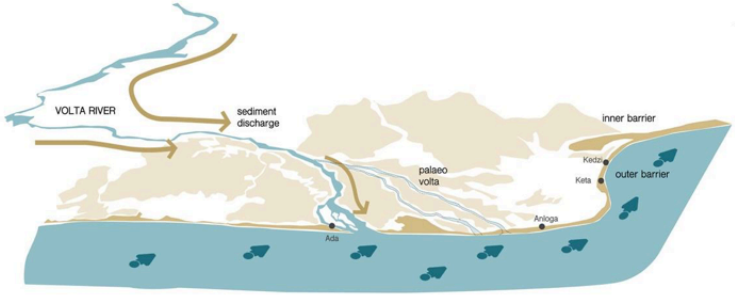
Mahakam Delta, Indonesia

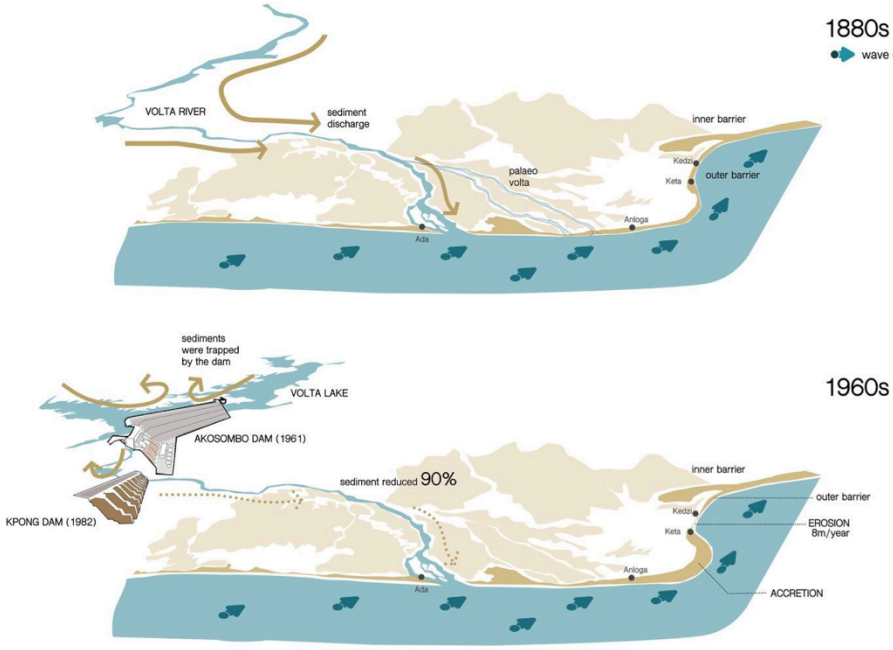


(Appeaning-Addo et al., 2015)

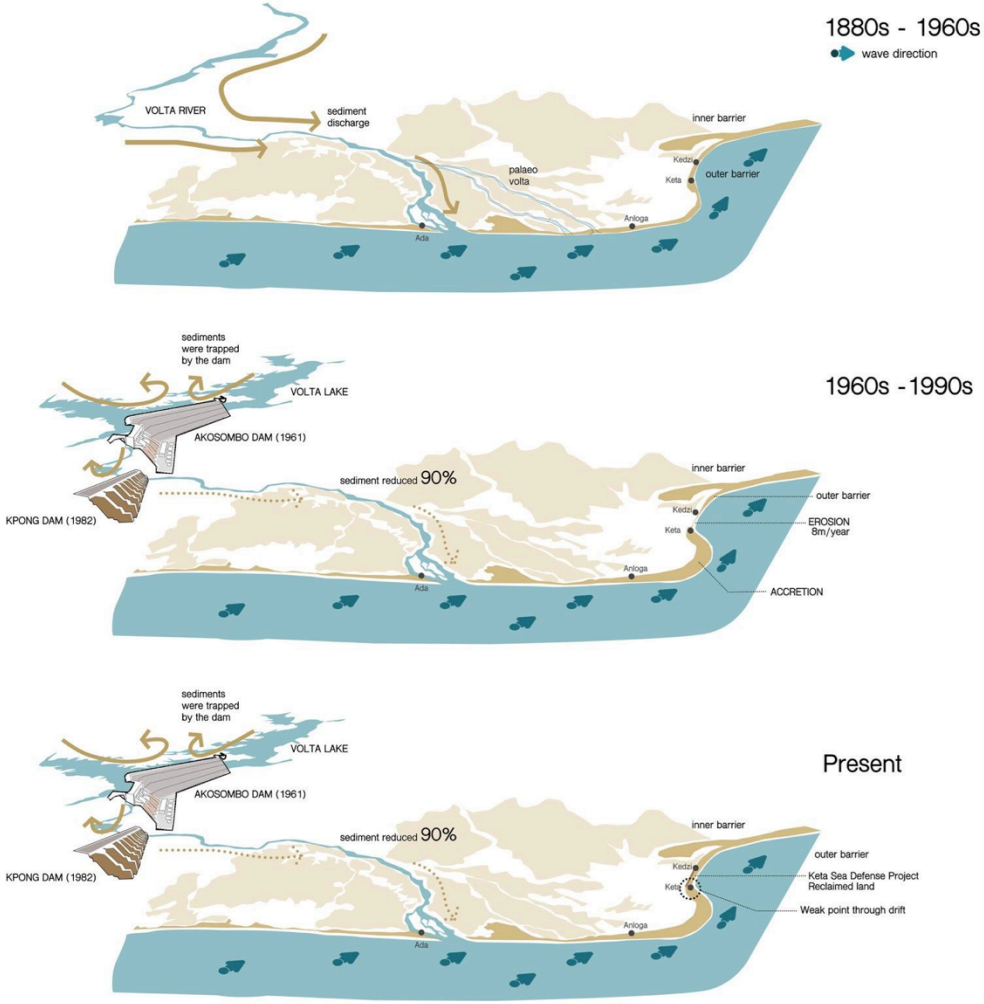
#1

COASTAL EROSION


1880s - 1960s
wave direction
VOLTA RIVER
sediment
discharge
palaeo
volta
inner barrier
Kedzi
Keta
outer barrier
Anloga
Ada



www.ghanalive.tv



www.researchplanning.com

Problem Field

#2

URBANIZATION AND NATURE BALANCE

2.5% per year
POPULATION GROWTH

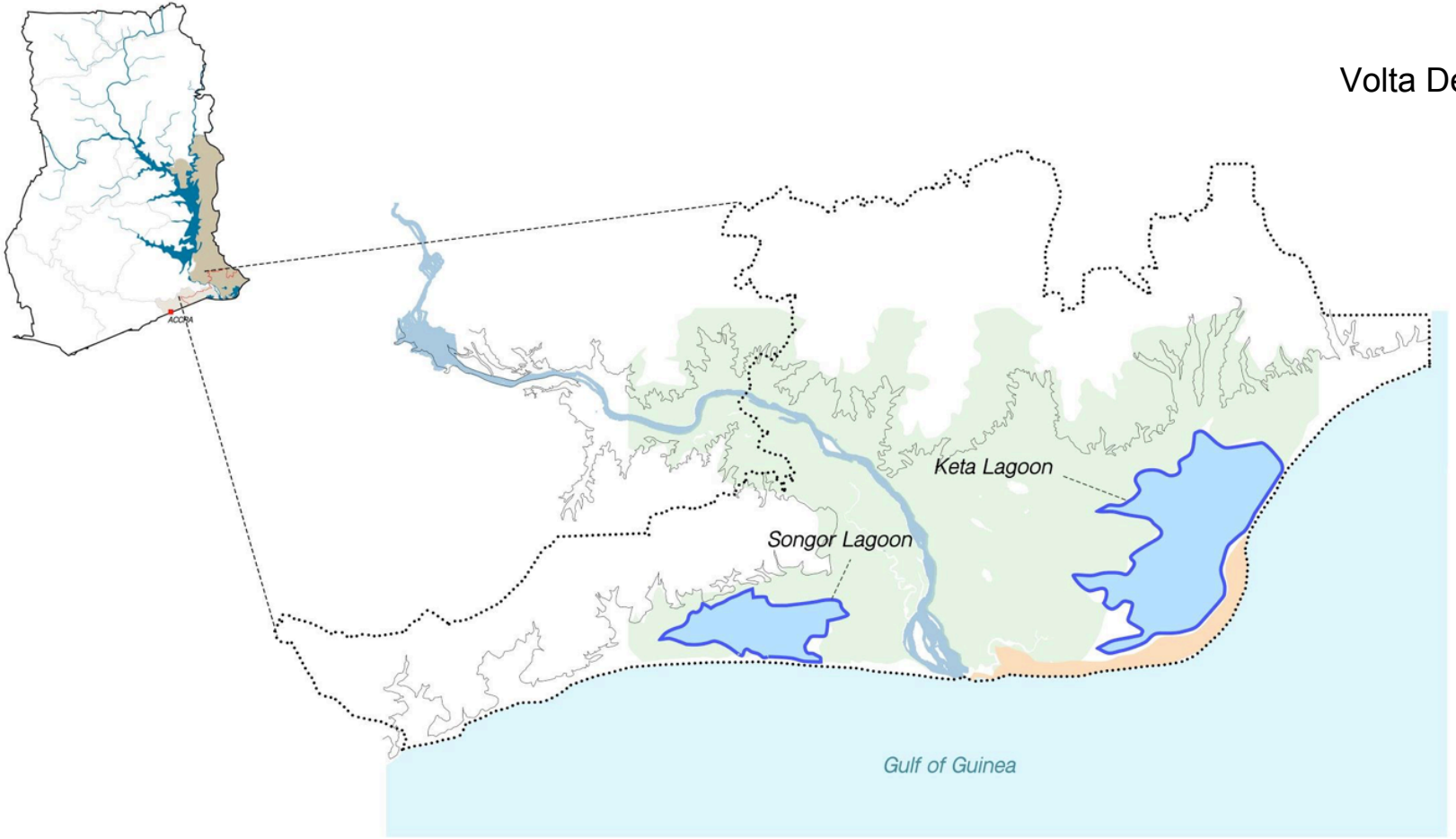
NATURAL RESOURCES
INDUSTRIALIZATION

NO LONG-TERM
PLANNING

Volta Delta, Ghana

Volta Delta, Ghana

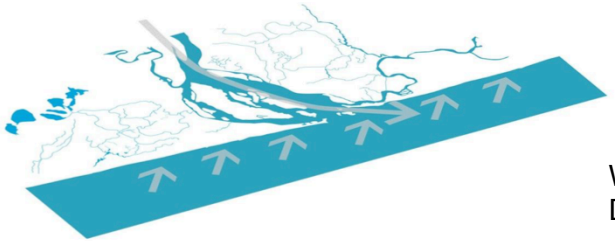
Volta Delta, Ghana



Volta Delta, Ghana

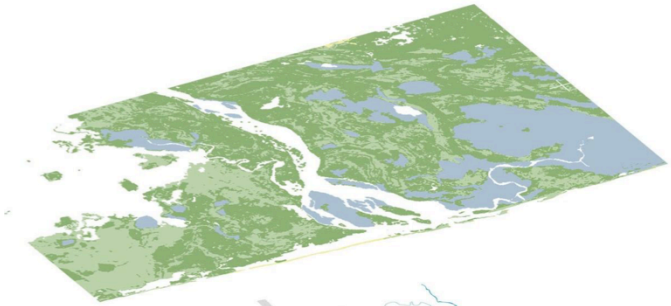
ESTUARY

ESTUARY

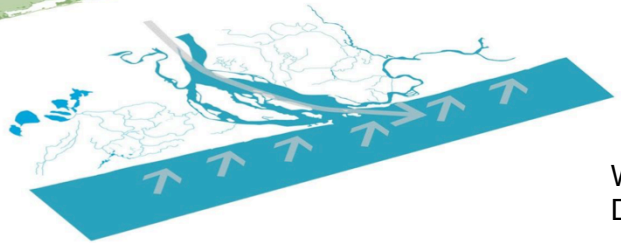


WATER
DYNAMICS

ESTUARY

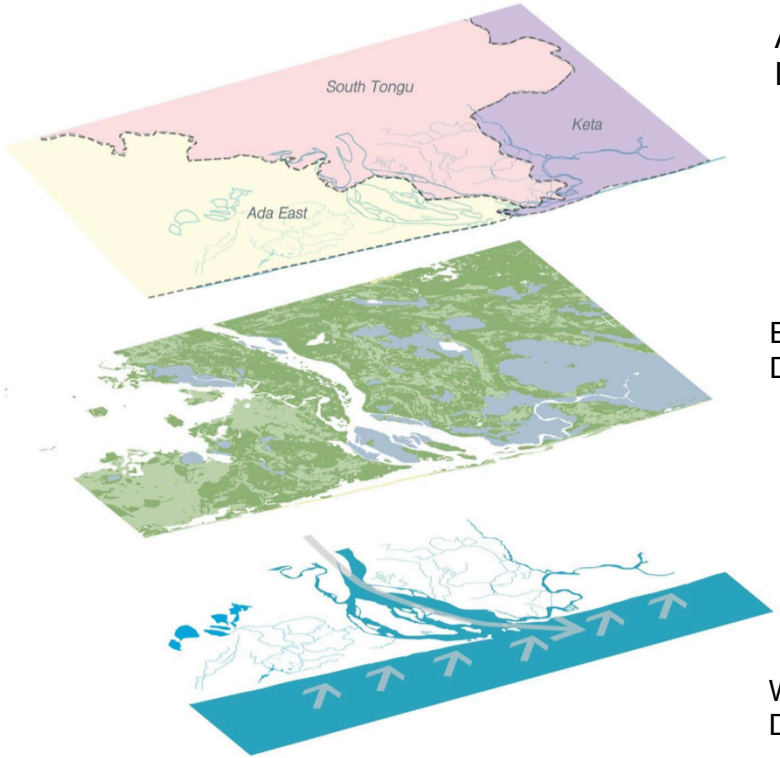


ECOSYSTEM DYNAMICS



WATER DYNAMICS

ESTUARY



ANTHROPO-
DYNAMICS

ECOSYSTEM
DYNAMICS

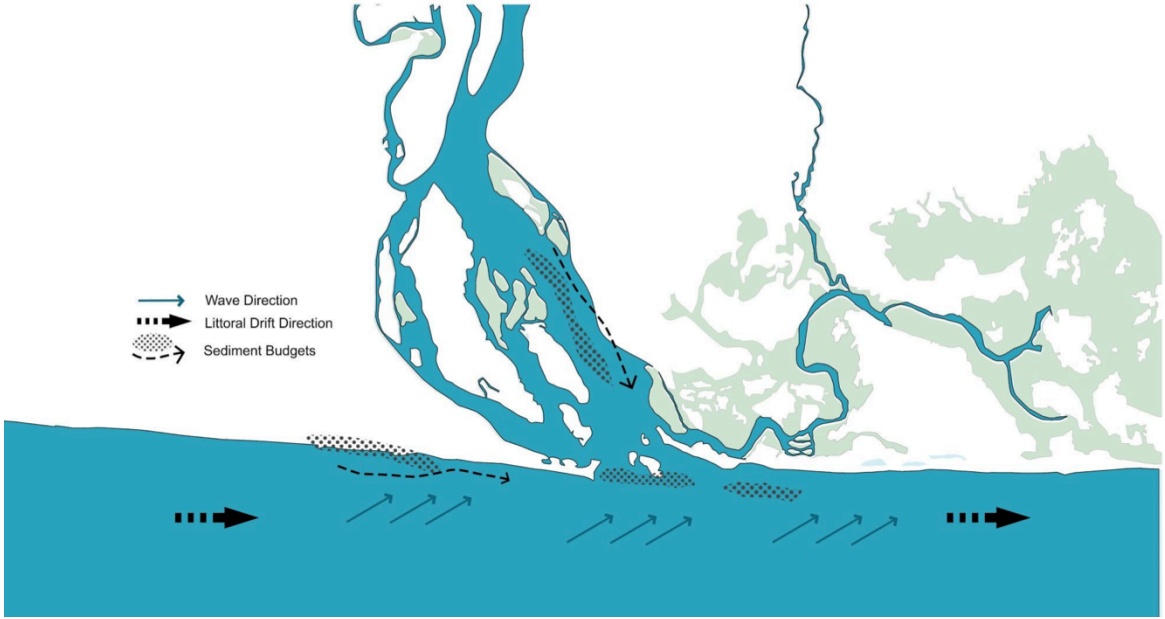
WATER
DYNAMICS

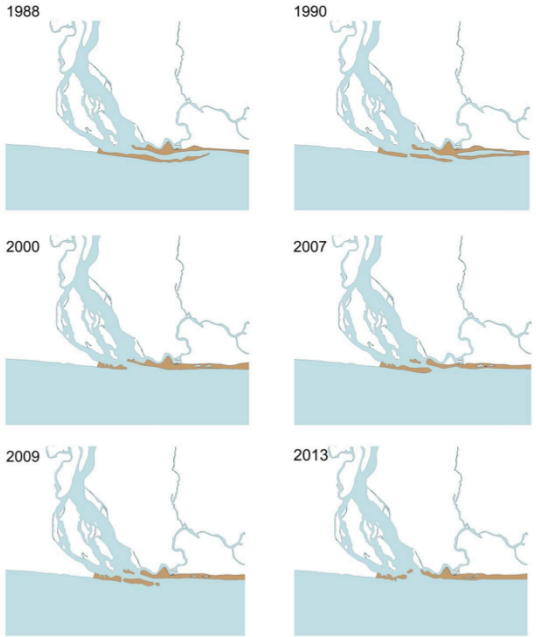
How to develop landscape architectonic design principles for a future adaptive strategy to integrate the water, ecosystem, and anthropo-dynamics, to enhance spatial and living quality in the estuary of Volta Delta?

LANDSCAPE AS PROCESSES

stage 1

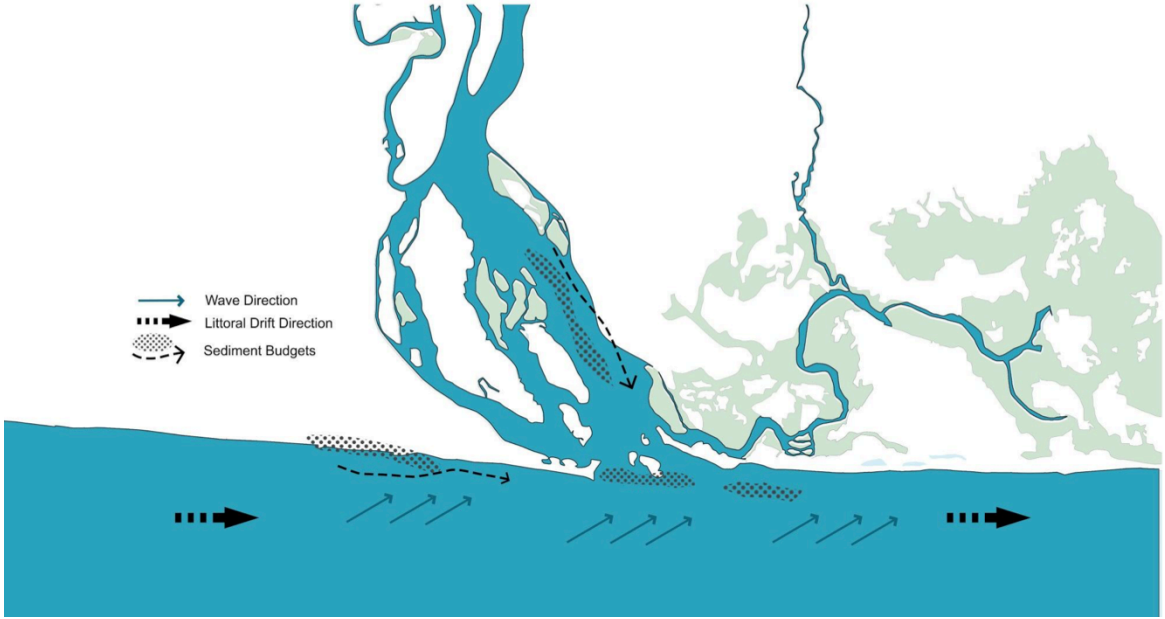
ESTUARY WATER DYNAMICS

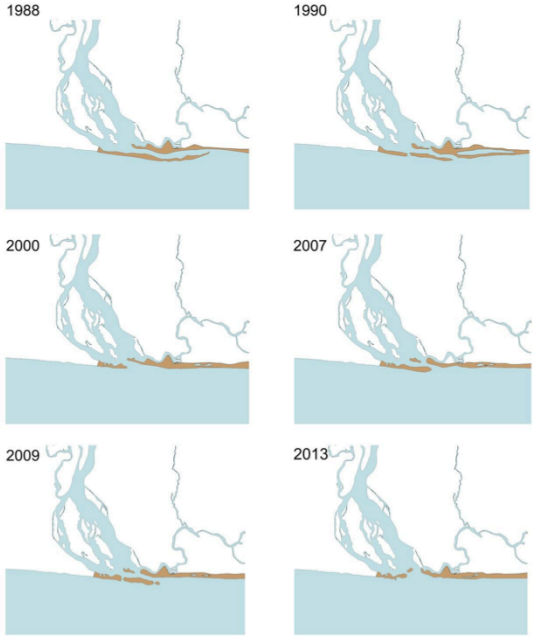




ESTUARY WATER DYNAMICS

- Periodic higher river water discharge





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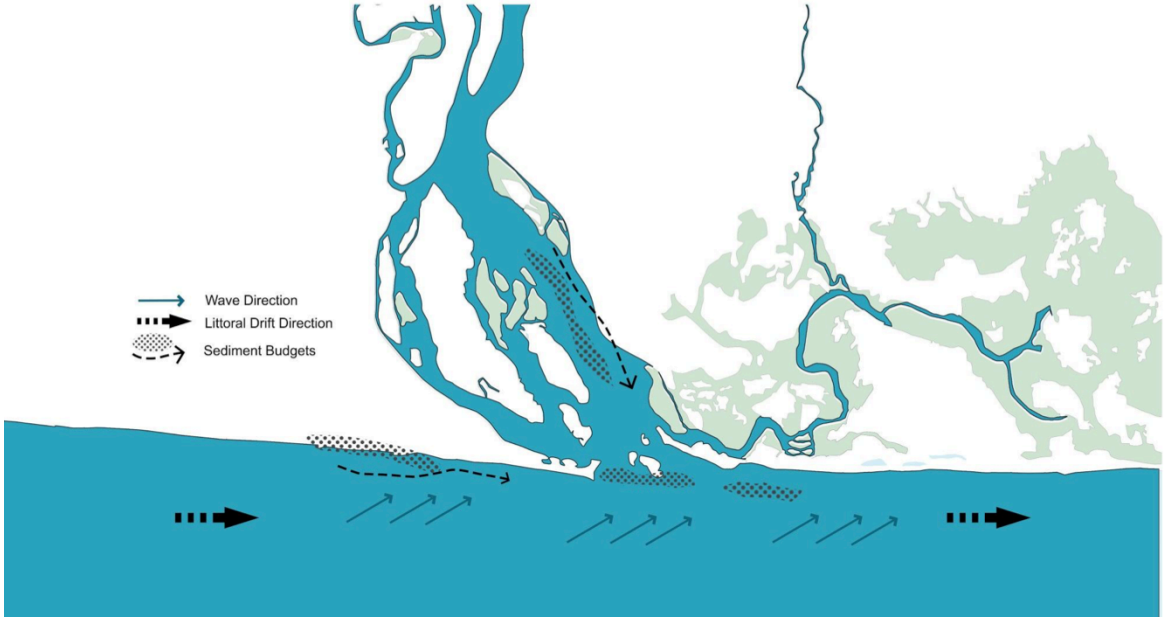
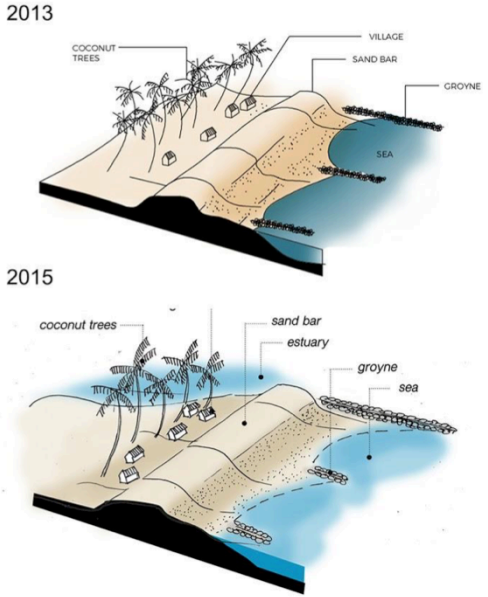
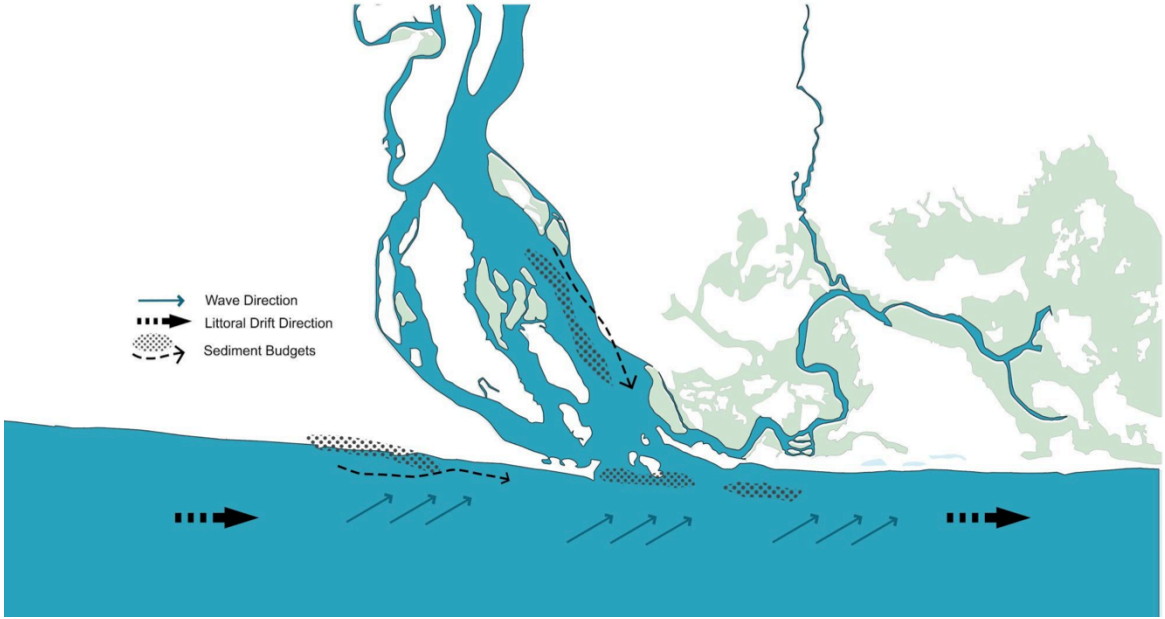
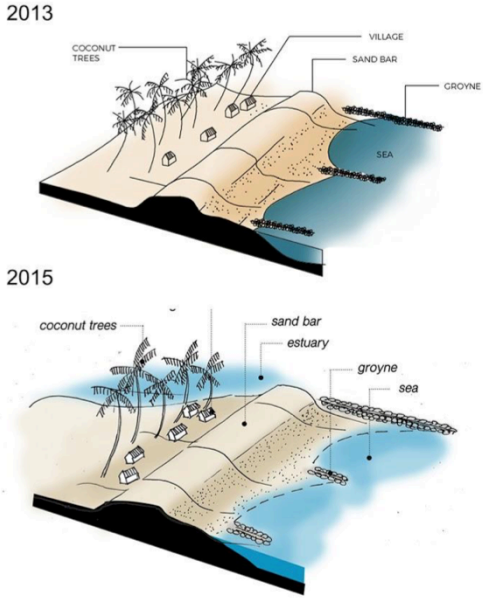




