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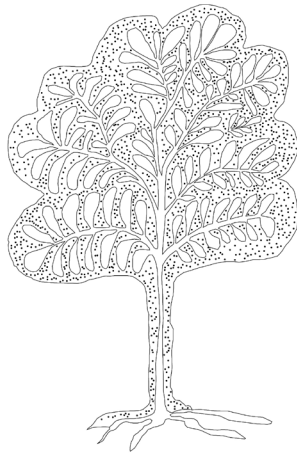
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Fig 1.1 Fishermen wearing masks with a reverse face to confuse the tiger as a safety measure while going to the forest. (source: naturepl.com, Ashok Jain, WWF)



MAN, MANGROVE, TIGER AND THE TIGERSHRIMP

CAN WE SHIFT THE DYNAMICS TOWARDS A RESILIENT
HUMAN-FOREST INTERFACE AT THE SUNDARBANS?

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Fig 1.2 Location of the Sundarbans mangrove forest



Fig 1.3 A typical forest village interface at the Sundarbans (source: Google)

Abstract

Due to some incongruous decisions taken with an intention to control and exploit some parts of the tropical Ganges delta, the balance between the ecology and the cultural practices at the human-forest interface of 'the Sundarbans' has been changed, resulting in mass reduction of some of the endemic species, degradation of biodiversity, deforestation, and migration of local people.

The first phase of this research tries to illustrate the complex web of the interdependent actors of this situation by analyzing the relationship among some of the major noticeable key factors such as people, the mangrove plants, honey harvesting, fishing, shrimp farming and extinction of the tigers.

Since edge condition of the meander lines plays an important role in the Sundarbans ecosystem, precedents have been studied for people using similar techniques of edge conditions evolved in nature to do farming and generate economy. Studies of the silvofishery projects in Vietnam, Philippine and Indonesia show people creating mangrove edge conditions by using brackish water. While doing so, the necessity to control tidal water makes them create patterns which are very similar to maze and labyrinths. The geometric principles tell us that those patterns are very close relatives to the meander patterns.

While adaptation of the silvofishery techniques in the Sundarbans interface can initiate a better ecology; analyzing and establishing relationships among those patterns such as maze, labyrinths and the meanders could give us necessary tools like matrix, patch and corridors on the drawing board. And finally, combining those geometric values with social, mythical and ecological values through design can help evolving a new cultural landscape at the interface of the mangrove delta.



Fig 1.4.A Hindu village in the Sundarbans (source: F.P. Layard. Ferozepore 1843)

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CHAPTER 1: IS THE SHRIMP KILLING THE TIGER?



1.1 The Holy Mangrove



Covering more than 10,000 square km of deltaic floodplains across Bangladesh and India, the Sundarbans region contains arguably the largest continuous block of mangrove ecosystem remaining in the world. In Bengali, Sundarban means beautiful forest.¹

The Sundarbans can be considered as the first line of defense for the Ganges delta against some of the biggest tropical cyclones of the earth. The thick and dense foliage of the mangroves takes the first blow of the super storms and wave surges that are created in this region due to the joint participation of the intertropical convergence zone, the Coriolis forces and the swatch of no ground - a sudden and huge drop in the continental shelf.

This is the place where a tremendous quantity of freshwater supply accompanied by sediments washed away from the slopes of the Himalayas meets salt water of the Bay of Bengal. This mixing has created a very complex ecology and biodiversity of flora and fauna.

Due to a little change in elevation and the continuous flow of large volume of water all over the year, the landform has produced a complex network of branching fractal pattern of meander rivers. Along the edges of the meanders, the land is always under a

process of erosion and sedimentation. This mangrove forest is home to some of the most exotic creatures of the world, among which the Royal Bengal Tiger is the most prominent one. The Indian and Bangladeshi Sundarbans is currently home to some 114 (according to 'www.dhakatribune.com', MAY 21, 2019) of those, which is the largest number of the existing tigers in a single continuous forest. Besides, there are salt water crocodiles, fresh water dolphins, spotted dears, a range of wild cats, snakes, wild boar, otter, fishes and birds.