ESTUARY WATER DYNAMICS

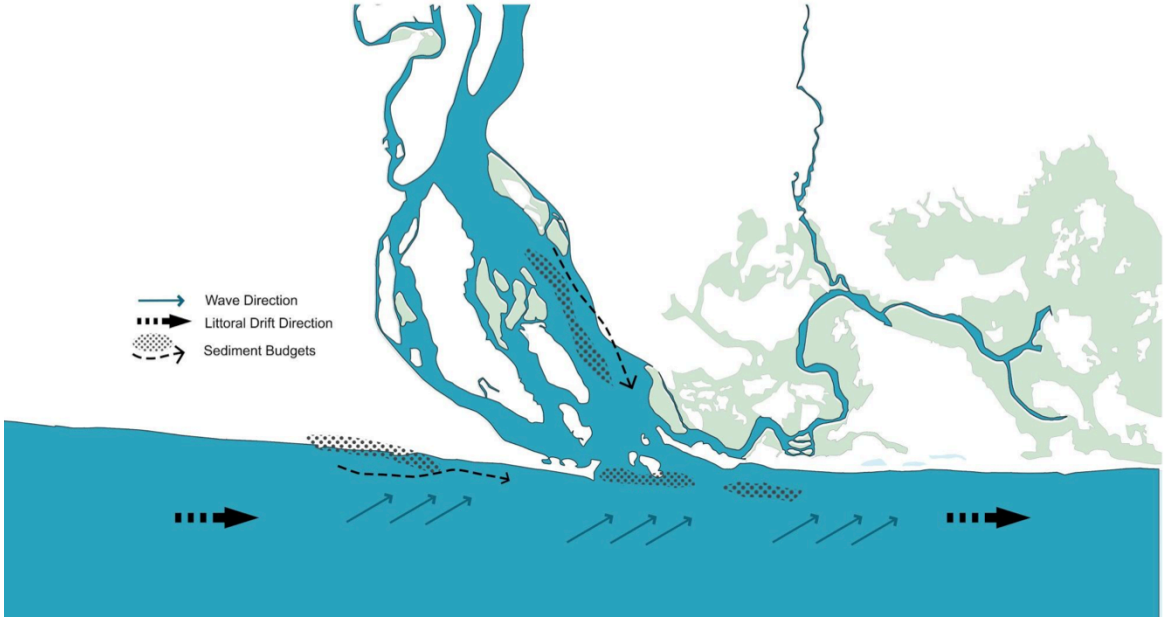
- Periodic higher river water discharge
- Integration with nature system

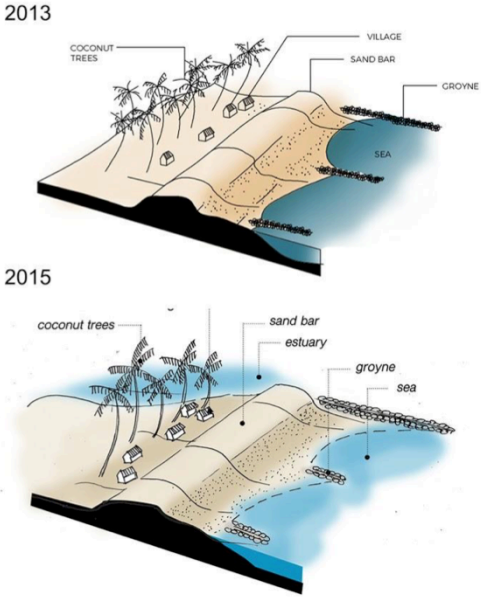




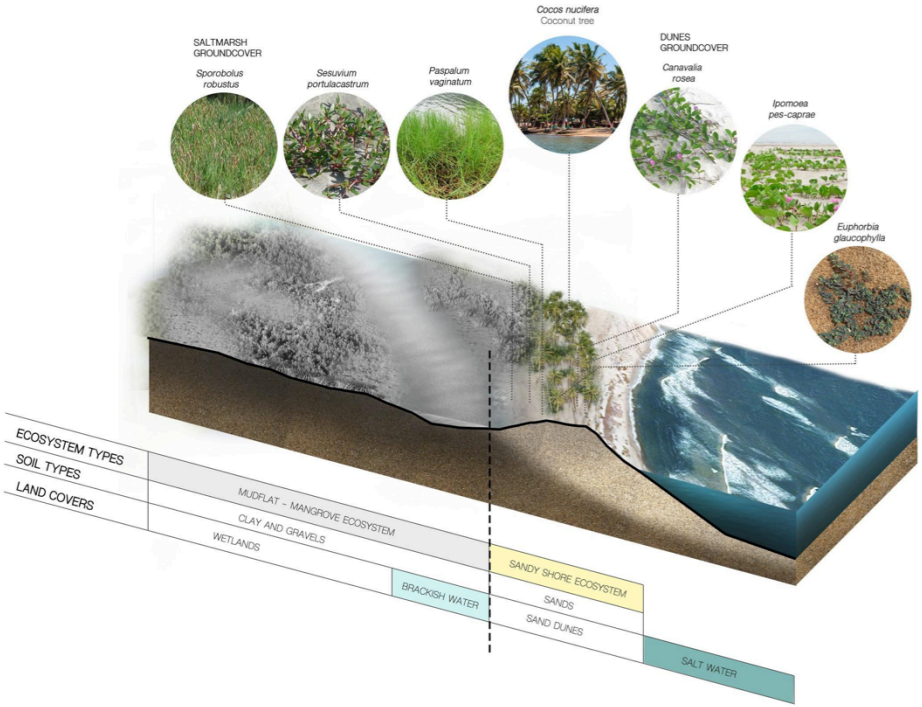
ESTUARY WATER DYNAMICS

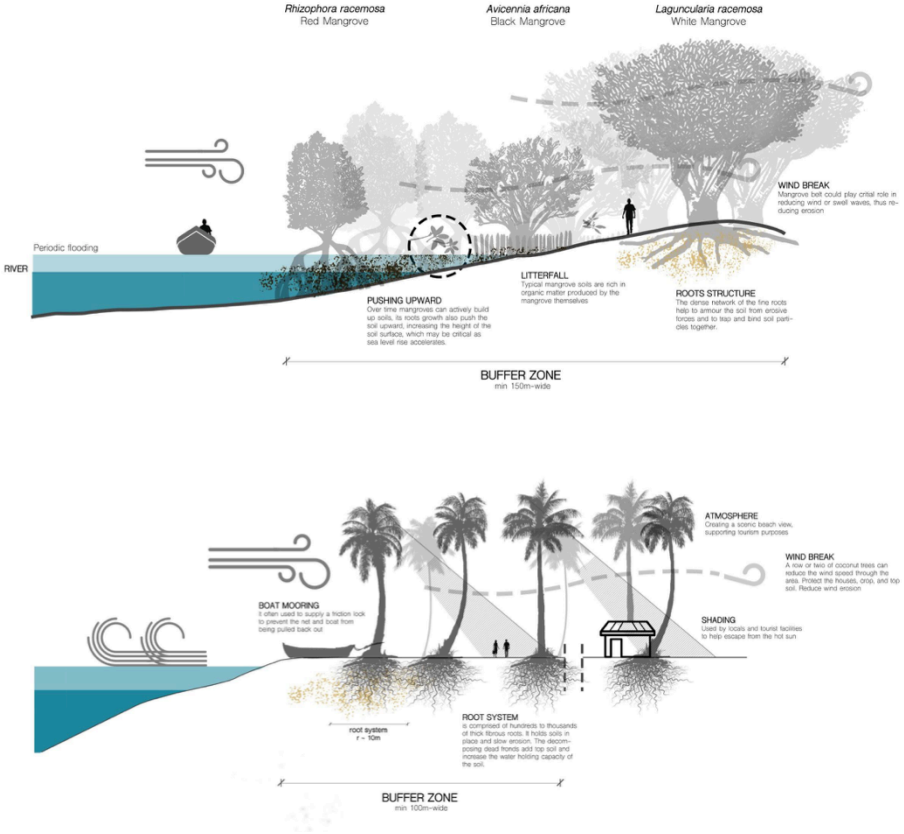
- Periodic higher river water discharge
- Integration with nature system
- Give space for erosion

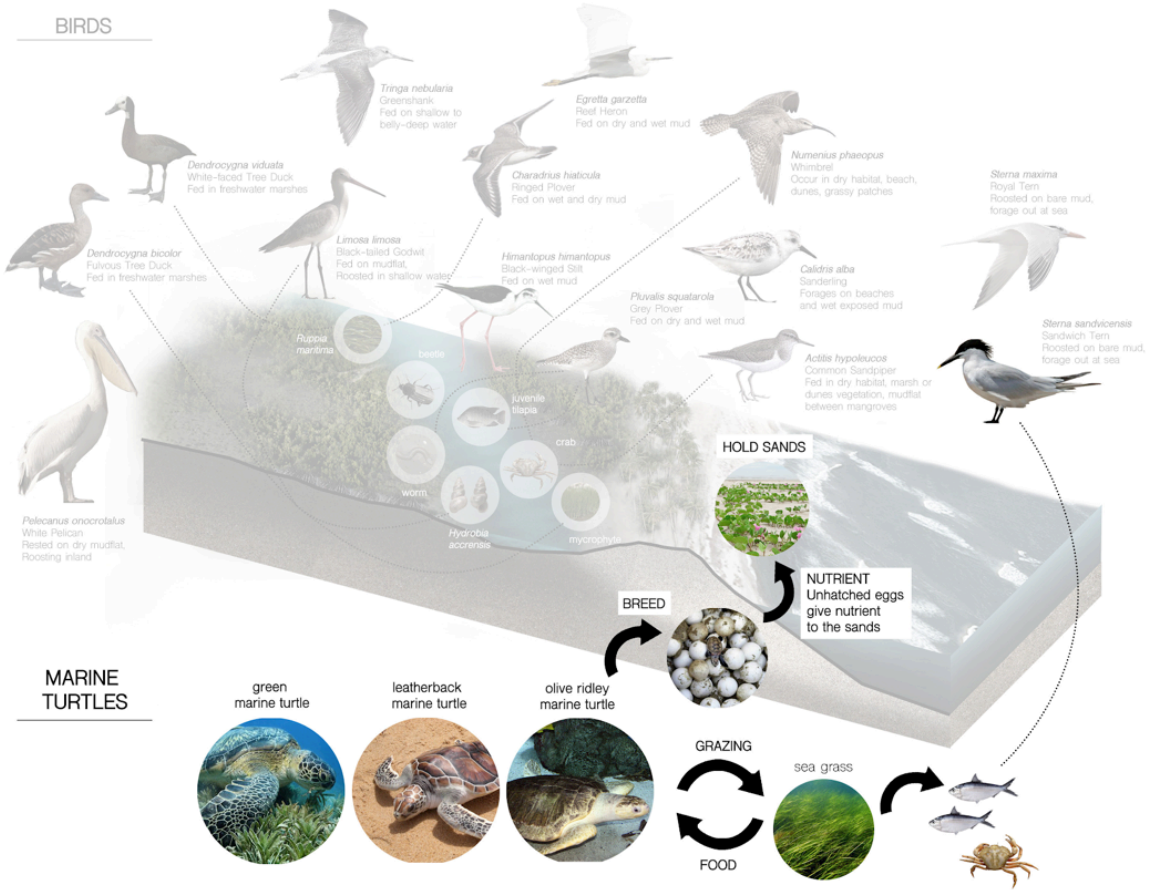




ESTUARY ECOSYSTEM DYNAMICS



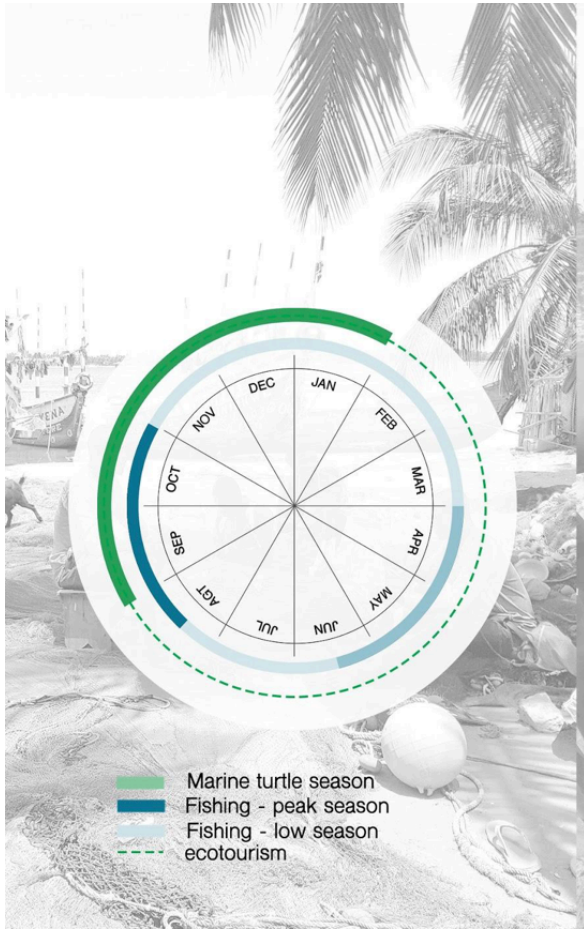




- Re-establish buffer zone
- Conserve turtle breeding beach by not constructing hard edge on the coastline

EYE SIKA ASEM

EYE SIKA ASEM
PROSPEROUS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DEC
Marine turtle season
Fishing - peak season
Fishing - low season
ecotourism

JAN
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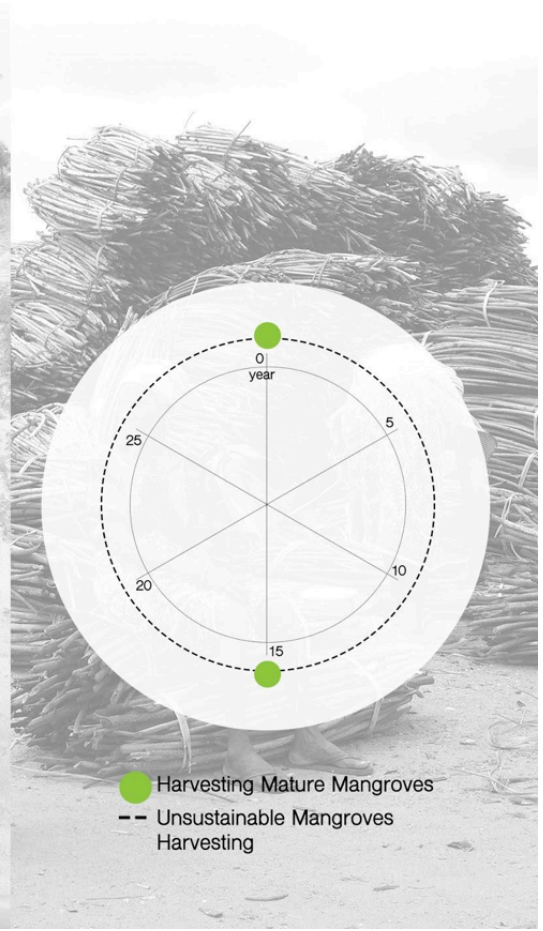
DEC
Platnting Period
Harvesting Period
Growing Period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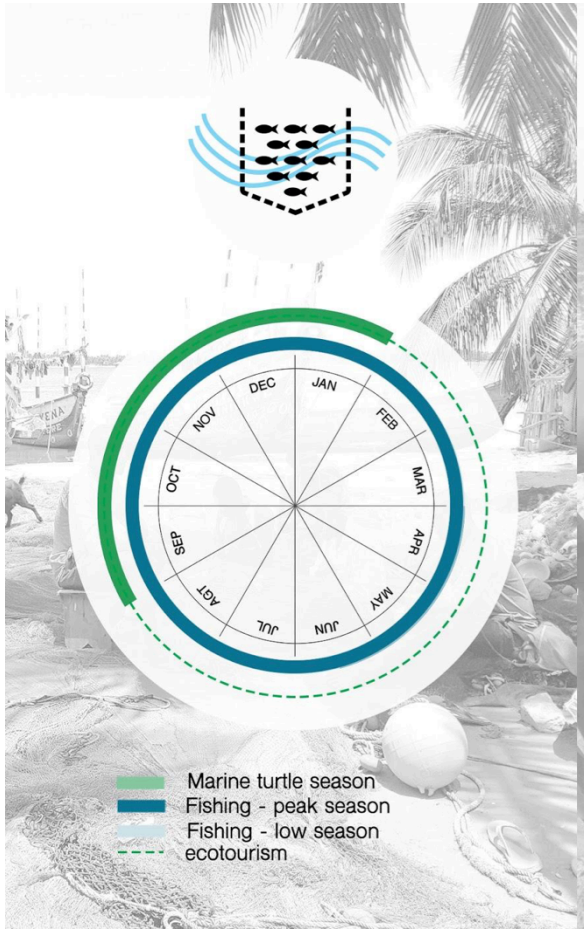
Harvesting Mature Mangroves
Unsustainable Mangroves Harvesting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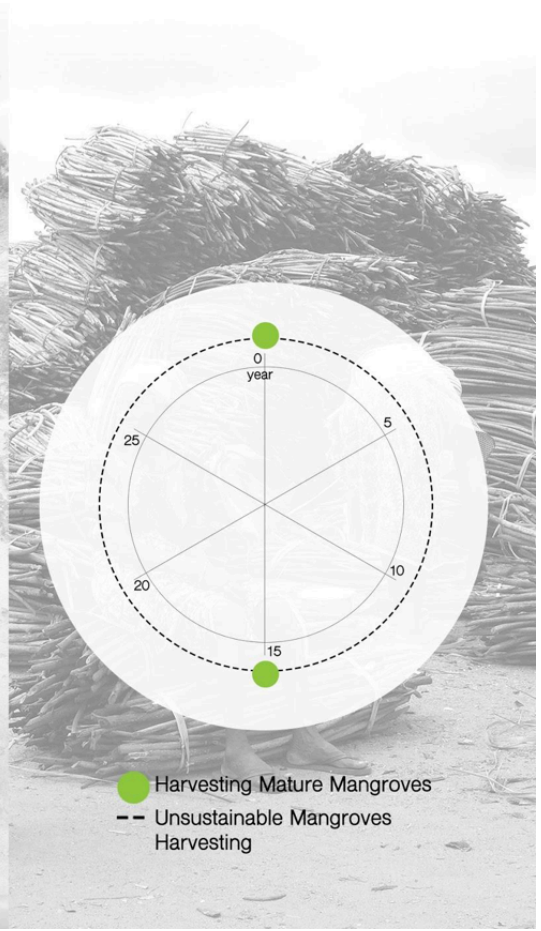
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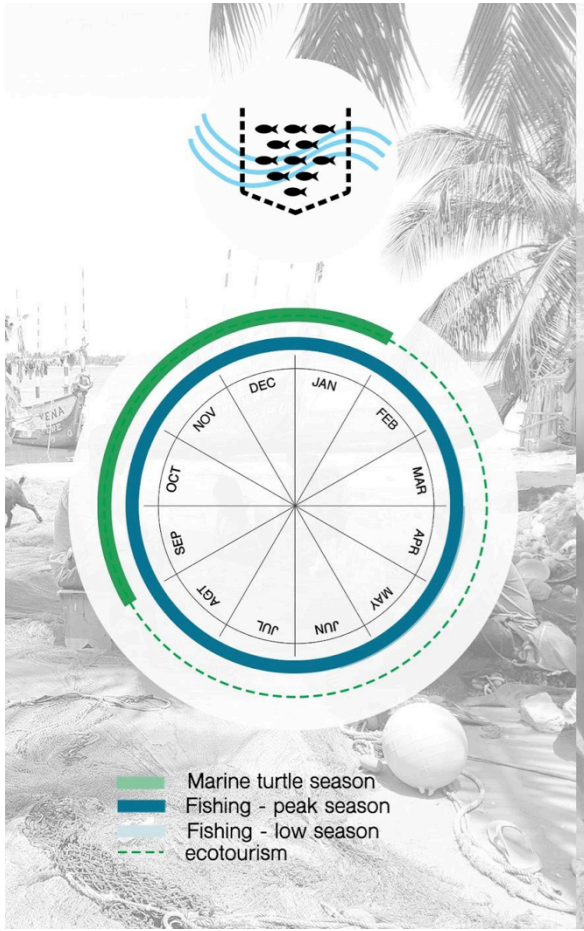
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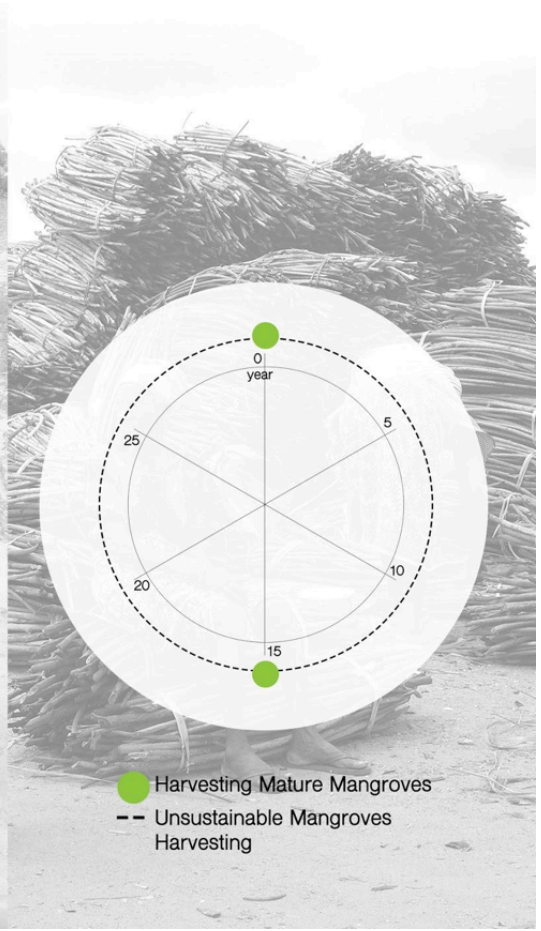
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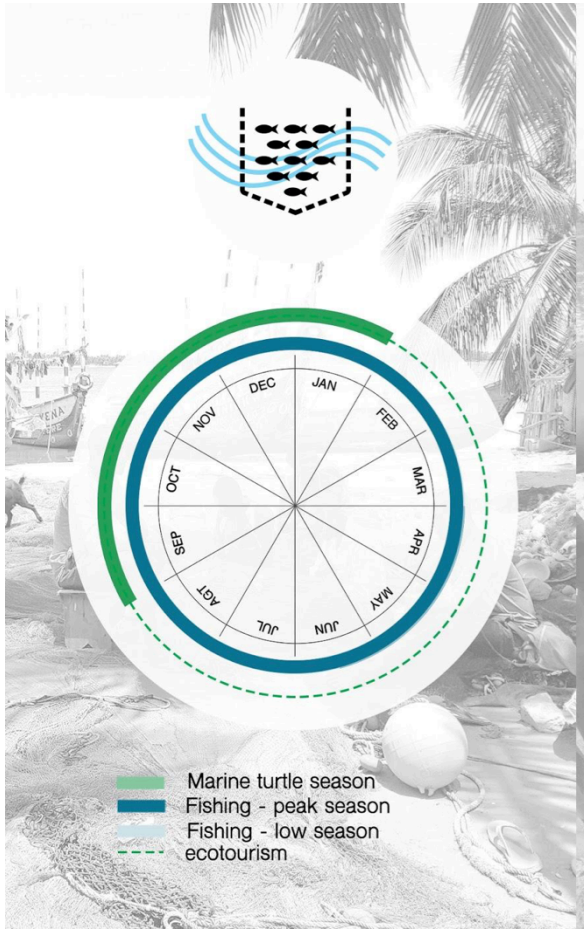
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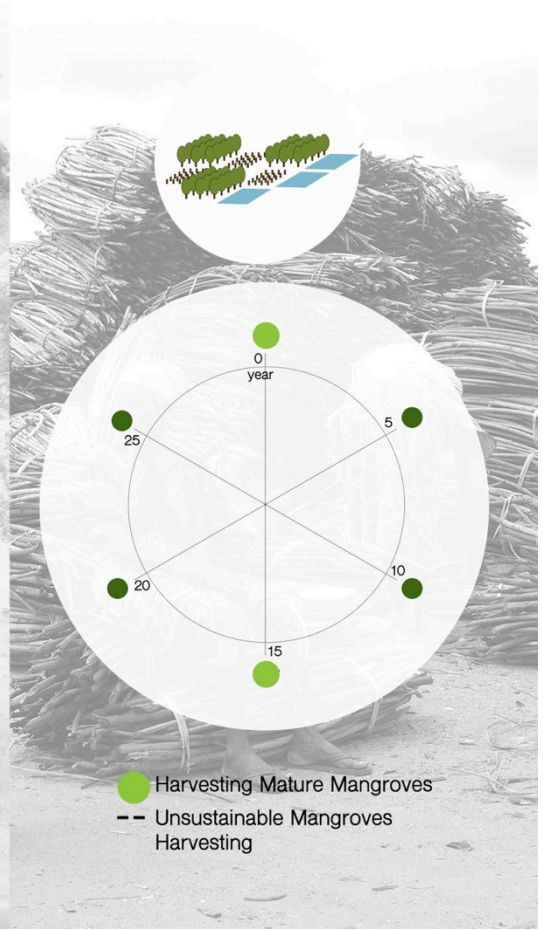
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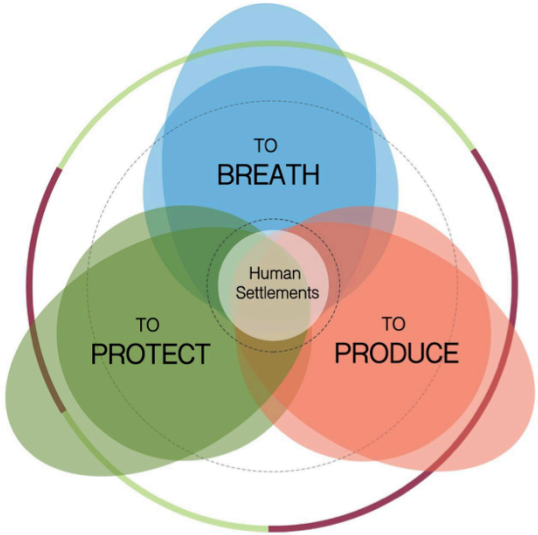
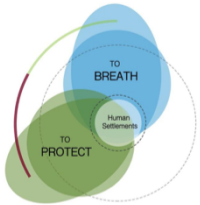
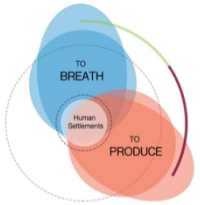
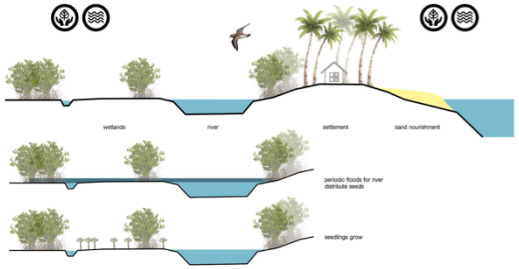
Interrelation between the three dynamics - Design Principles

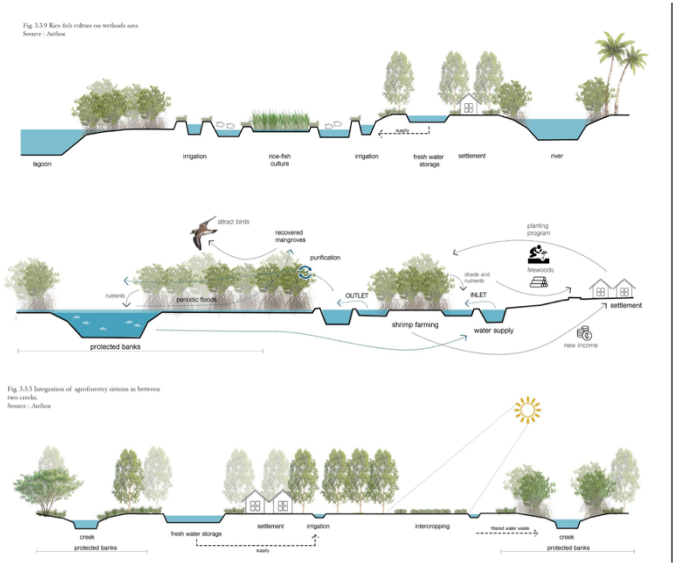


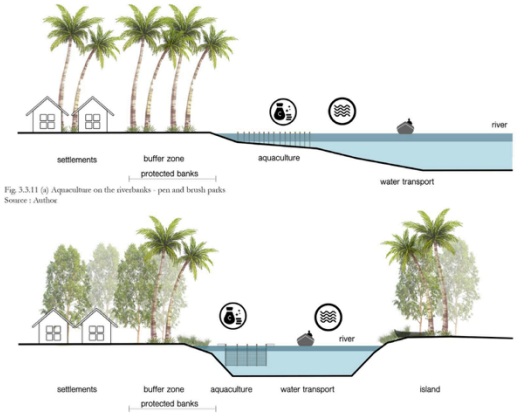
Relation between Human Settlements, Natural and Cultural Landscapes