The flora of the Sundarbans is also very unique because they all have been evolved in a way that they have generated their own way of breathing, reproducing and avoiding salt in different tidal conditions. The halophytic roots, the pneumatophores and the salt accumulation system of their stomata of the leaf vary from species to species in this area following different levels of salinity, water level and density of sediments.

The history of resource consumption by humans in this forest dates back to the Mughals, when they first decided to create more revenue from the forest. After the Mughal regime, under British rule, maps were created and later on more and more legislation regarding forest jurisdiction were added.

¹ 'Sundarhans' is the anglicised version of the Bengali shundor (beautiful) and ban (forest).



*Fig 1.6 Satellite view of the Sundarbans mangrove forest in Bangladesh
(source: NASA)*



1.2 The Dutch Polders

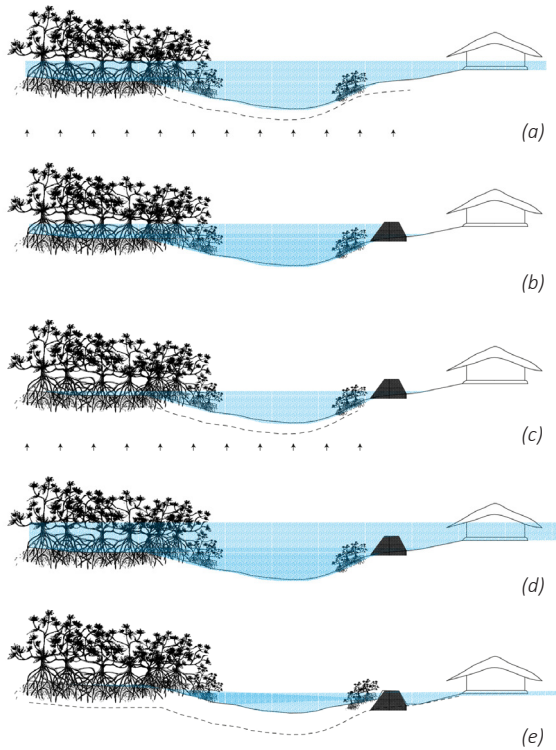


Fig 1.7 A visual description of the polders at work in Bangladesh (a) Annual flooding before polders, (b) Inland flooding stopped after polders built, (c) Inland will not rise because no flood-sediments, (d) Larger surges of salt water created by super cyclones, (e) Water blocked inside inland because the inland bottom level is lower than the river bed.

A polder is a low-lying tract of land enclosed by dikes that forms an artificial hydrological entity, meaning it has no connection with outside water other than through manually operated devices.

In Netherlands, they create polders in order to hold the water back from coming inside the inland by creating an elevation by earth and rock dumping method. Later this elevation become infrastructure and people use them for communication and settlement spines. the polders were introduced to Bangladesh in the 1960's.

The initial purpose of the polders was to save the coast from tidal flooding and reduce salinity incursion. Of the 123 polders of Bangladesh, 49 are sea facing and plays vital role in protecting local agriculture and livelihoods.

The four-meter-high earthen walls served the country very well in initial years of installation. The rivers of the Netherlands are different from the ones from Bangladesh in a way that they are not as dynamic as the ones in the Ganges delta. The large quantity of sediments that comes with the river and the flood makes it act very uniquely. In the past local people of the coastal Bangladesh were familiar with this natural flood that occurred periodically. After each flood, the local farmers used their own method of using the sediments to grow foods and create new lands. But despite the local practices, the coast was very

vulnerable to coastal floods. After the British left, the then rulers of the West Pakistan government decided to solve this issue with quick decisions and as a result, the polders were created hiring the technology from abroad.