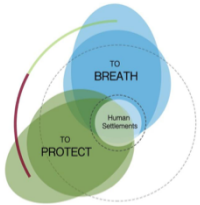


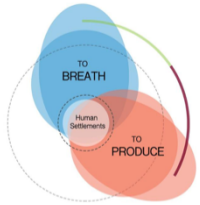


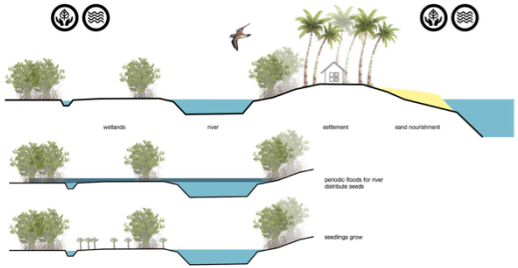


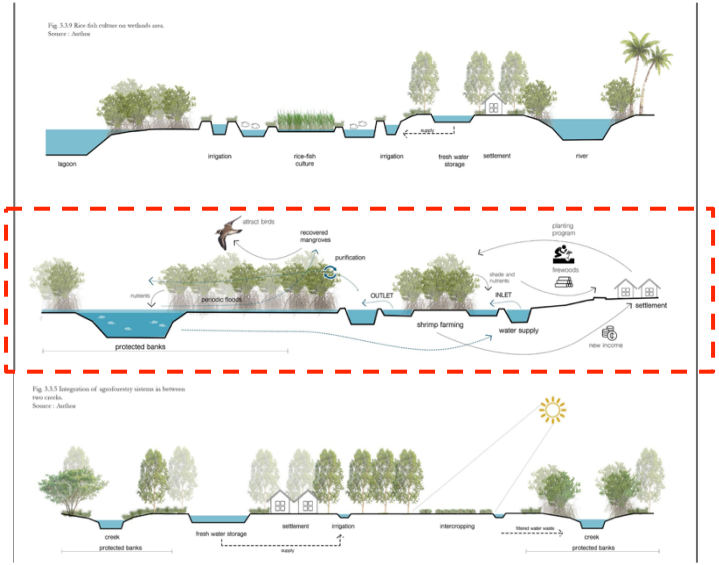


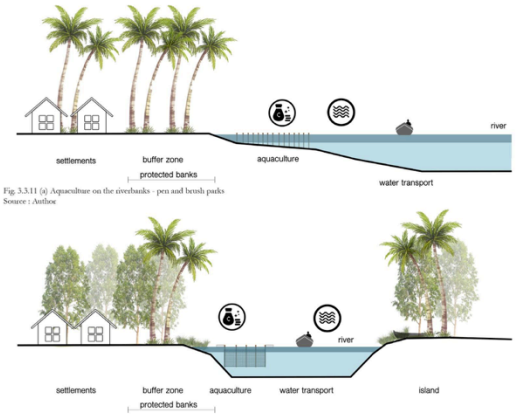
Design Principles



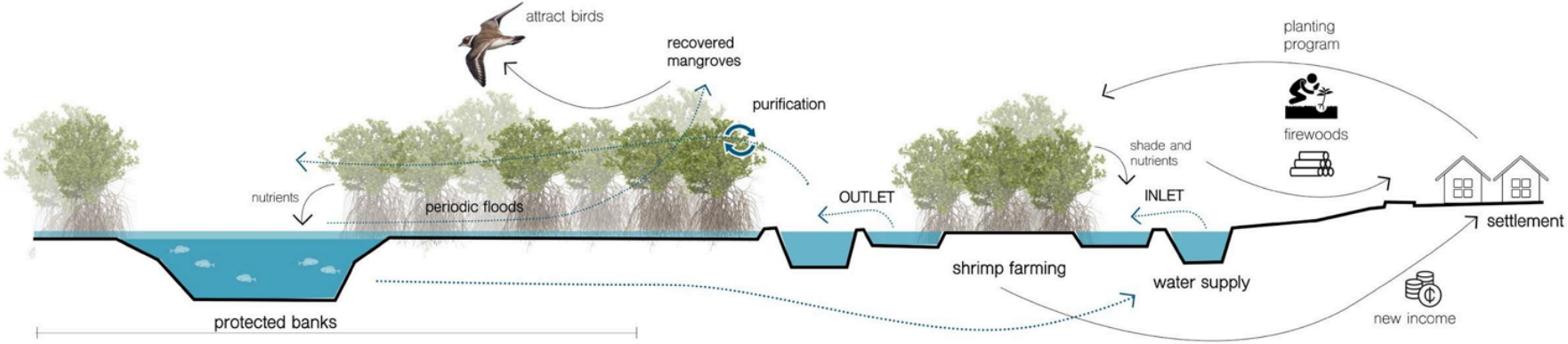




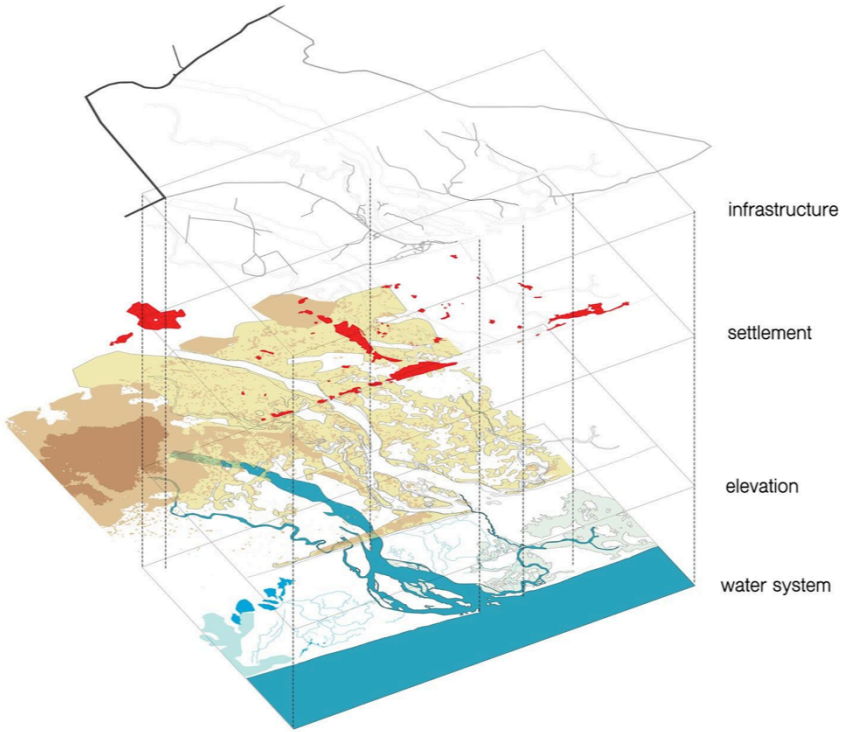




Design Principles



SILVO-FISHERY



ADAPTIVE DESIGN STRATEGY

stage 2

Scenario Building

Constant Variable

Sea level rise - Coastal erosion

Independent Variables

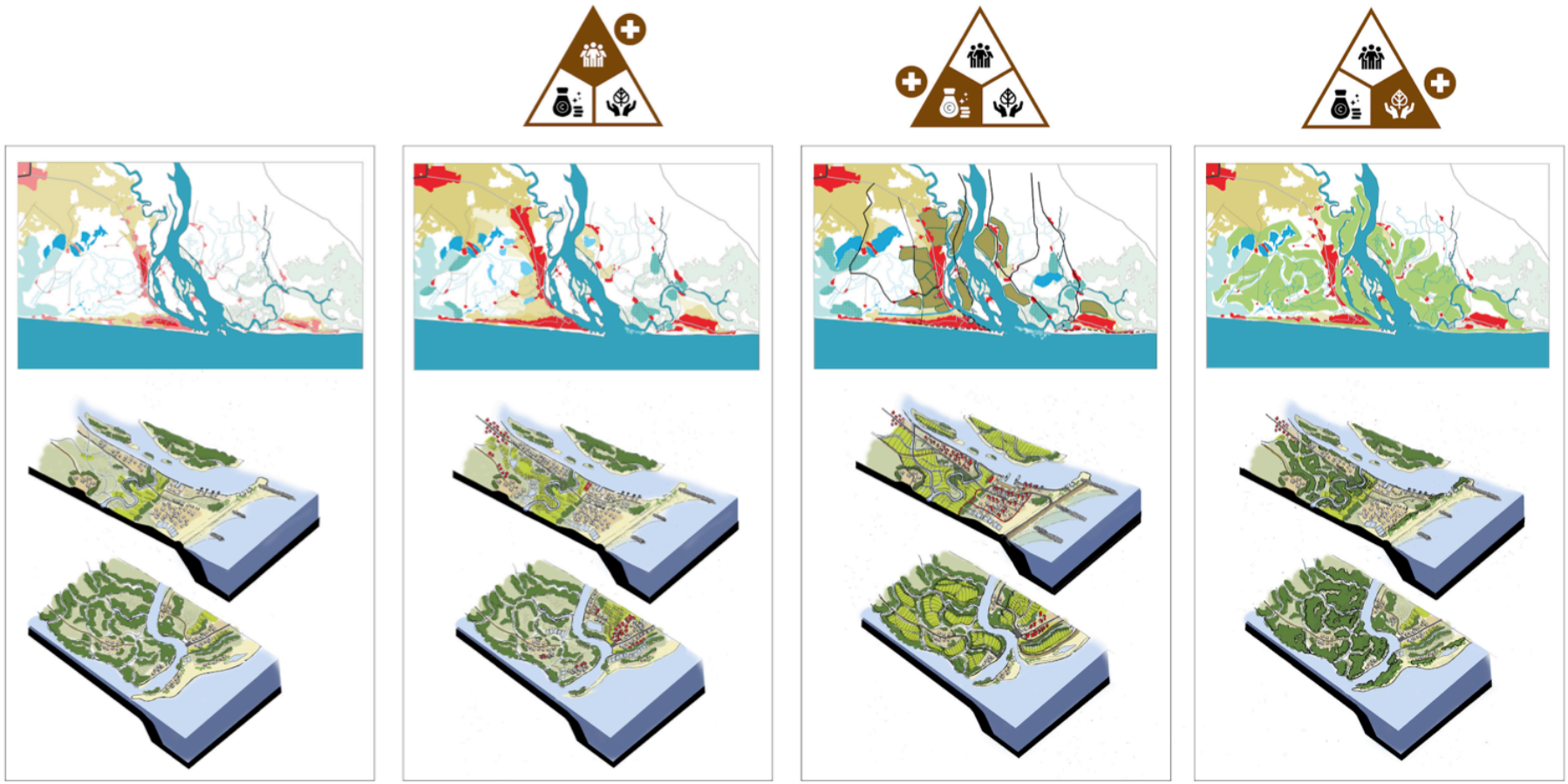
Dependent Variables

Erosion Control

Water management

Food Production

Settlement & Mobility

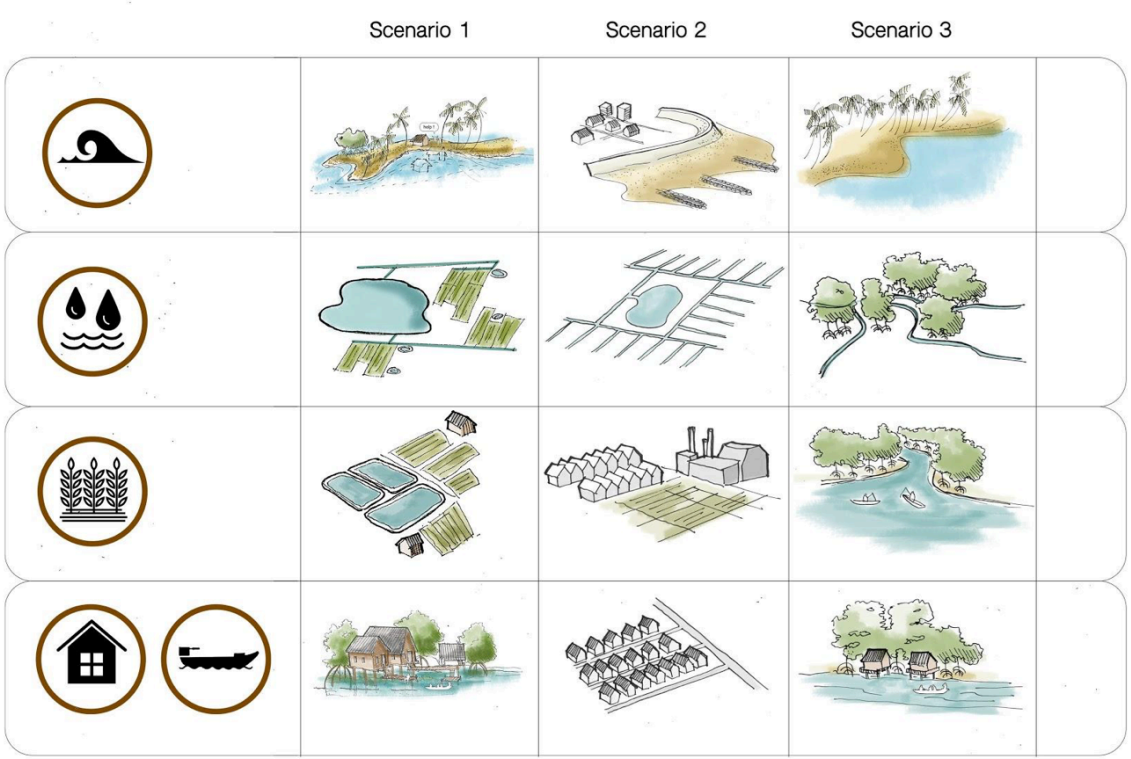


SCENARIO 1

SCENARIO 2

SCENARIO 3

Comparing the Dependent Variables

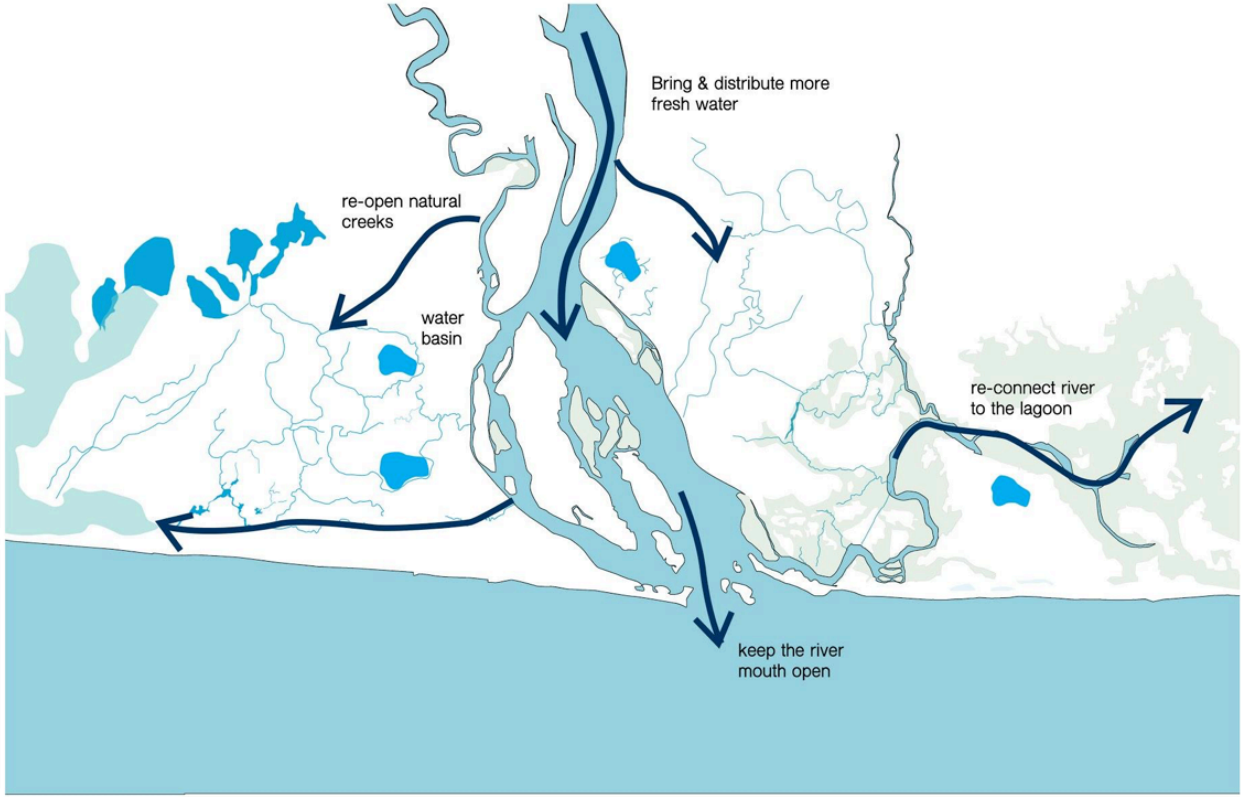


Erosion Control

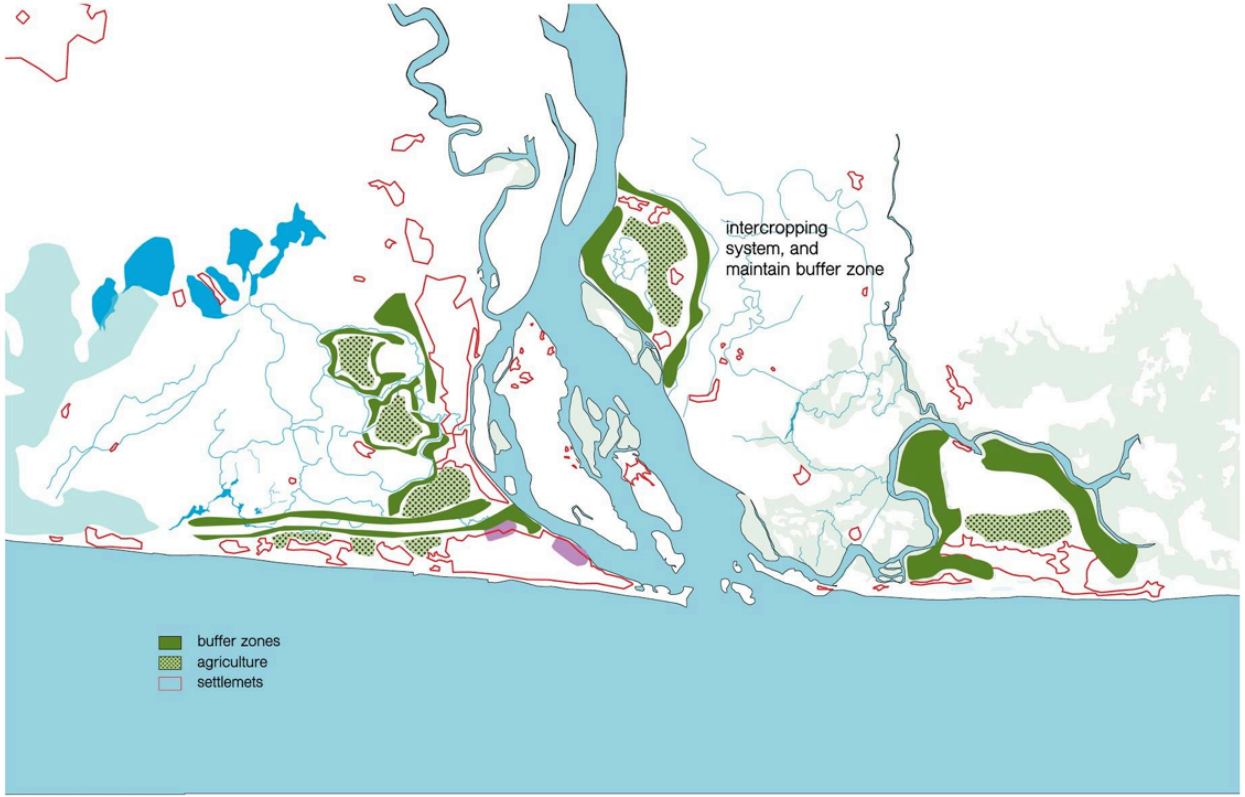
Water management

Food Production

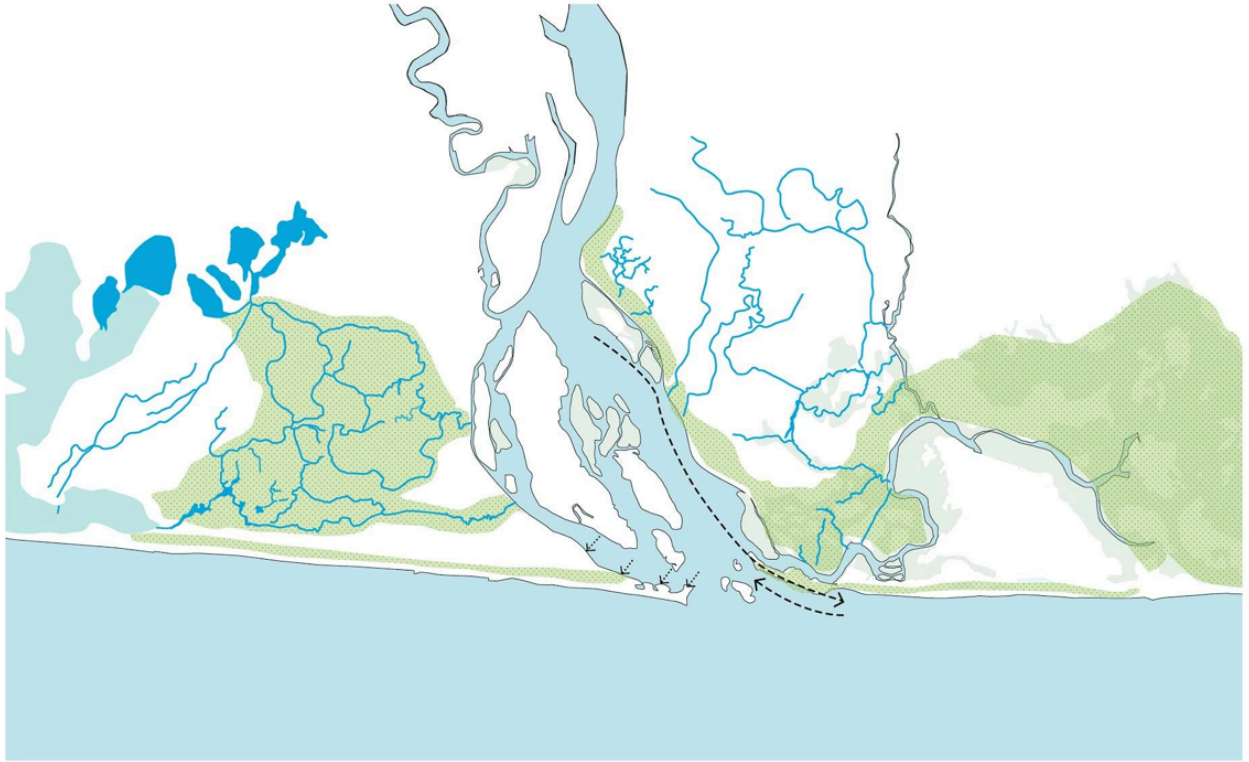
Settlement & Mobility



- Water management

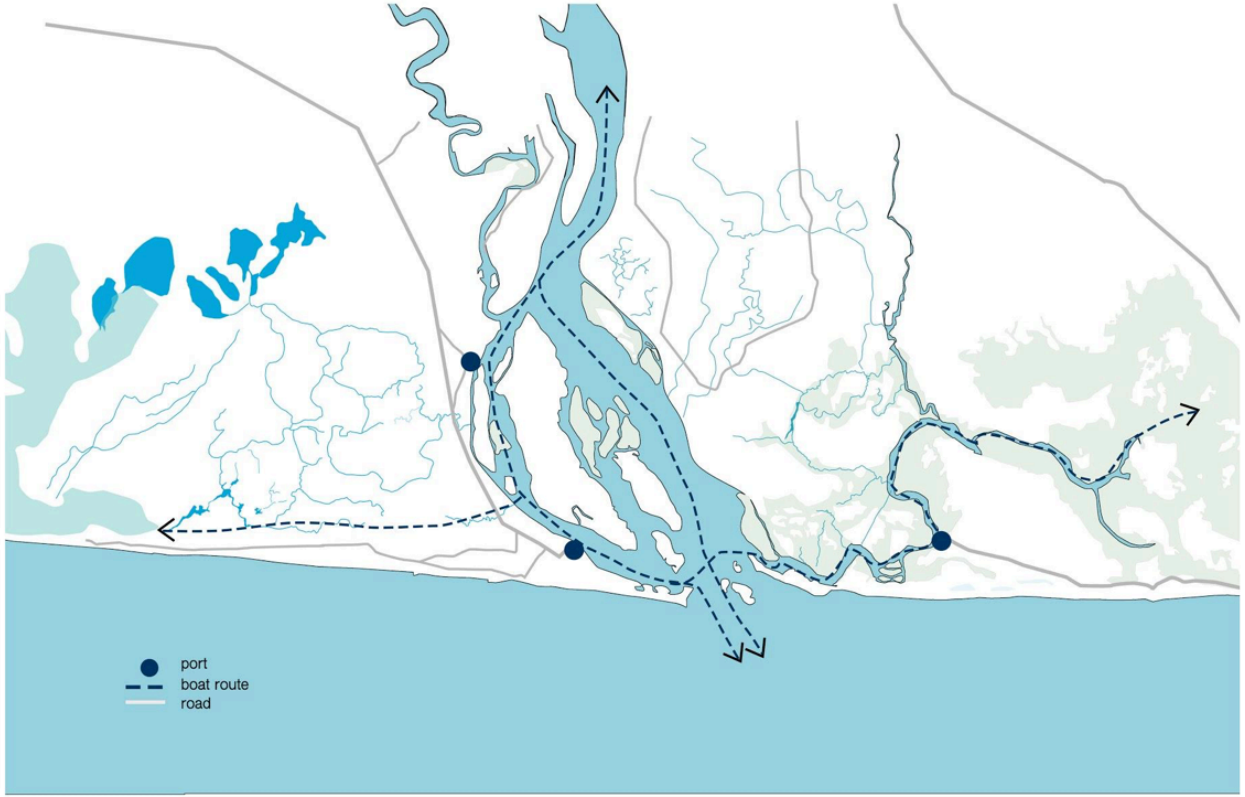


- Water management
- Food production



- Water management
- Food production
- Erosion control

- Water management
- Food production
- Erosion control
- Settlement and mobility



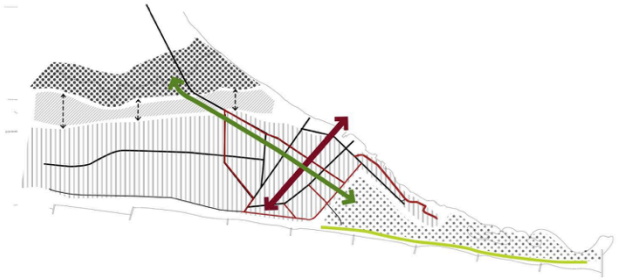
- Water management
- Food production
- Erosion control
- Settlement and mobility

3
2
1

1. Relation between the river and the sea, existing groynes, and fishing communities.
2. Relation between the river and the sea, settlement and tourism facilities, lost wetlands.
3. Water inlet from river, town fringe, settlements and floodplain agriculture.

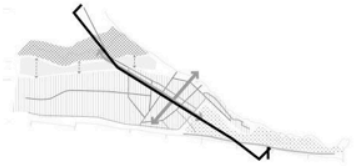
DESIGN IMPLEMENTATION

stage 3

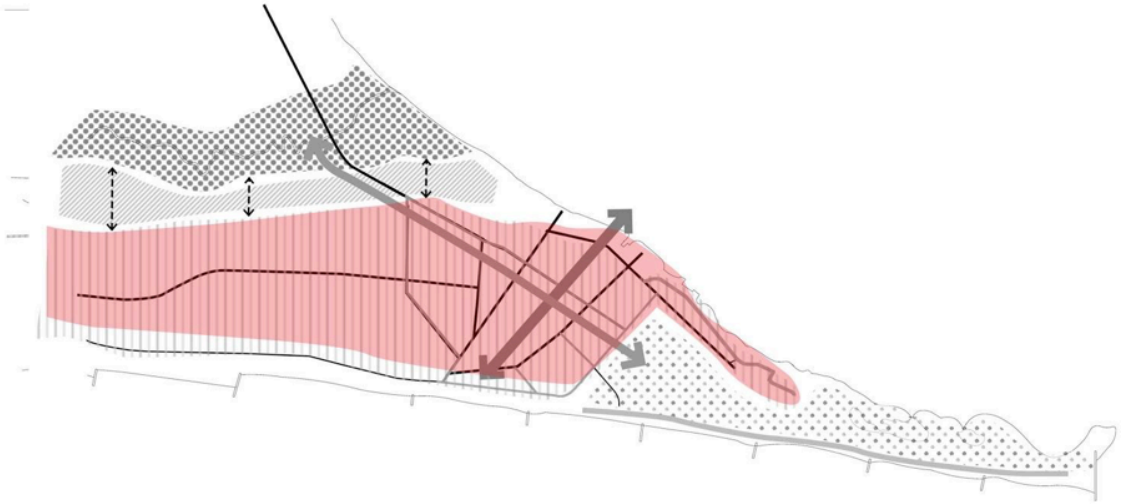


Trigger & Restrain

vulnerability



section



settlement & agriculture development

fishing village with nature restoration

preserved floodplain

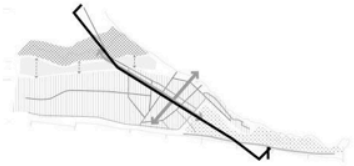
transition zone (hampers settlement development)

green connection

industry & economic axis

conserved marine turtle sites

vulnerability



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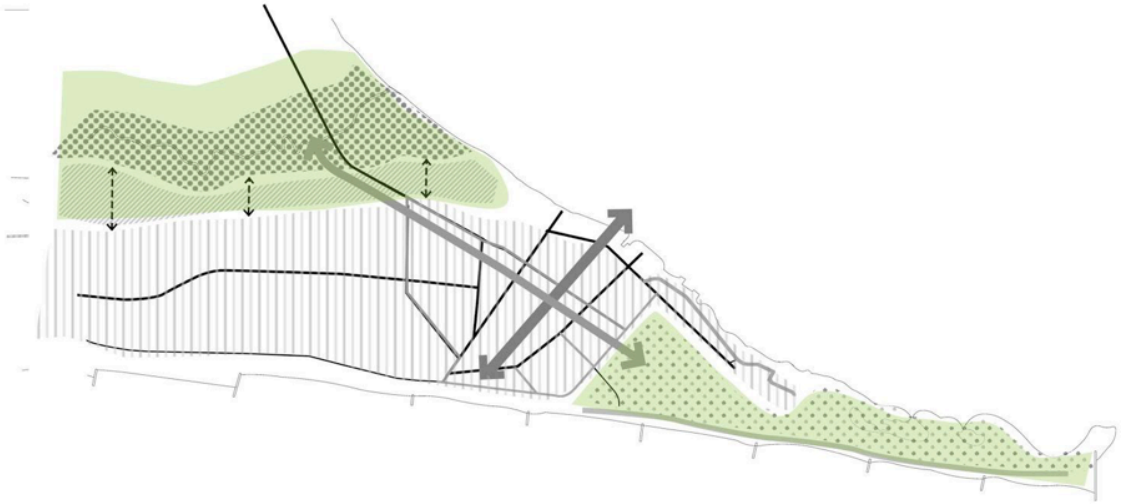

settlement & agriculture development

fishing village with nature restoration

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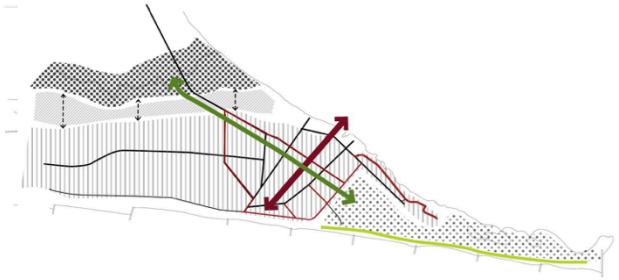
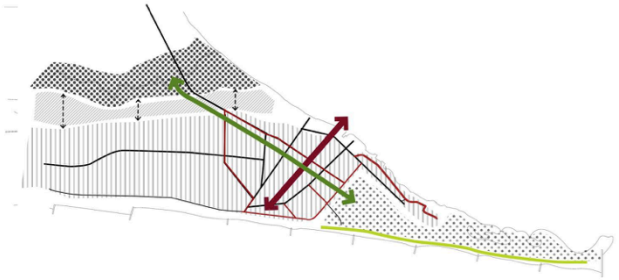
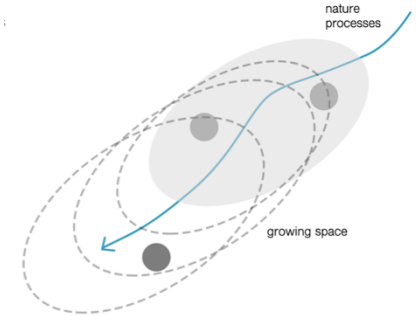


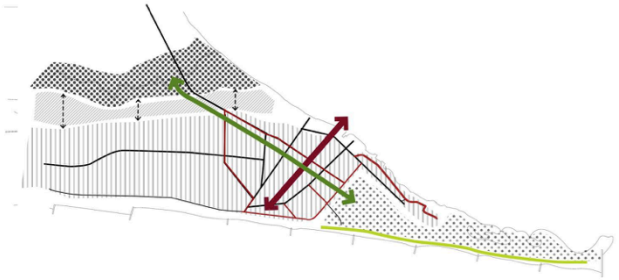
Trigger & Restrain



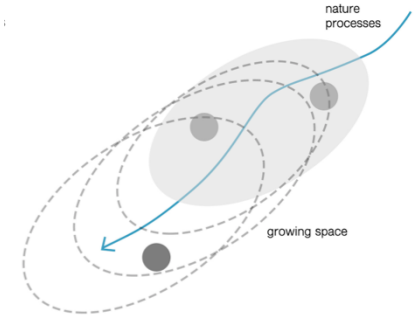
Trigger & Restrain



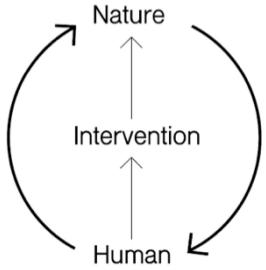
Growing spaces



Trigger & Restrain



Growing spaces

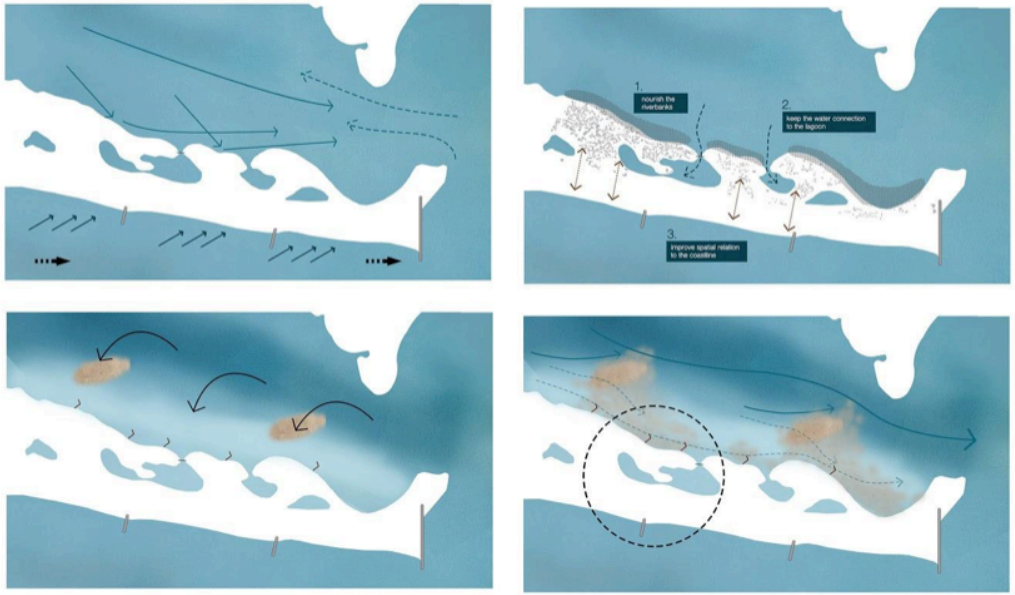


Circular systems

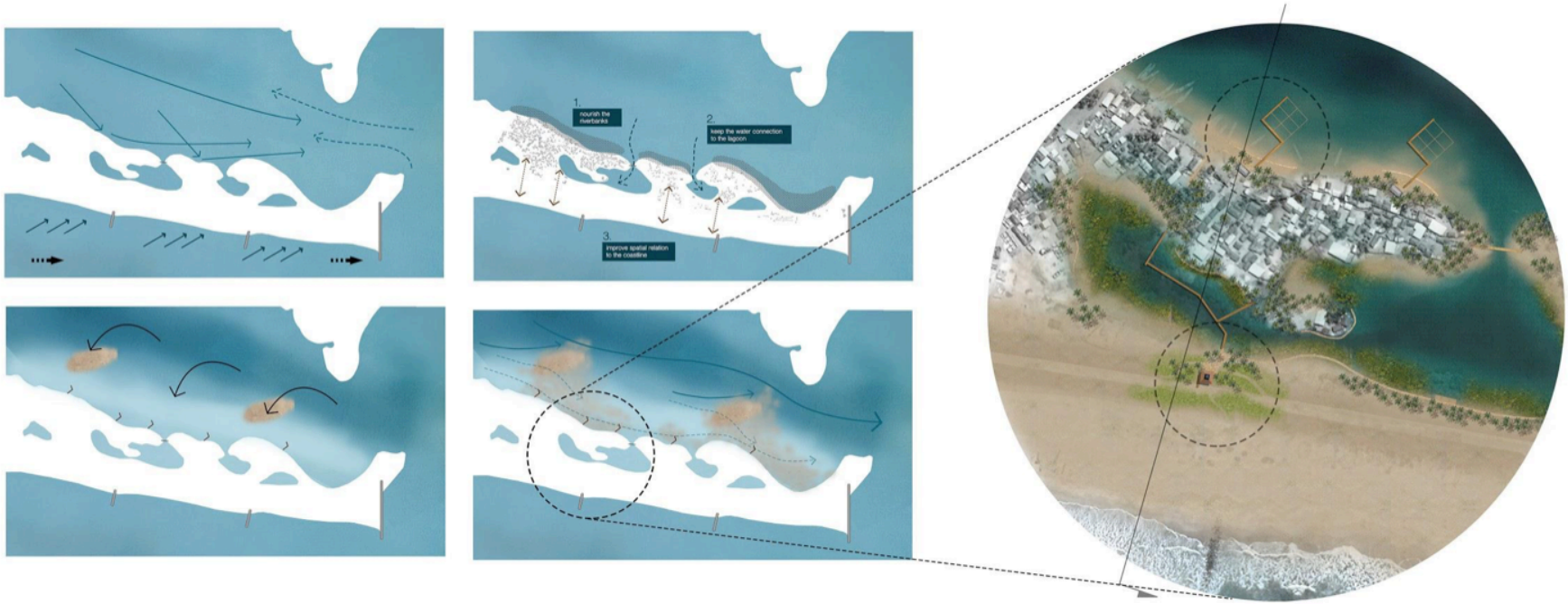
0m
200m
500m

SITE 3
Buffering the Edge
SITE 2
Recovering
the Wetlands
SITE 1
Compromising
the Erosion
0m
200m
500m

SITE 1 : Compromising the erosion



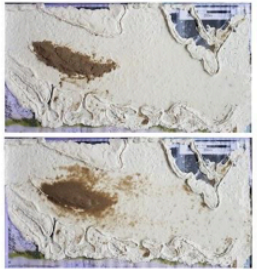
SITE 1 : Compromising the erosion

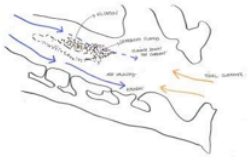


EXPERIMENT 1

TEST 1

Sand nourishment in one large area in a distance in front of the tourism facilities

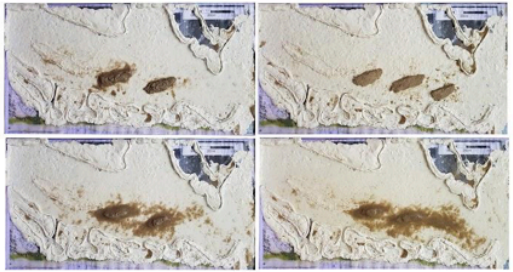


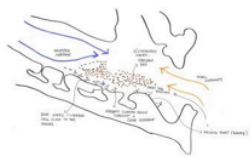


In this test, the sand placed almost parallel to the flow of water does not make the sand distribution to the riverbank effectively. The river flow is not too strong, it will create a sitation around the nourished area which actually could slow the current velocity. And even though it can be distributed to riverbank it will take a long time while the flow on the inner side will accelerate and increase the erosion rate in the riverbank before the sand reach it.

TEST 2

sand nourishment in multiple areas at a certain angle with a distance from the riverbank.

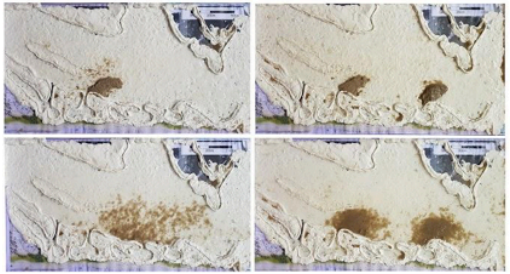


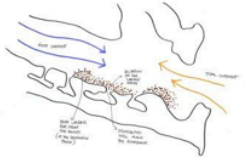


In this test, the sand that is positioned with a certain angle can deflect the direction of river flow thus reducing the potential for erosion on the riverbank. Loose sands are able to be distributed which also causes sitsation that shallow the river beds and reduce velocity of the current.
With a certain distance the boat can still be landed close to the houses and use coconut trees to secure it from the river stream. In the initial phase, permeable groynes is able to slow down river currents on the island's edges.

TEST 3

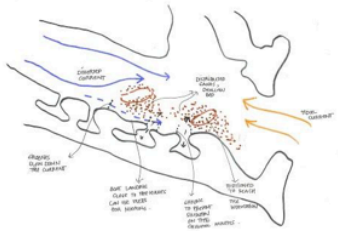
sand nourishment was put attached to the main islands





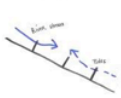
In this test, the sand can be well distributed by the stream flow. However, to distribute it along the riverbank, sitsation will also occur on the waterway leading to lagoons which are undesirable. In the initial phase, large addition of sand at one point will make a long distance to land the fishing boats from the houses and vegetation that can keep the boat in place. It is also not expected given the tendency of the fishermen who always wanted to make sure his boat was safe from being swept away by river streams or tides.

Selected Intervention



From the three types of sand nourishment positions tested, it was concluded that by considering the efficiency of sand distribution with the help of natural flow from the river flow and maintaining the accessibility of the fisherman to his fishing boat, sand nourishment will be placed at a certain distance from the riverbank in two positions to reach the intended locations. Permeable groynes will be placed close to the lagoons waterway, to slow the flow of the river and block the sitsation at the mouth so that the waterway connecting it to the river can be maintained.

EXPERIMENT 2

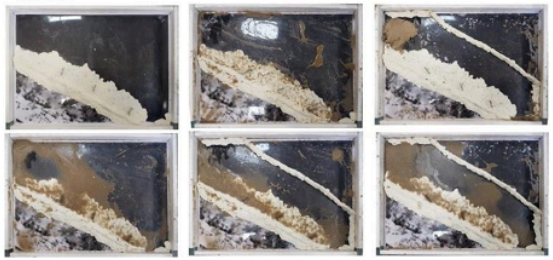


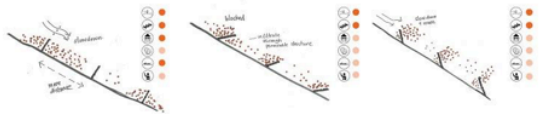
The experiment is aimed to find out the sedimentation processes produced by a particular structure with variations of angle, distance and shape. This experiment also to test the possibility of functions and programs that can be utilized by the local community.

The experiment was carried out using a water and sand medium with a riverbank representation using clay and permeable groyne represented by nails. The movement of the water was made in the form of alternating movement representing river stream and tides that have the opposite direction.

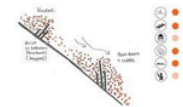
Possible programs

TEST 1 Angles

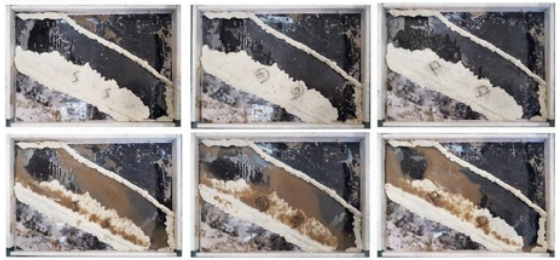


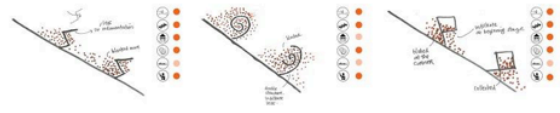


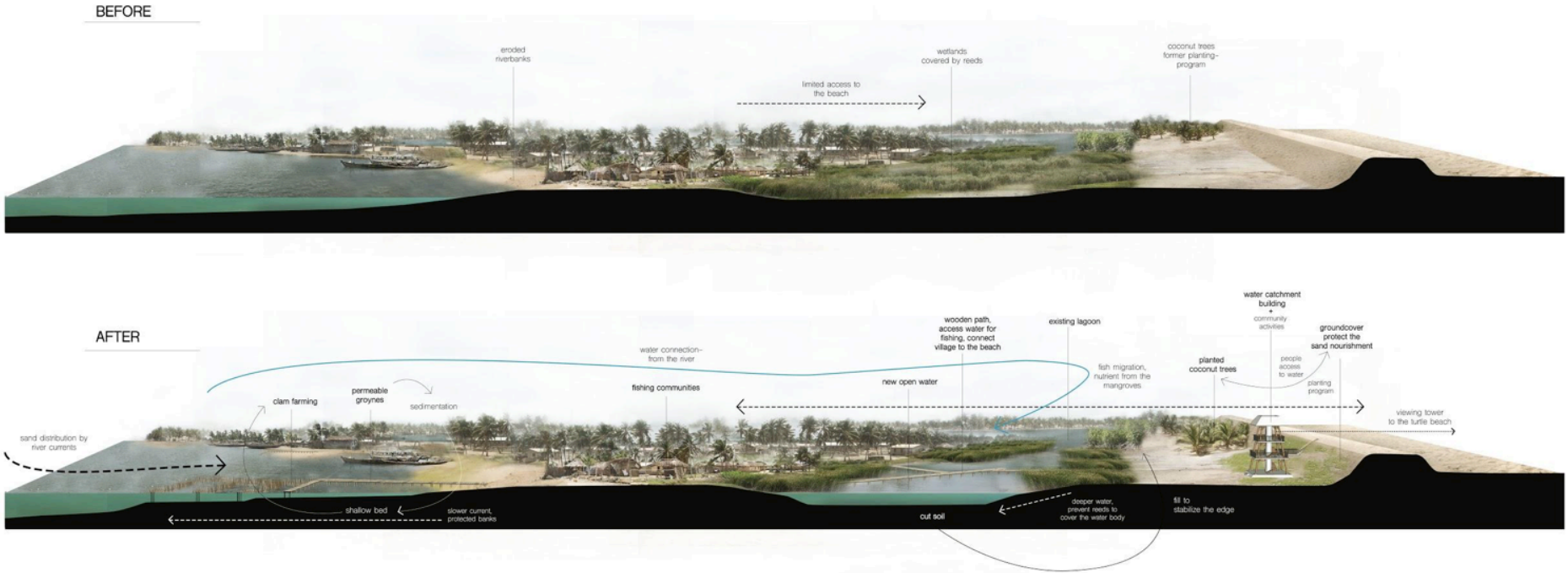
TEST 2 Distance

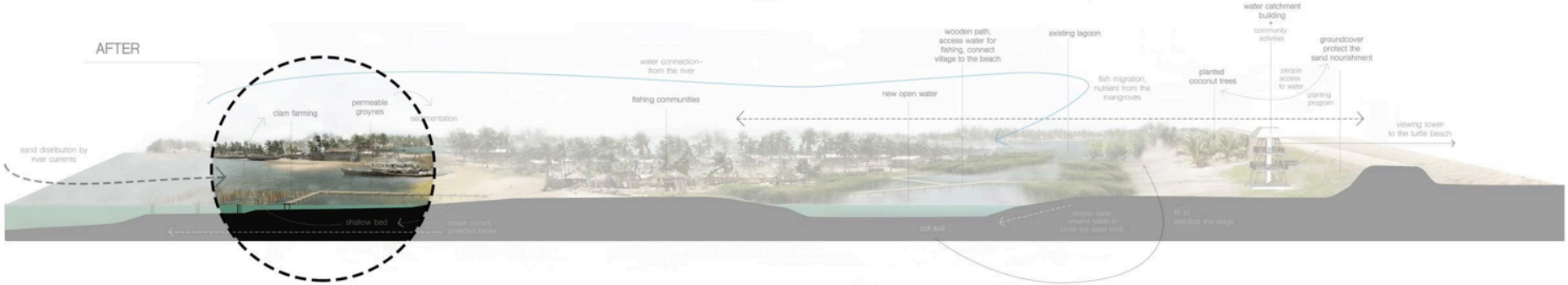


TEST 3 Shape, movements






BEFORE
eroded riverbanks
limited access to the beach
wetlands covered by reeds
coconut trees former planting-program
AFTER
water connection- from the river
wooden path, access water for fishing, connect village to the beach
existing lagoon
water catchment building + community activities
groundcover protect the sand nourishment
planted coconut trees
people access to water
planting program
fish migration, nutrient from the mangroves
clam farming
permeable groynes
sedimentation
fishing communities
new open water
viewing tower to the turtle beach
sand distribution by river currents
shallow bed
slower current, protected banks
cut soil
deeper water, prevent reeds to cover the water body
fill to stabilize the edge


AFTER
water catchment building
+
community activities
groundcover protect the sand nourishment
wooden path, access water for fishing, connect village to the beach
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deeper water, prevent seeds to cover the water body
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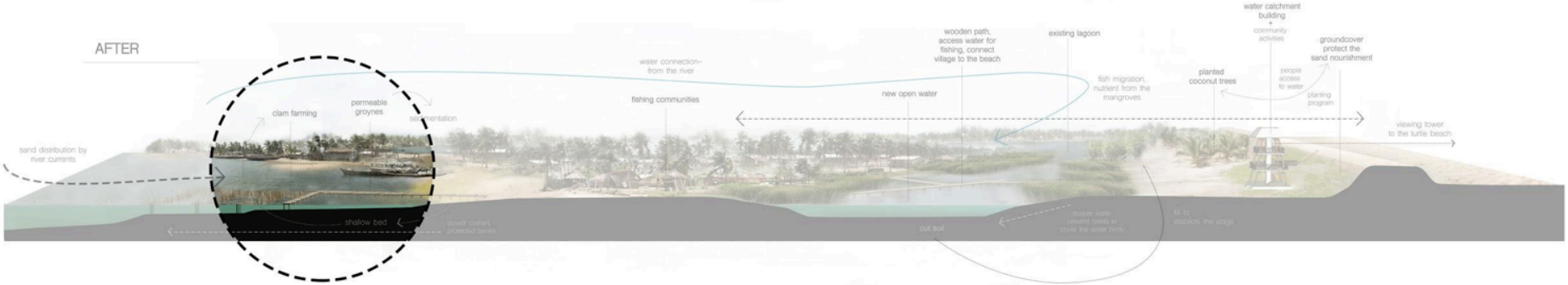
AFTER
clam farming
permeable groynes
sedimentation
water connection- from the river
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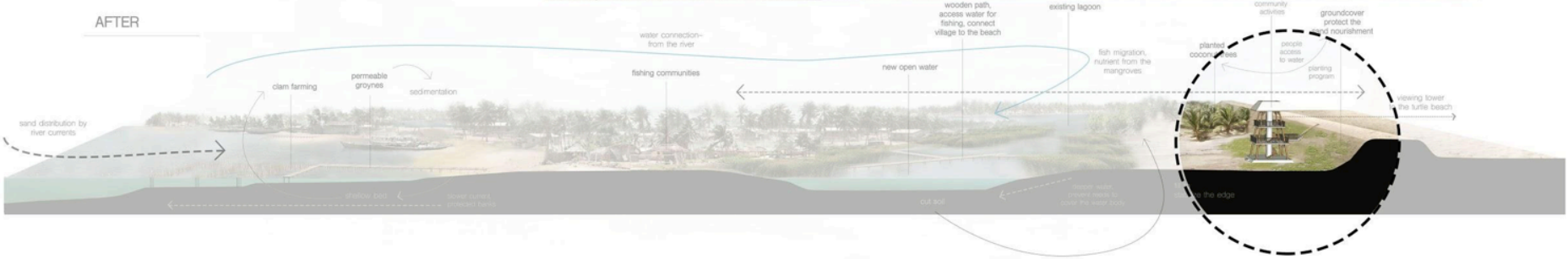
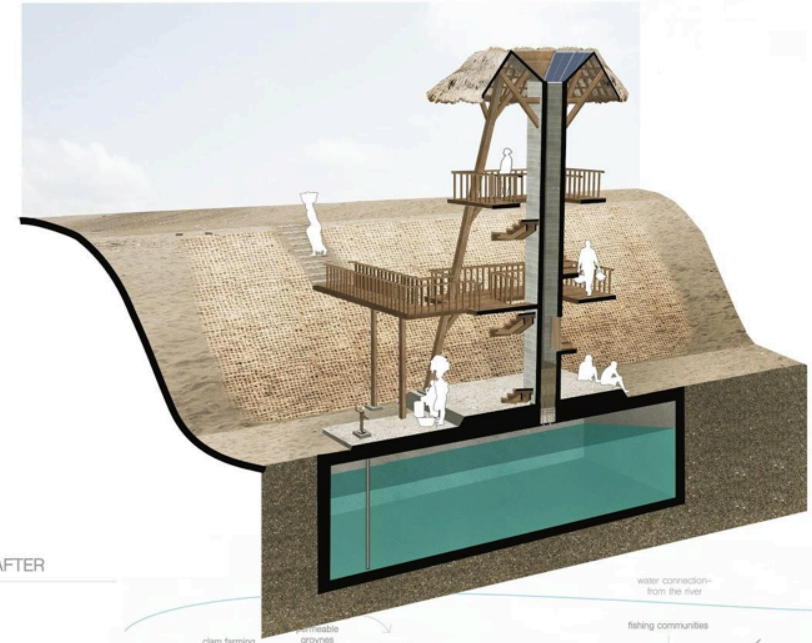
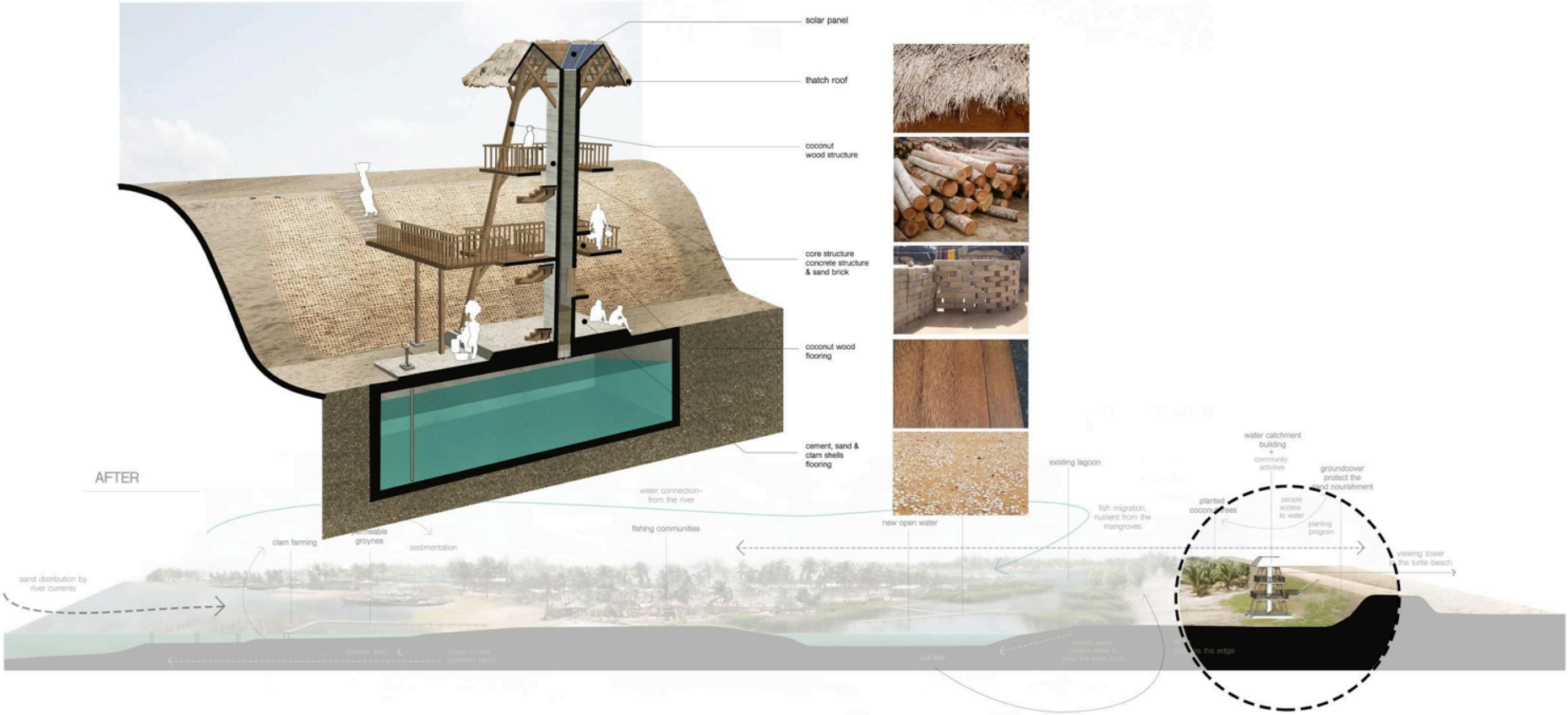
community activities
people access to water
planting program
groundcover protect the sand nourishment
viewing tower to the turtle beach
sand distribution by river currents
shallow bed
slower current protected banks
cut soil
deeper water, prevent seeds to cover the water body
fill to stabilize the edge

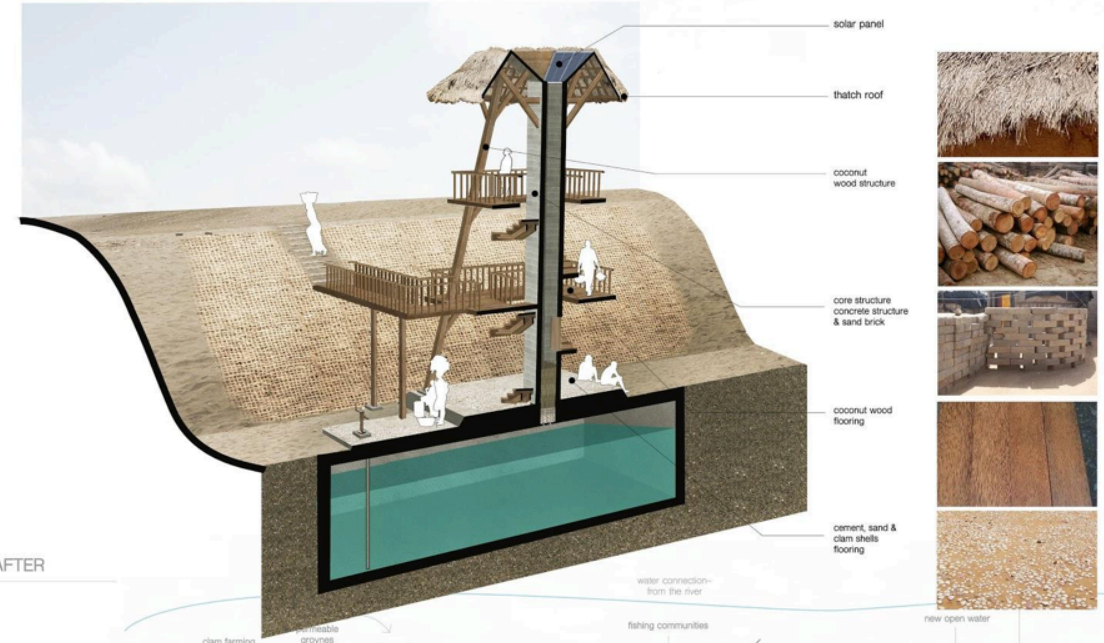

AFTER
wooden path, access water for fishing, connect village to the beach
existing lagoon
community activities
groundcover protect the sand nourishment
water connection- from the river
fish migration, nutrient from the mangroves
planted coconut trees
people access to water
planting program
fishing communities
new open water
clam farming
permeable groynes
sedimentation
viewing tower the turtle beach
sand distribution by river currents
shallow bed
slower current, protect beds
out sea
deeper water, covers reefs to cover the seagrass
the edge



AFTER

water catchment building + community activities
groundcover protect the soil nourishment
wooden path, access water for fishing, connect village to the beach
existing lagoon
water connection- from the river
fish migration, nutrient from the mangroves
planted coconut trees
people access to water
planting program
new open water
fishing communities
clam farming
permeable groynes
sedimentation
viewing tower at the turtle beach
sand distribution by river currents
shallow bed
slower current, protect beds
deeper water, prevent reeds to cover the water body
out sea
at the edge


solar panel
thatch roof
coconut
wood structure
core structure
concrete structure
& sand brick
coconut wood
flooring
cement, sand &
clam shells
flooring
AFTER
water connection-
from the river
existing lagoon
water catchment
building
+
community
activities
groundcover
protect the
and nourishment
planted
coconut trees
people
access
to water
planting
program
fish migration,
nutrient from the
mangroves
new open water
fishing communities
clam farming
permeable
groynes
sedimentation
sand distribution by
river currents
viewing tower
the turtle beach
shallow bed
slower current
protect beds
out soil
deposit water,
prevent weeds to
cover the water body
the edge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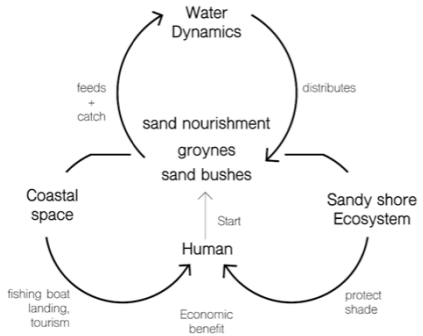
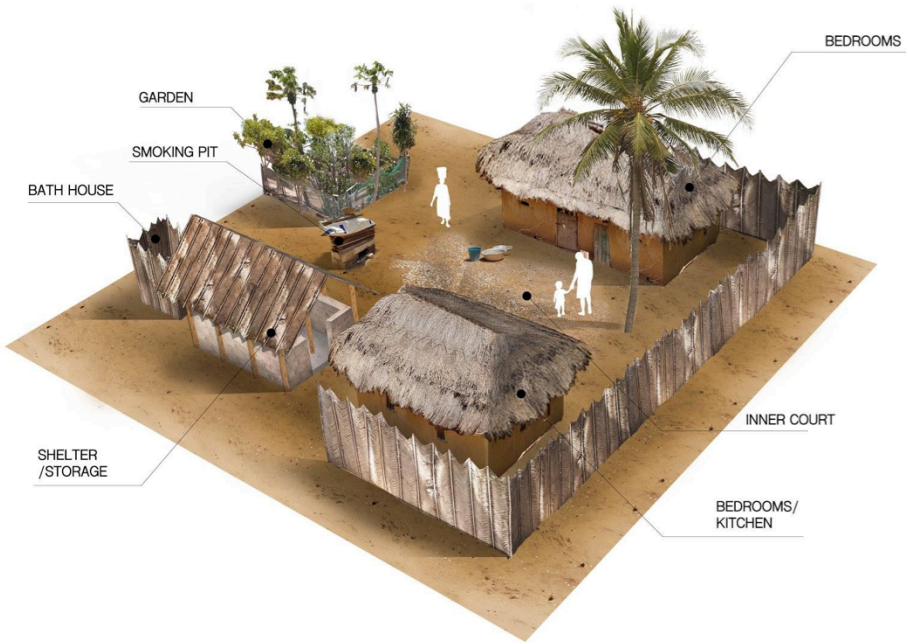

Water
Dynamics
feeds
+
catch
distributes
sand nourishment
groynes
sand bushes
Coastal
space
Sandy shore
Ecosystem
Start
Human
fishing boat
landing,
tourism
Economic
benefit
protect
shade

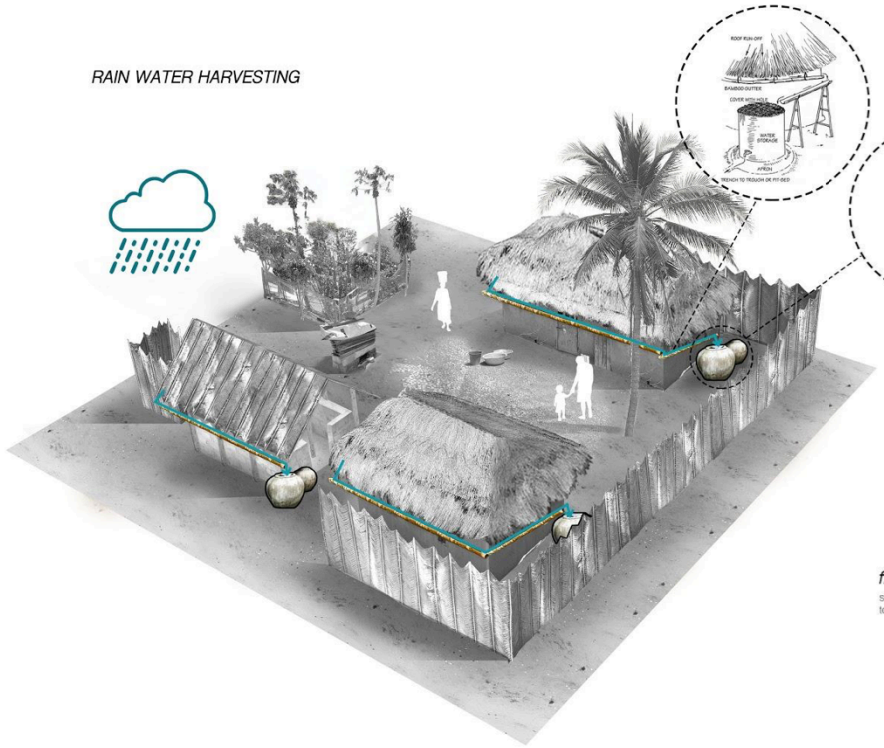
AFTER
water connection-
from the river
existing lagoon
water catchment
building
+
community
activities
groundcover
protect the
sand nourishment
planted
coconut trees
people
access
to water
planting
program
fish migration,
nutrient from the
mangroves
new open water
fishing communities
clam farming
permeable
groynes
sedimentation
sand distribution by
river currents
viewing tower
the turtle beach
shallow bed
slower current,
protect beds
out soil
deposit sand,
prevent seeds to
cover the seed beds
the edge

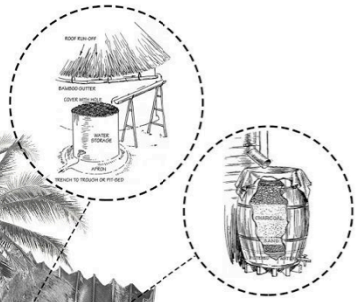
Atakpamé House



RAIN WATER HARVESTING

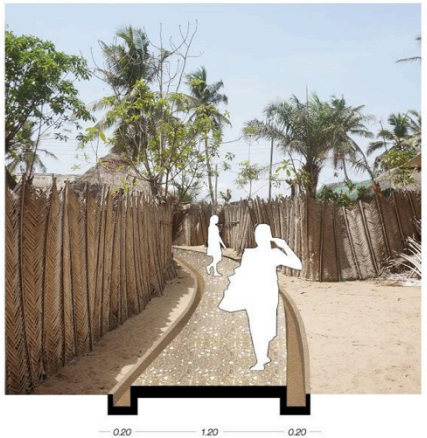
RAIN WATER HARVESTING





PATHWAY

mixed clam shells, gravel, sand and concrete



rain water collector

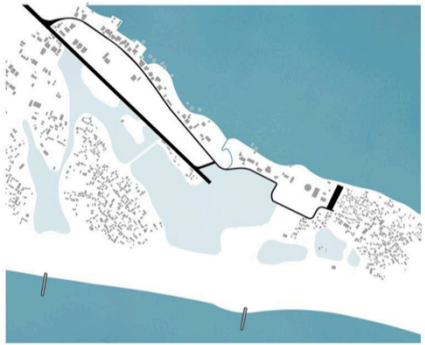
openable filter chamber for filtration and maintenance

fish smoking

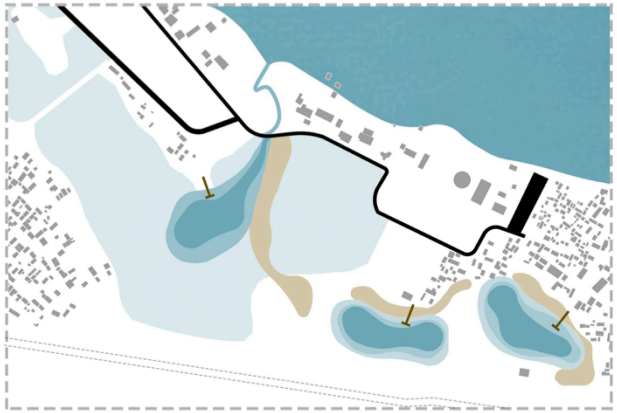
surrounded by tree to filter the air

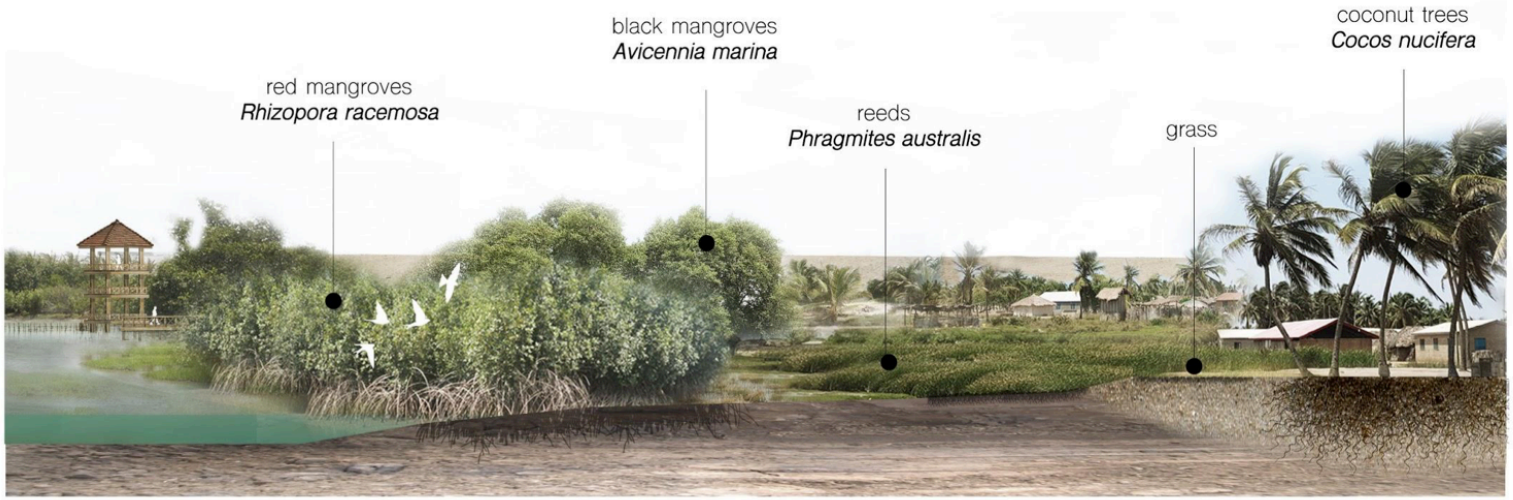
communal space

SITE 2 : Recovering the Wetlands

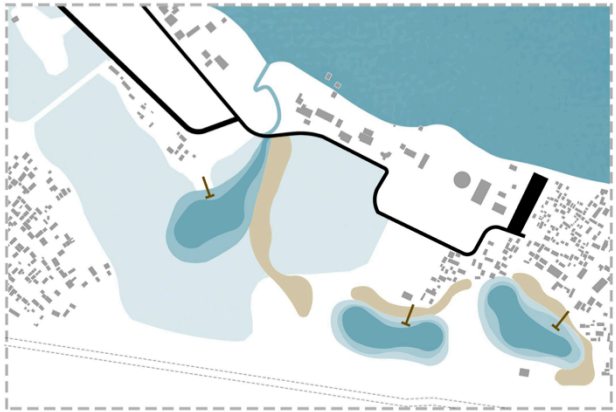


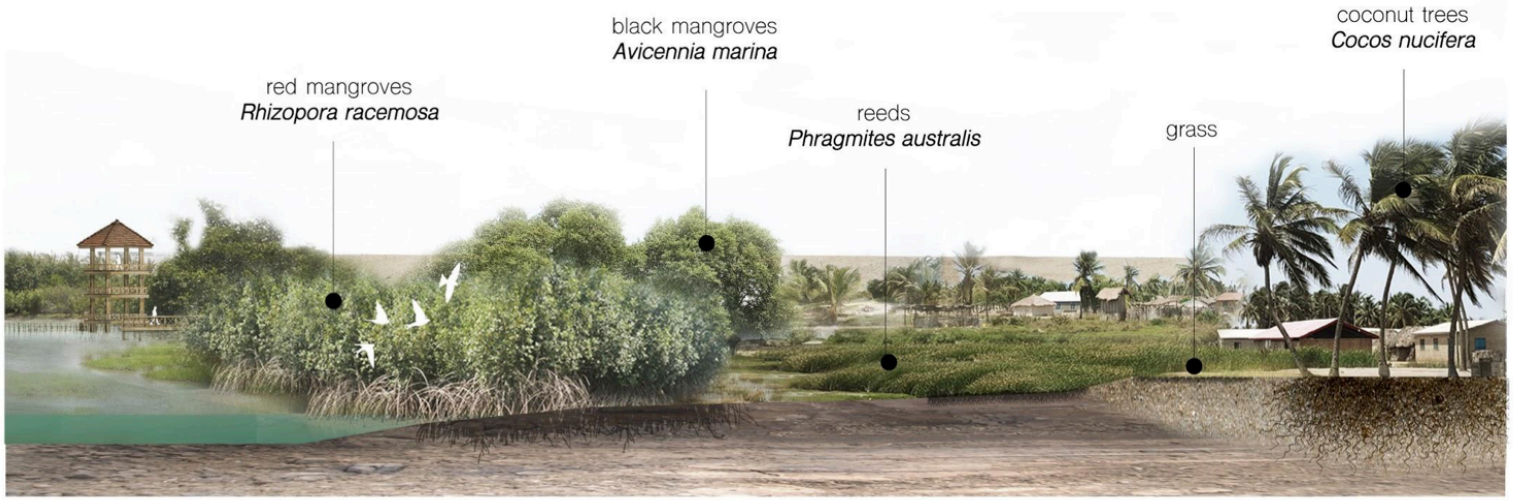
Re-profiling the topography



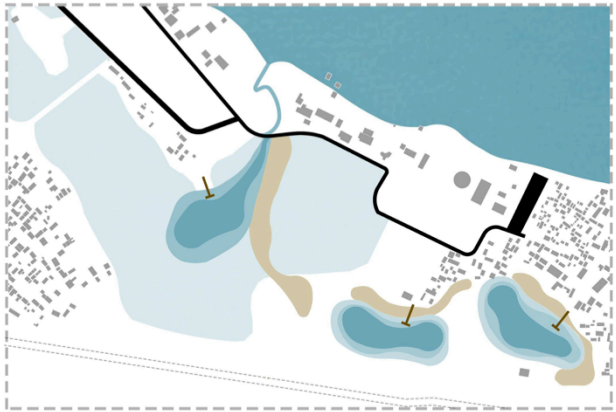


Re-profiling the topography

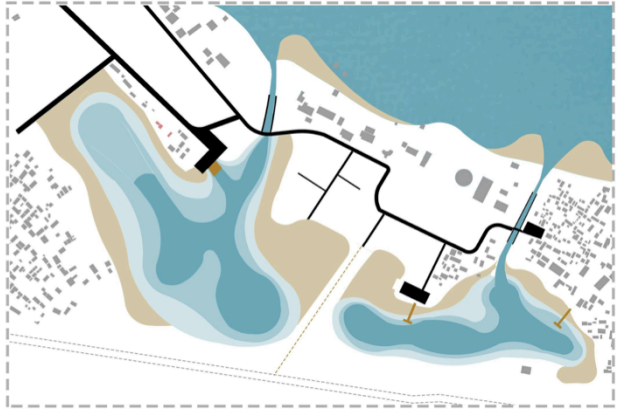


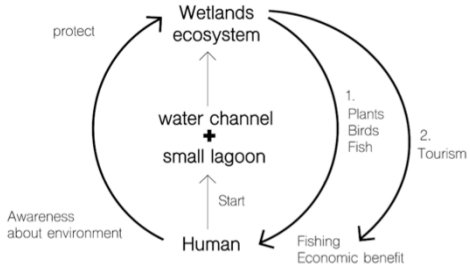


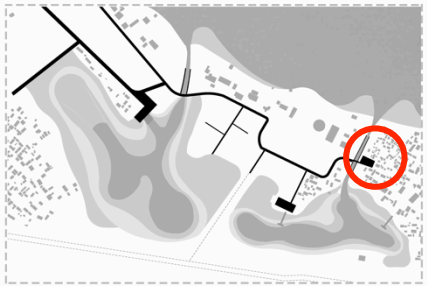
Re-profiling the topography

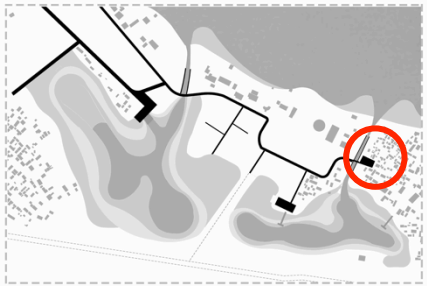


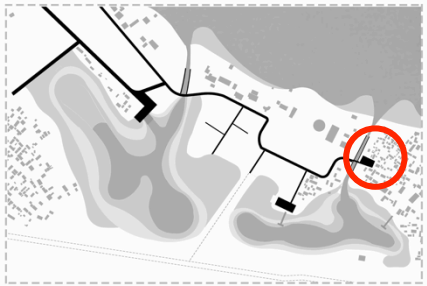
Opening new channel

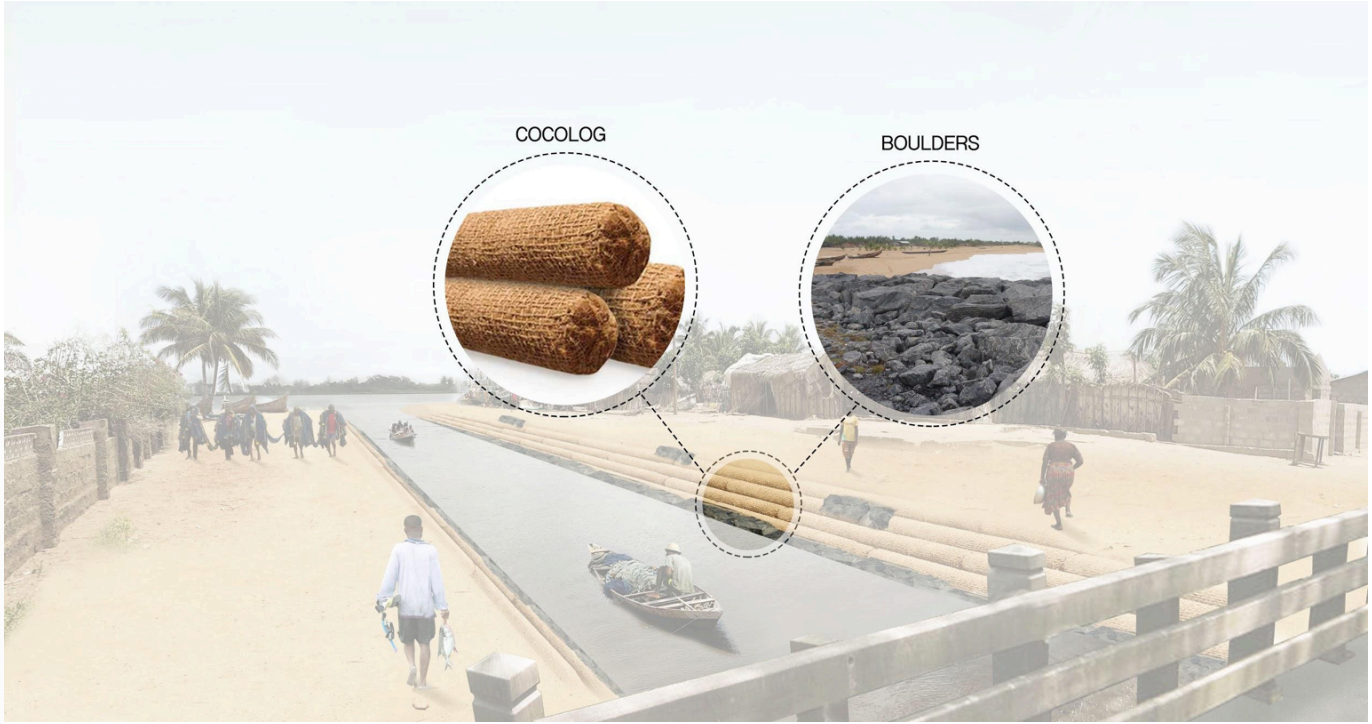


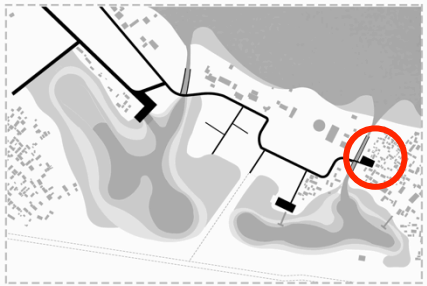




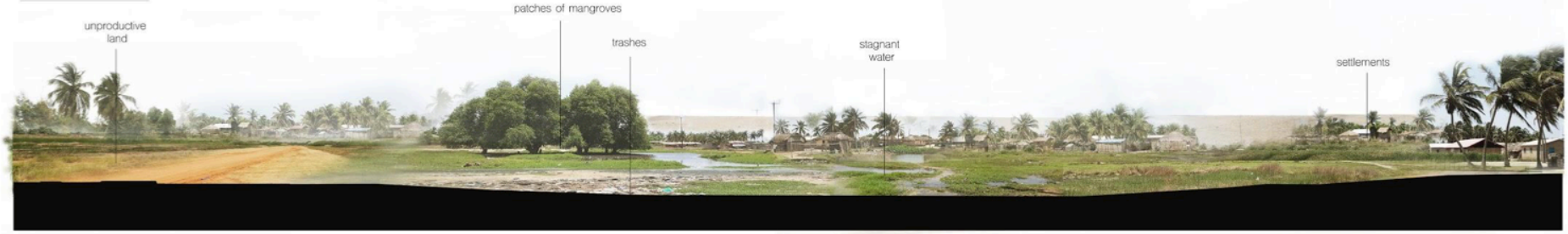




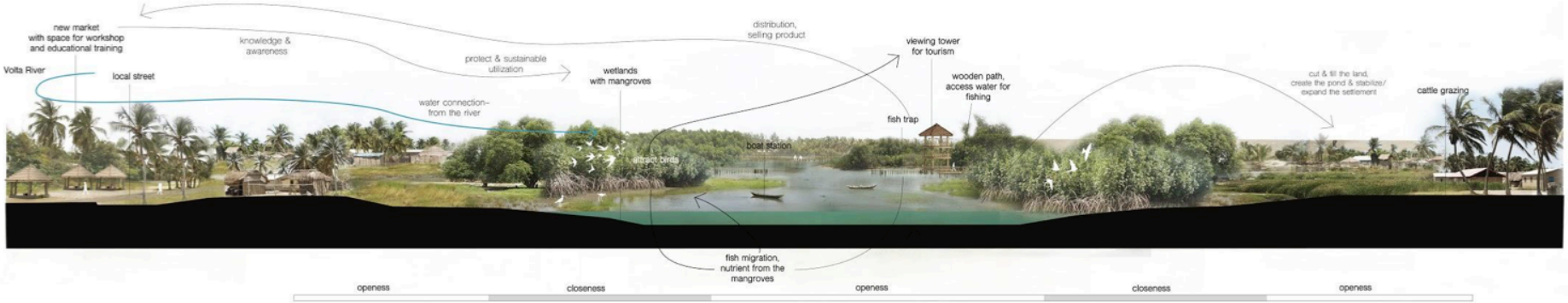

COCOLOG
BOULDERS



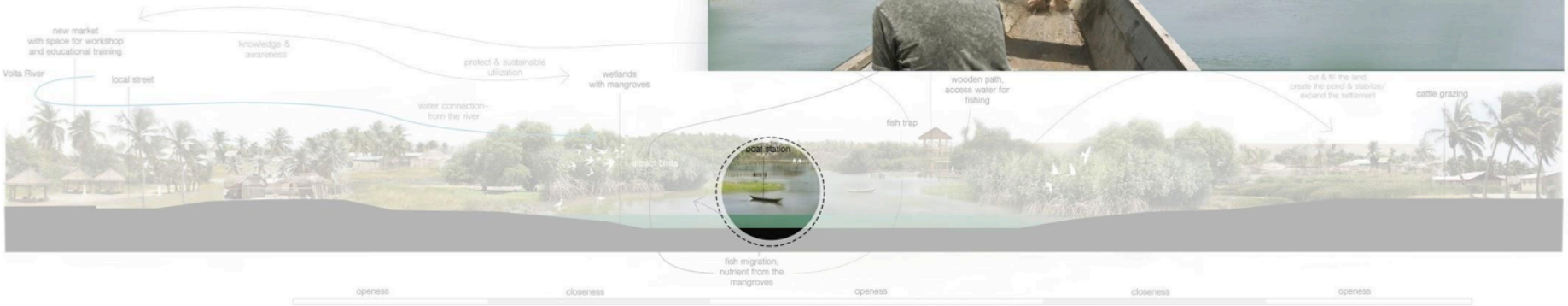
BEFORE



AFTER

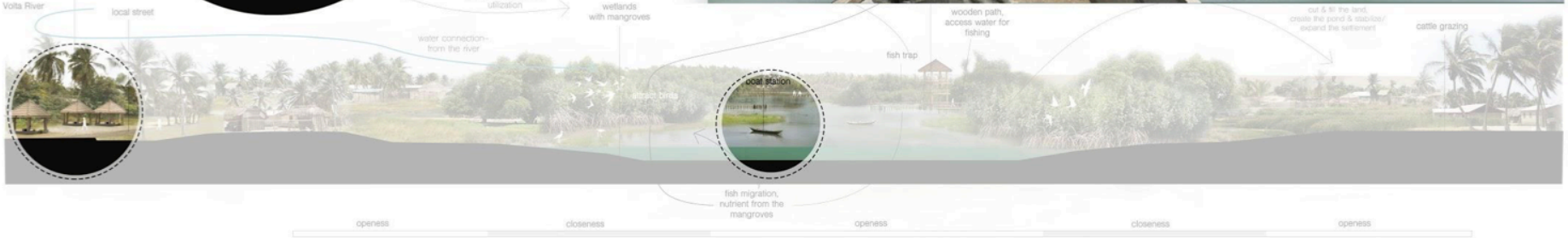


AFTER

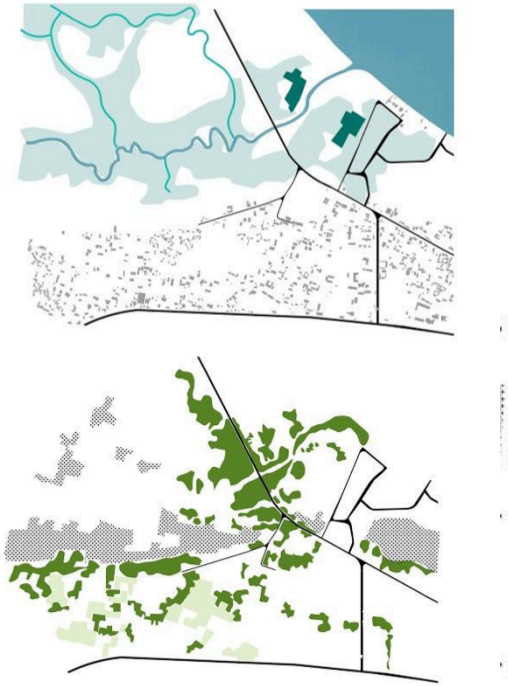

new market
with space for workshop
and educational training
knowledge &
awareness
protect & sustainable
utilization
wetlands
with mangroves
Volta River
local street
water connection
from the river
wooden path,
access water for
fishing
cut & fill the land,
create the pond & stabilize/
expand the settlement
cattle grazing
fish trap
coal station
fish migration,
nutrient from the
mangroves
openess
closeness
openess
closeness
openess

new market
& community center

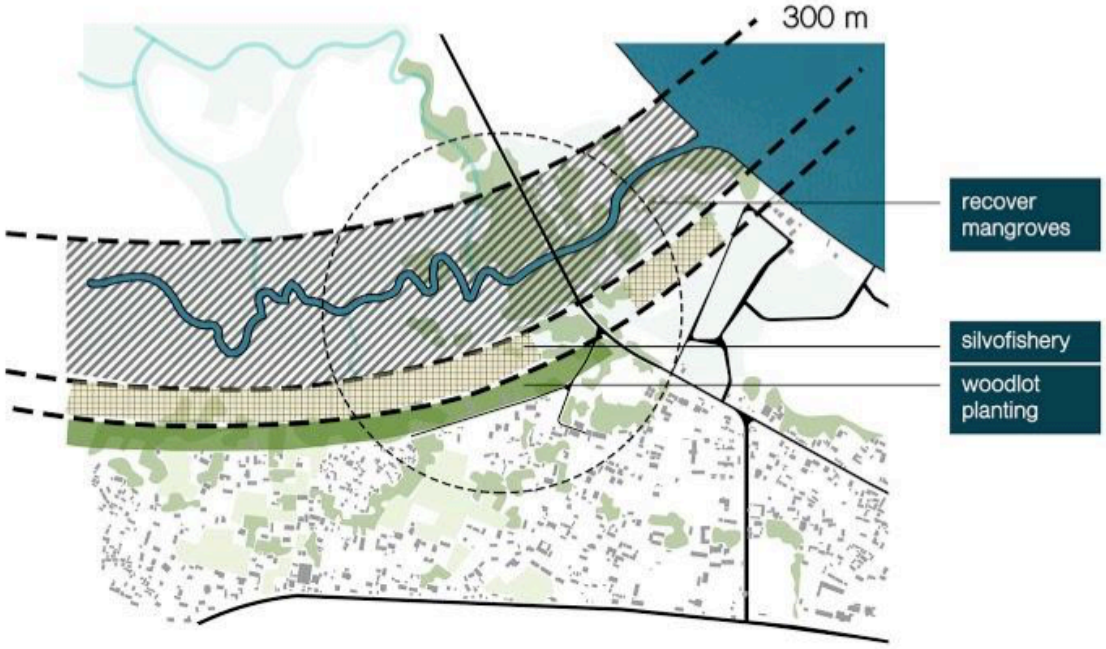
AFTER



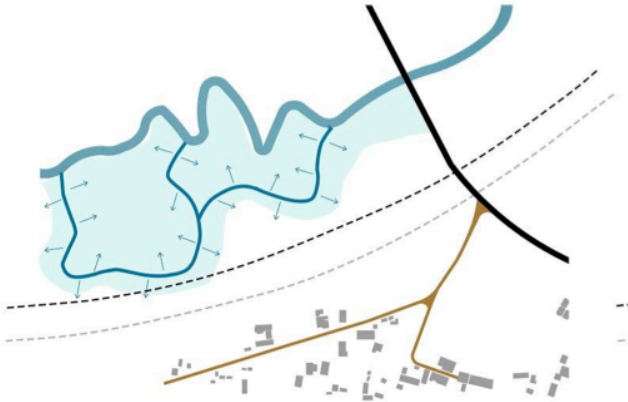
SITE 3 : Buffering the Edge

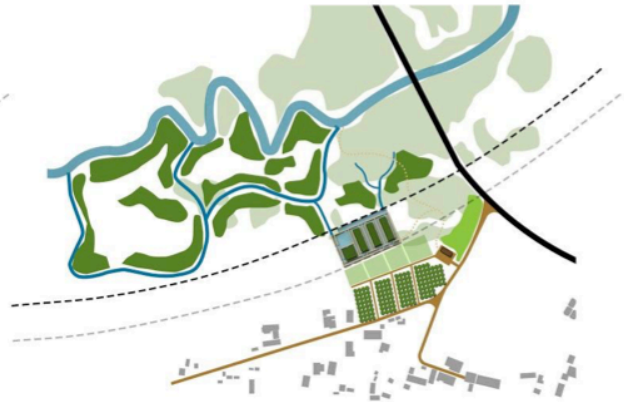


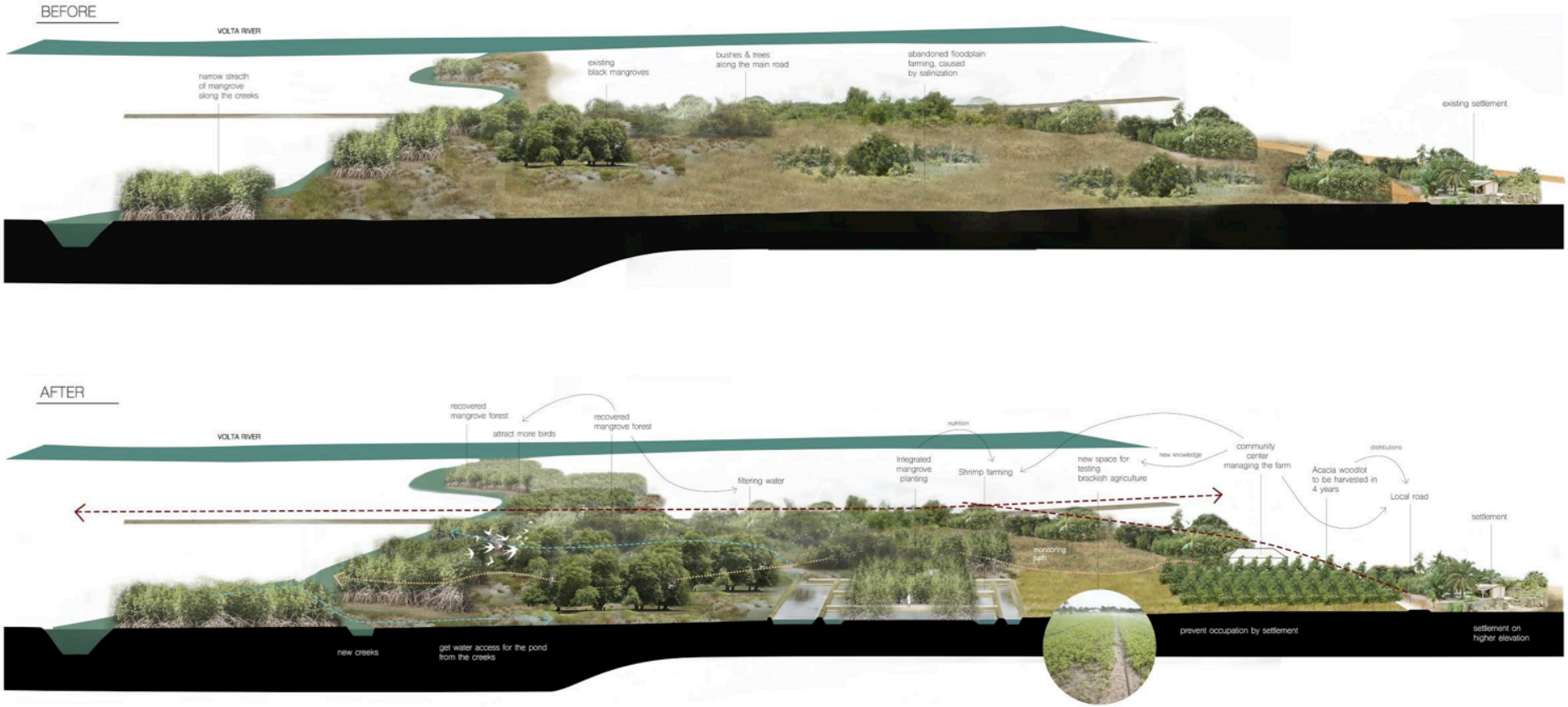
existing condition



design intention

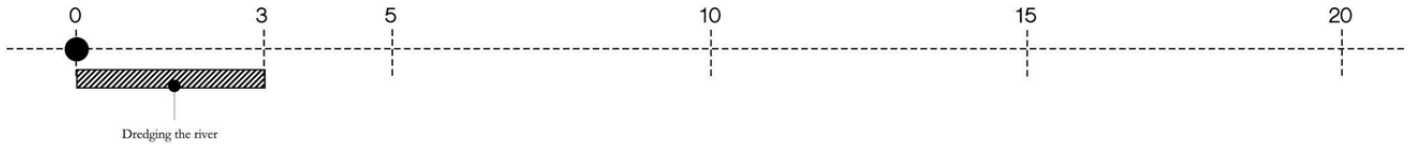


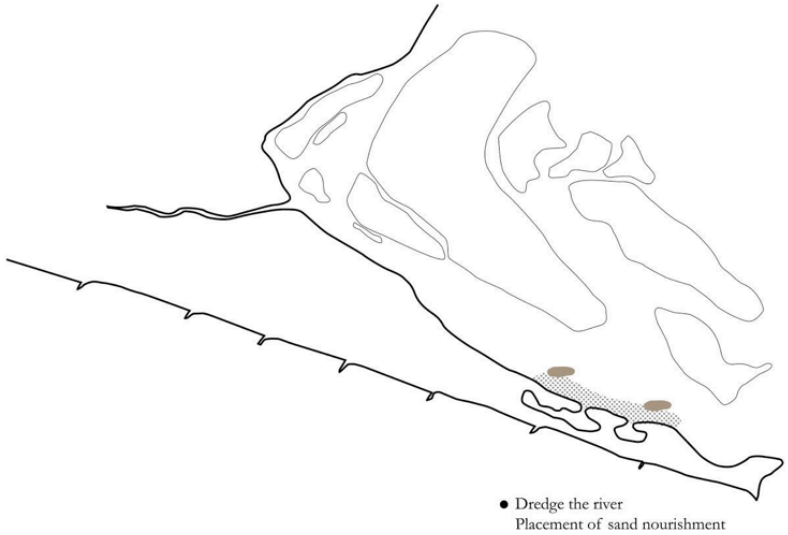


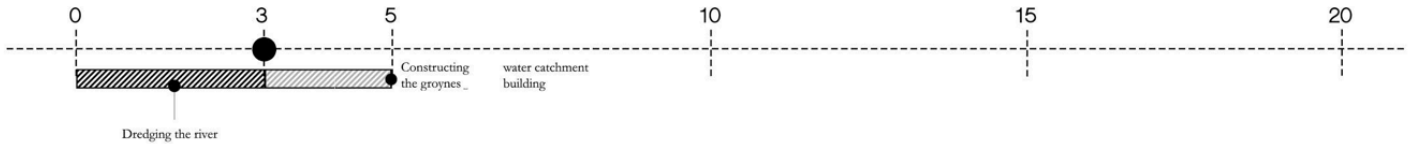

BEFORE
VOLTA RIVER
narrow strecth of mangrove along the creeks
existing black mangroves
bushes & trees along the main road
abandoned floodplain farming, caused by salinization
existing settlement
AFTER
VOLTA RIVER
recovered mangrove forest
attract more birds
recovered mangrove forest
filtering water
nutrition
Integrated mangrove planting
Shrimp farming
new space for testing brackish agriculture
new knowledge
community center managing the farm
distributions
Acacia woodlot to be harvested in 4 years
Local road
settlement
monitoring path
new creeks
get water access for the pond from the creeks
prevent occupation by settlement
settlement on higher elevation

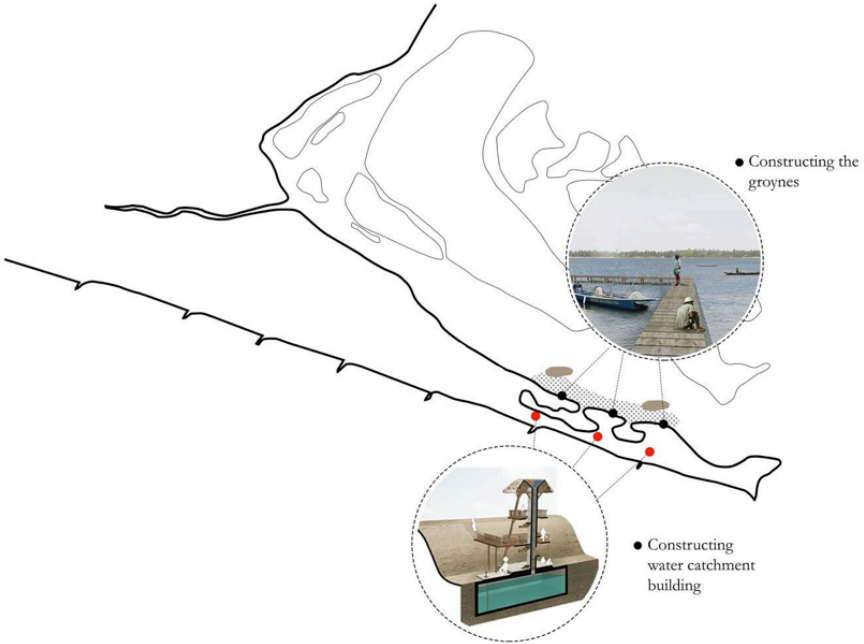
protect
breathing creekbanks
periodic floods
Fish migrations
re-open creeks
Start
Awareness about environment
Human
Silvo-fisheries Floodplain farming
Economic benefit

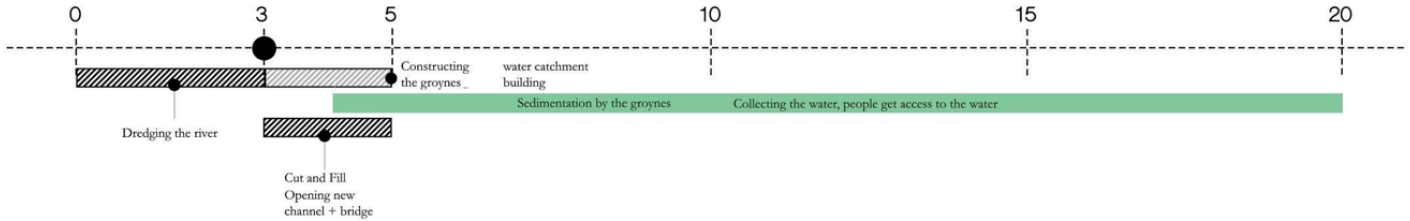
AFTER
VOLTA RIVER
0.80m
3.00m
1.20m
3.00m
new creeks
get water access for the pond from the creeks
prevent occupation by settlement
settlement on higher elevation

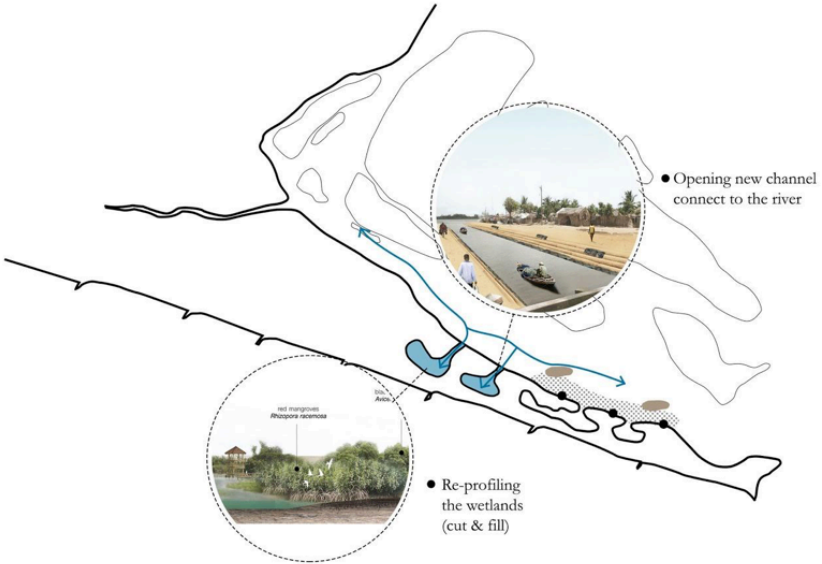

0
3
5
10
15
20
Dredging the river

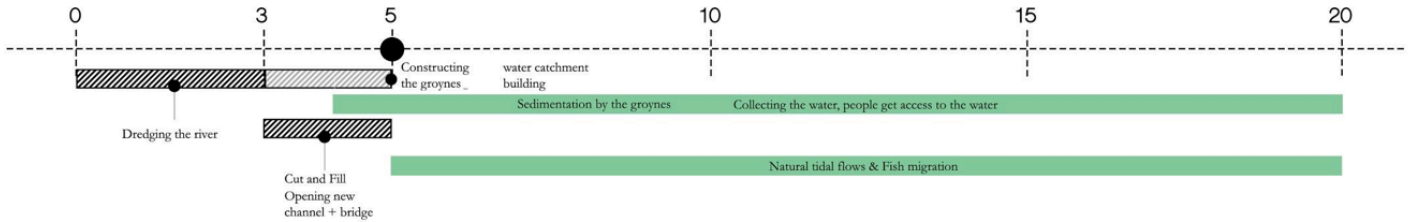

● Dredge the river
Placement of sand nourishment

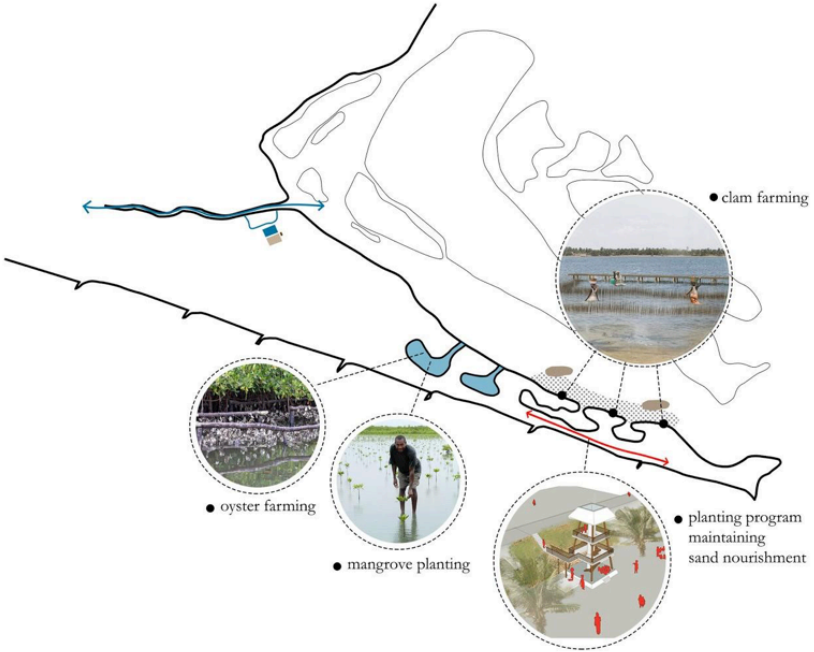

0
3
5
10
15
20
Constructing the groynes _
water catchment building
Dredging the river

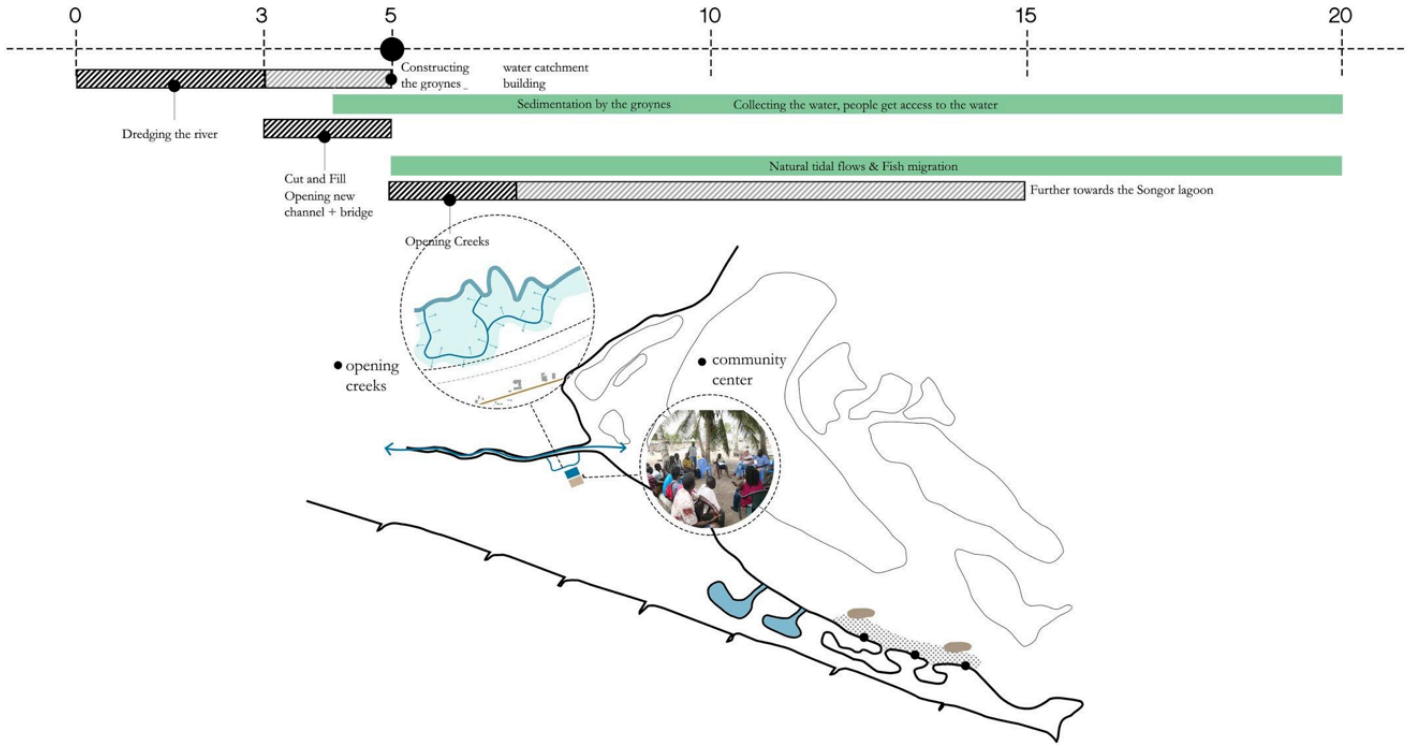

● Constructing the groynes
● Constructing water catchment building

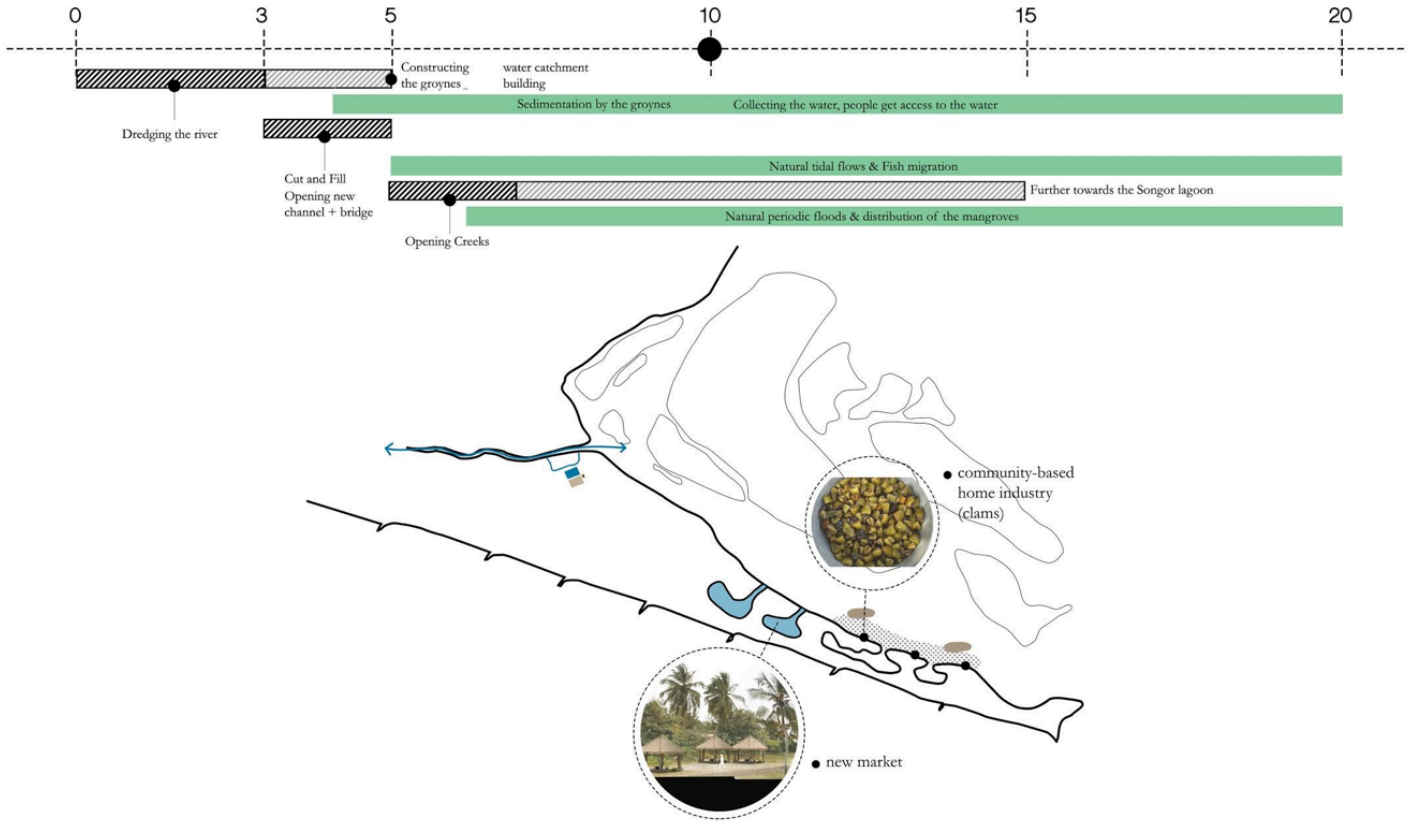

0
3
5
10
15
20
Constructing the groynes _
water catchment building
Sedimentation by the groynes
Collecting the water, people get access to the water
Dredging the river
Cut and Fill
Opening new channel + bridge

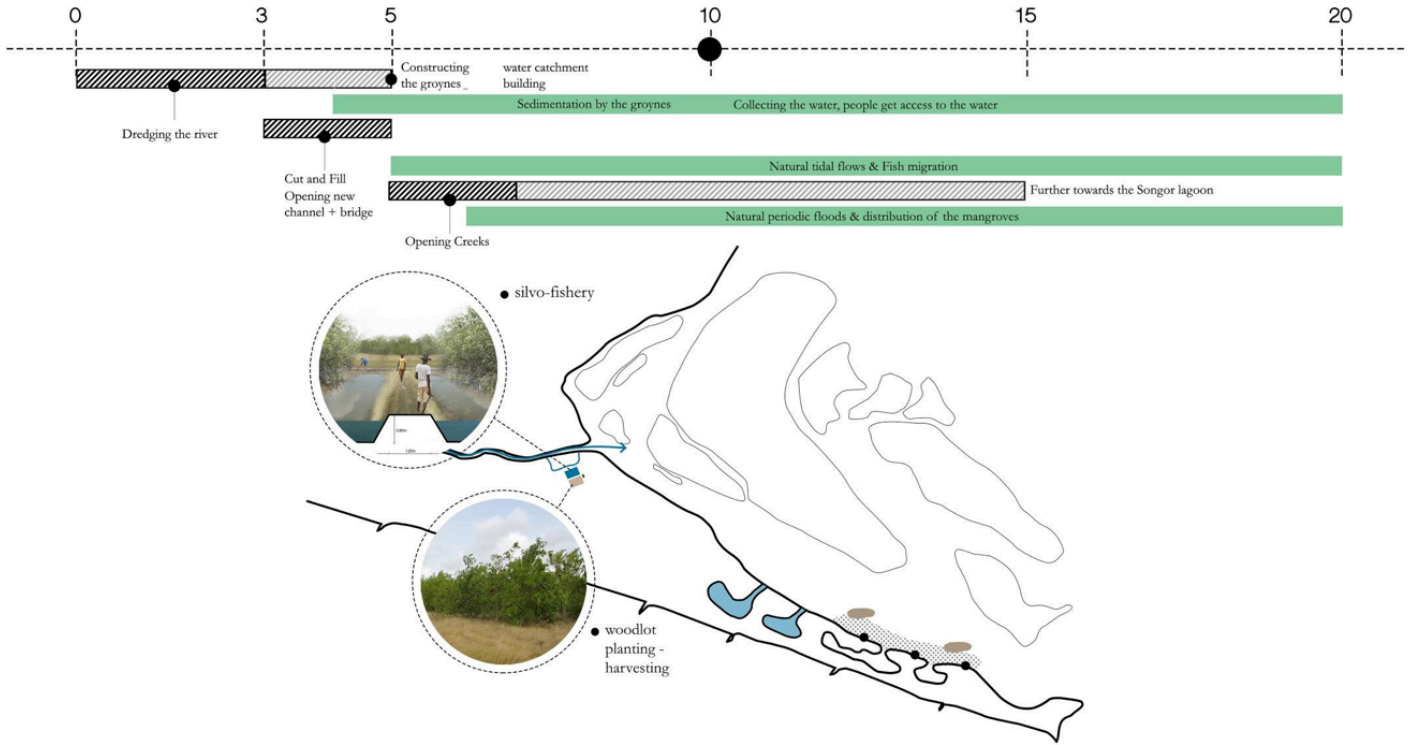

Opening new channel connect to the river
red mangroves
Rhizopora racemosa
Re-profiling the wetlands (cut & fill)

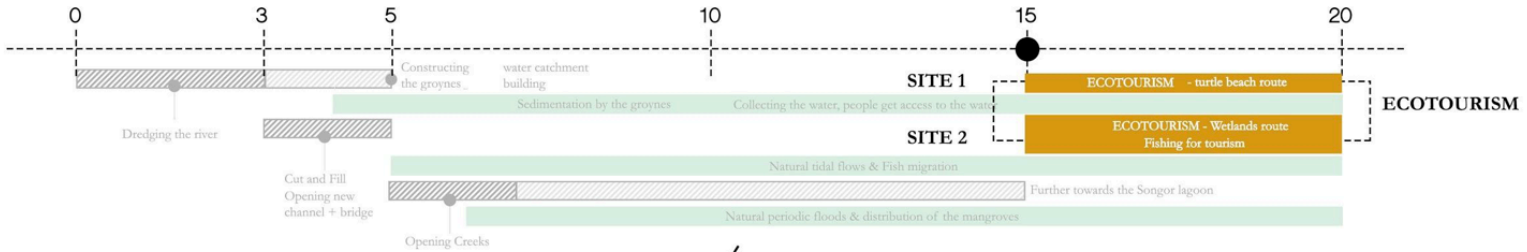

0
3
5
10
15
20
Constructing the groynes _
water catchment building
Sedimentation by the groynes
Collecting the water, people get access to the water
Dredging the river
Natural tidal flows & Fish migration
Cut and Fill
Opening new channel + bridge

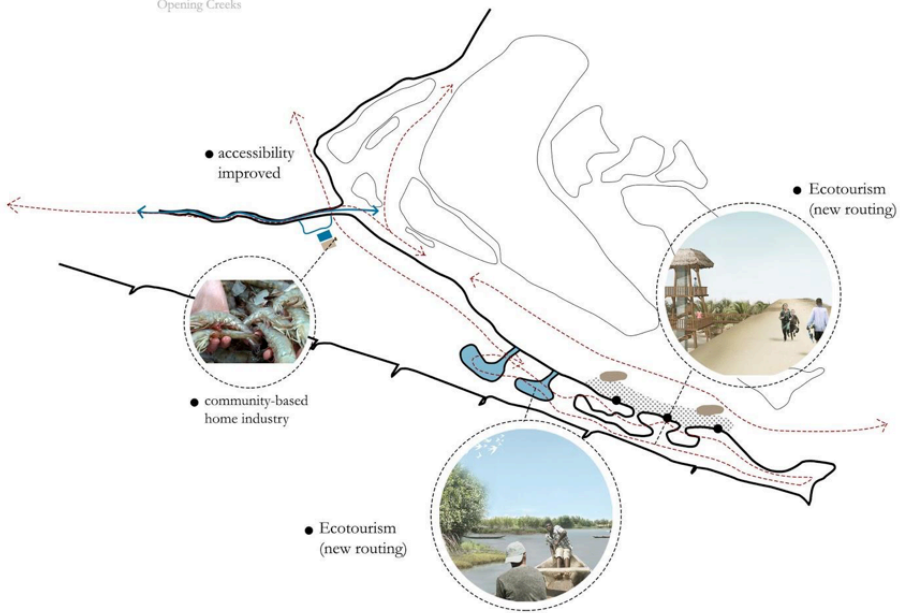

clam farming
oyster farming
mangrove planting
planting program maintaining sand nourishment

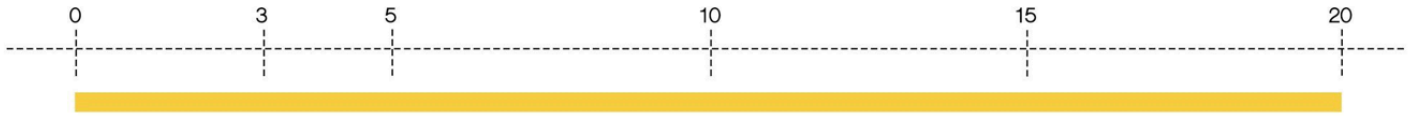

0
3
5
10
15
20
Constructing the groynes _
water catchment building
Sedimentation by the groynes
Collecting the water, people get access to the water
Dredging the river
Natural tidal flows & Fish migration
Cut and Fill
Opening new channel + bridge
Further towards the Songor lagoon
Opening Creeks
opening creeks
community center


0
3
5
10
15
20
Constructing the groynes
water catchment building
Sedimentation by the groynes
Collecting the water, people get access to the water
Dredging the river
Natural tidal flows & Fish migration
Cut and Fill
Opening new channel + bridge
Further towards the Songor lagoon
Opening Creeks
Natural periodic floods & distribution of the mangroves
community-based home industry (clams)
new market

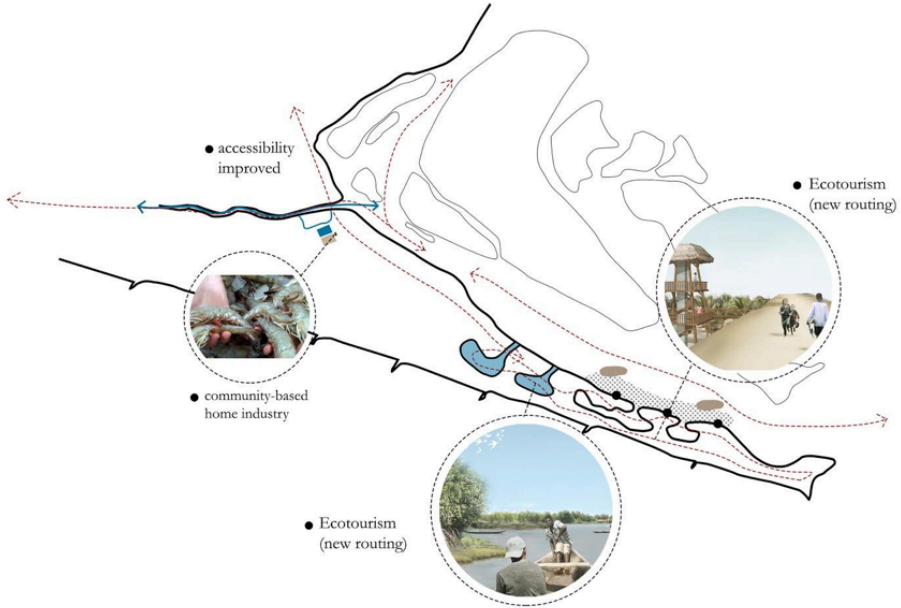

0
3
5
10
15
20
Constructing the groynes _
water catchment building
Sedimentation by the groynes
Collecting the water, people get access to the water
Dredging the river
Natural tidal flows & Fish migration
Cut and Fill
Opening new channel + bridge
Further towards the Songor lagoon
Natural periodic floods & distribution of the mangroves
Opening Creeks
silvo-fishery
woodlot planting - harvesting

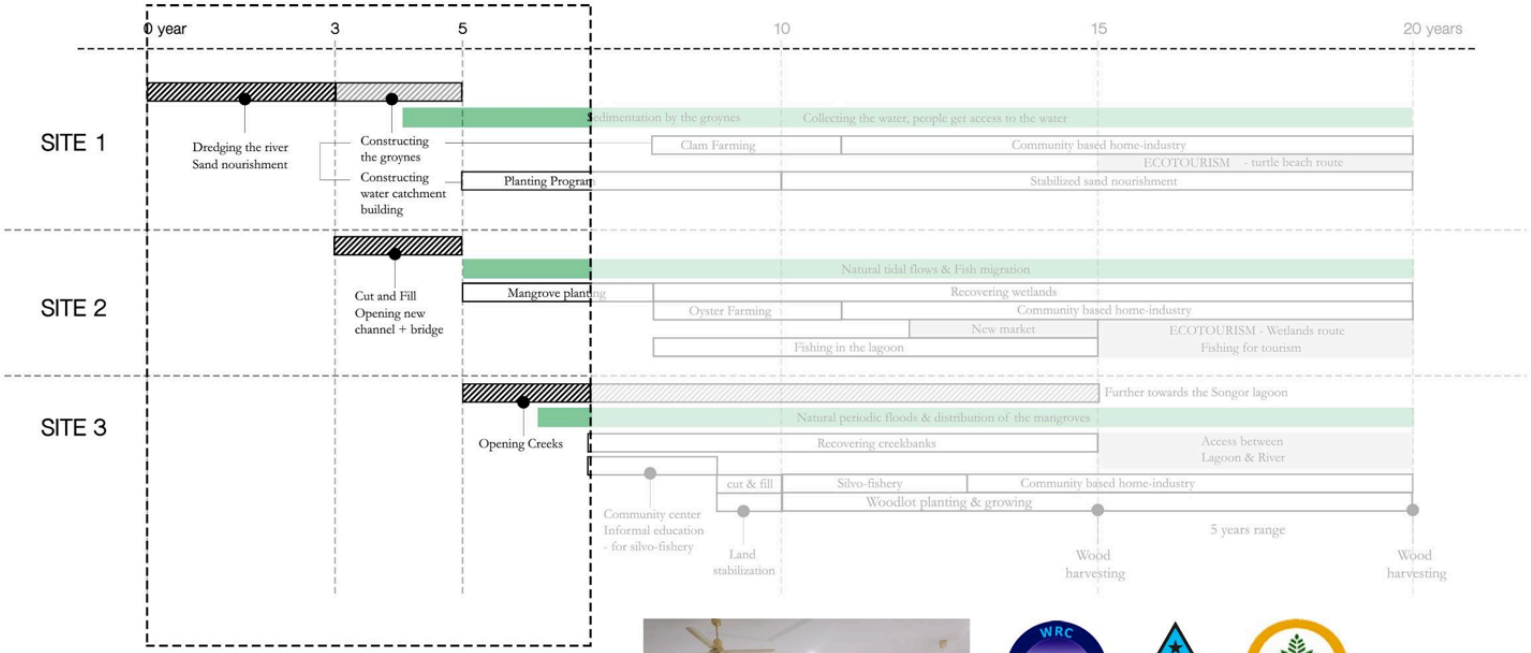

0
3
5
10
15
20
Constructing the groynes
water catchment building
SITE 1
ECOTOURISM - turtle beach route
Sedimentation by the groynes
Collecting the water, people get access to the wat
ECOTOURISM
Dredging the river
SITE 2
ECOTOURISM - Wetlands route
Fishing for tourism
Natural tidal flows & Fish migration
Cut and Fill
Opening new channel + bridge
Further towards the Songor lagoon
Natural periodic floods & distribution of the mangroves
Opening Creeks


accessibility improved
Ecotourism (new routing)
community-based home industry
Ecotourism (new routing)



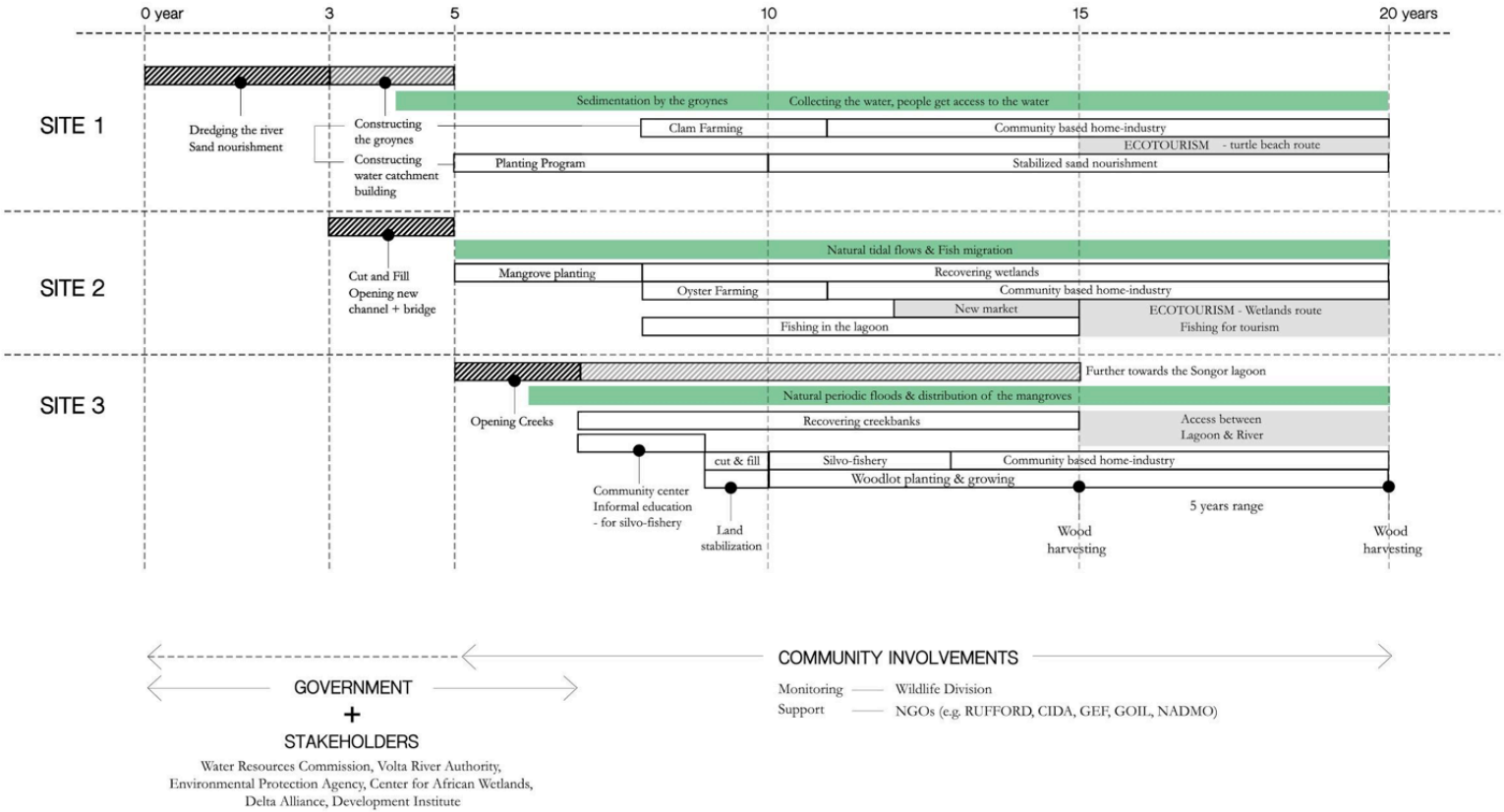
Informal Education



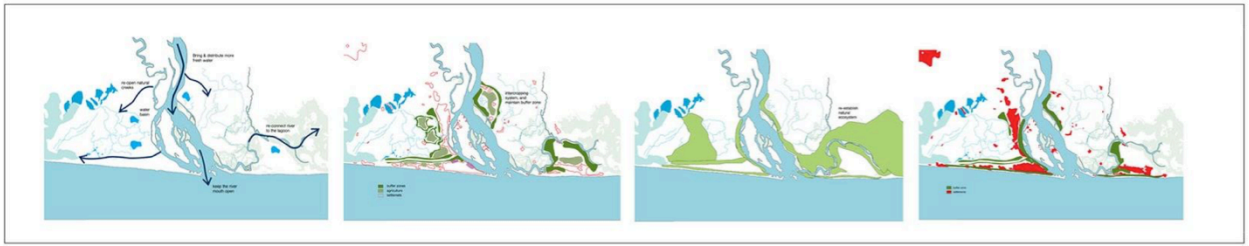


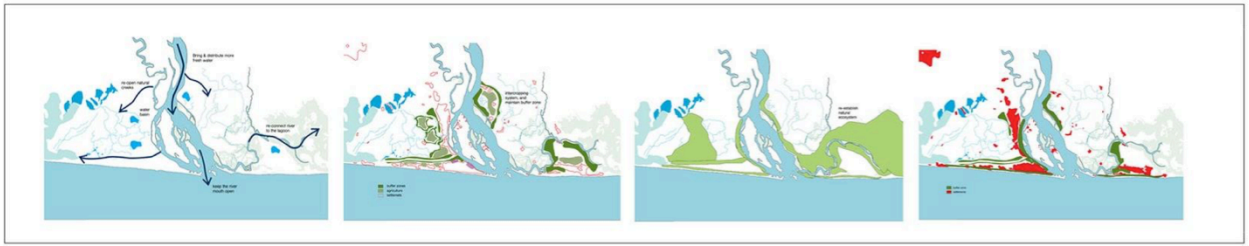
GOVERNMENT
+
STAKEHOLDERS

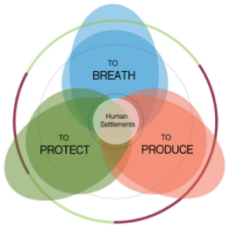
Water Resources Commission, Volta River Authority,
Environmental Protection Agency, Center for African Wetlands,
Delta Alliance, Development Institute

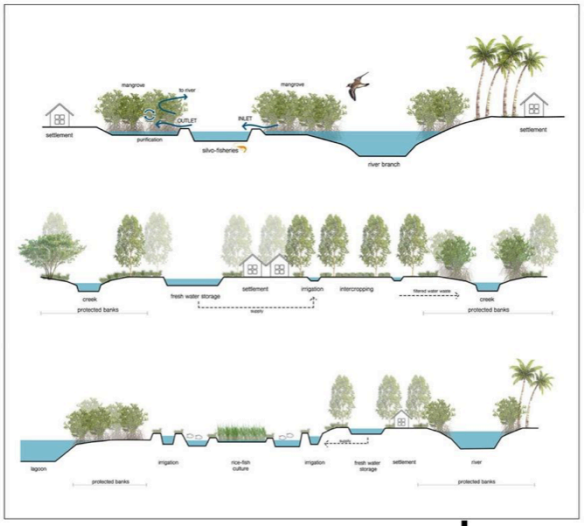

0 year
3
5
10
15
20 years
SITE 1
Dredging the river
Sand nourishment
Constructing
the groynes
Constructing
water catchment
building
Sedimentation by the groynes
Collecting the water, people get access to the water
Clam Farming
Community based home-industry
ECOTOURISM - turtle beach route
Planting Program
Stabilized sand nourishment
SITE 2
Cut and Fill
Opening new
channel + bridge
Natural tidal flows & Fish migration
Mangrove planting
Recovering wetlands
Oyster Farming
Community based home-industry
New market
ECOTOURISM - Wetlands route
Fishing for tourism
Fishing in the lagoon
SITE 3
Further towards the Songor lagoon
Natural periodic floods & distribution of the mangroves
Opening Creeks
Recovering creekbanks
Access between
Lagoon & River
cut & fill
Silvo-fishery
Community based home-industry
Woodlot planting & growing
Community center
Informal education
- for silvo-fishery
Land
stabilization
5 years range
Wood
harvesting
Wood
harvesting
GOVERNMENT
+
STAKEHOLDERS
Water Resources Commission, Volta River Authority,
Environmental Protection Agency, Center for African Wetlands,
Delta Alliance, Development Institute
COMMUNITY INVOLVEMENTS
Monitoring — Wildlife Division
Support — NGOs (e.g. RUFFORD, CIDA, GEF, GOIL, NADMO)

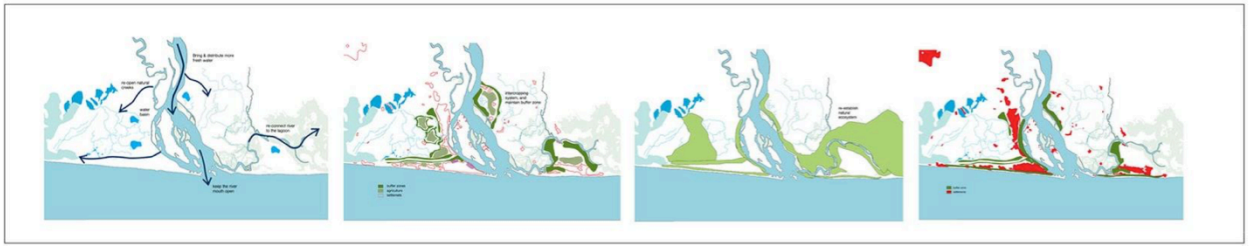
VULNERABILITY

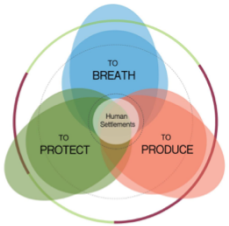

Bring & distribute more fresh water
re-open natural rivers
water basin
re-connect river to the lagoon
keep the river mouth open
interchanging system and maintain buffer zone
re-establish natural ecosystem

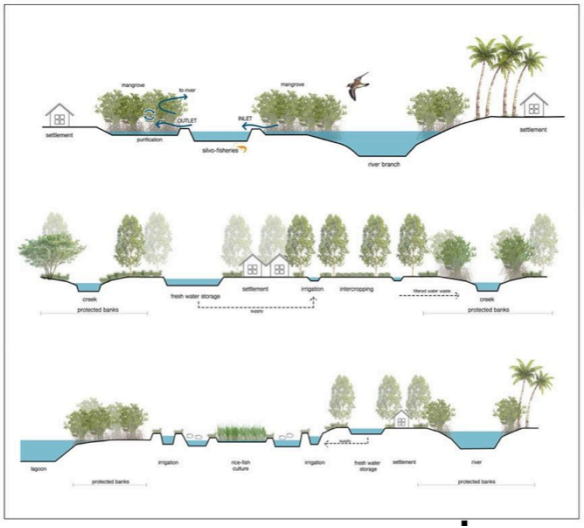


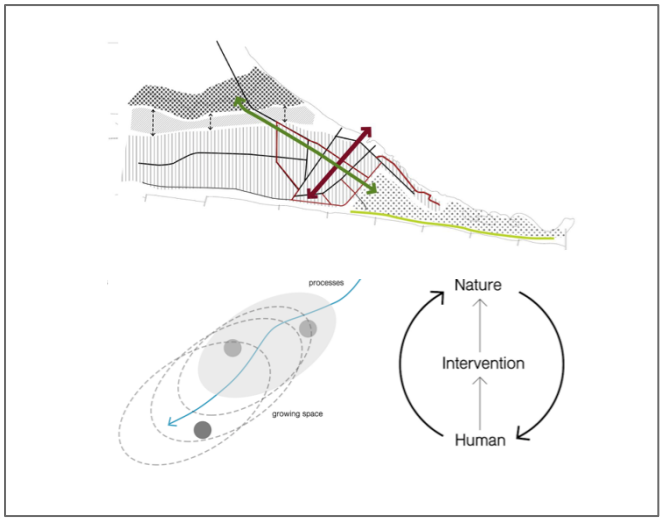

TO
BREATH
Human
Settlements
TO
PROTECT
TO
PRODUCE


mangrove
fish water
OUTLET
INLET
settlement
purification
silvo-fisheries
river branch
creek
protected banks
fresh water storage
irrigation
intercropping
creek
protected banks
lagoon
irrigation
rice-fish culture
irrigation
fresh water storage
settlement
river
protected banks




TO
BREATH
Human
Settlements
TO
PROTECT
TO
PRODUCE


mangrove
fish water
mangrove
settlement
purification
OUTLET
INLET
silvo-fisheries
river branch
settlement
creek
protected banks
fresh water storage
settlement
irrigation
intercropping
creek
protected banks
lagoon
protected banks
irrigation
rice-fish
culture
irrigation
fresh water
storage
settlement
river
protected banks


processes
growing space
Nature
Intervention
Human