The polders protected the coast from annual flooding and people created more and more cultivable lands inside the polders. But since it was not bringing the flood, it could not bring the sediments also. And since the inland was not exposed to those sediments, it could not rise anymore. On the other hand, the river beds were still rising due to regular sedimentation. This became a crucial and critical problem when some of the super storms took place. The super storms produced large storm surges, which the polder walls could not hold back. So, the polders eventually broke at some points and the inland was flooded. Later, when the surge was going back, the water did not go out from the polder inland because the land bottom was already lower than the river bottom.

This blocked water was salty which stayed inland for months, eventually creating more salination of the lands than it would have naturally. People lost lives, the land lost fertility and agriculture had to be turned into shrimp farming from rice cultivation.



Fig 1.8 Villagers taking part at a polder reconstruction in Bangladesh (source: Perera D. (2016). Uncertain Waters: Deltaic Interventions in Bangladesh amid Precarious Conditions. Michigan Joournal of Sustainability, 29)



1.3 The Shrimp Farms



Fig 1.9 Shrimp for sale, photo by Allison Joyce (modified by author)

Bangladesh is the 12th largest cultured shrimp producing country of the world. Shrimp culture is the third major foreign currency earning source of the country. The industry provides employment to over 1 million people and supports over 3.5 million dependents (Kabir SH 2013).

The shrimp farms started replacing the rice cultivation fields of the coastal area from the 80's when people realized that it earns a lot of money because of the huge demand of the shrimp in the global market. Later, with time and promotion of several international projects in the name of poverty reduction, more and more lands were converted to shrimp farms. Later the business became so big that these companies actually started to introduce artificial salinity to the lands to produce more shrimps.

As a result, local people lost lot of farm lands and habitable lands. And due to the incurred salinity, there are no scopes to produce any other agricultural products such as vegetables or fruits. Besides, in some areas, even tube wells cannot produce fresh water for drinking. The shrimp farms actually need a very little man power or human labor for operation. Due to jobless conditions, lack of food and fresh water people are moving out from the coastal areas to more dense urban areas. The shrimp farming is also involved in some of the illegal and self-destructive activities for the environment and ecology. One thing is that the farms need continuous supply

of salt water, which, during rainy season becomes scarce. Because of the salts from the land being washed away by the rain, the shrimp farmers are often seen spraying raw salts on the shrimp cultivation lands. They also install a water drain locally named 'Goi', which they set up on the polder walls, which eventually affects the strength of the embankment, making it more vulnerable to the floods and storm surges.

Shrimp farming has long been causing severe threats to ecological systems of Bangladesh, such as deterioration of soil and water quality, depletion of mangrove forest, decrease of local variety of fish and shellfish, saline water intrusion in ground water, local water pollution and change of local hydrology (Kabir and Iva, 2014) .

The farms need supply of shrimp seeds that is collected from the forest rivers. People do this part of the job in a nasty way by using very thin nets which eventually destroys all kinds of species that takes shelter in the meandering rivers. The fishing even destroys the mangrove roots which is affecting the whole forest ecosystem. The shrimp farms often share borders with the Sundarbans.



Fig 1.10 Shrimp farms inside the polders (source: global aquaculture alliance)



1.4 The Bee



Fig 1.11 Honey produced in Sundarban (source: dhakadough.com)

The mangrove flowers attract bees, Chak moumachhi (*Apis dorsata*), and the bees create beehive in the forest. In the Sundarbans a lot of beehives can be found inside the deep parts of the forest. The honey produced by these beehives are of super good quality and has a great market demand. Besides honey, the bees also produce wax, which also has a good market value as a by product of the harvesting process.

The traditional honey collectors of the Sundarbans are called the 'Mouli' people. They usually go to forest without any weapon or equipment for self defense against the attacks of tiger, crocodiles or snakes. Besides there are also risks of the pirates who would take them captive for money and loot their boat and all gears including the honey they collect. Despite all risks these people go to forest to harvest honey and wax to earn a livelihood.

In past, the 'Mouli' people were the only ones who would go inside the forest to collect honey. They also had good traditional knowledge of harvesting honey in way that it does not ruin the beehive by not killing the queen bee. They also could study the forest and knew where or which parts of the forest they should go in which part of the year.

After the shrimp farms been introduced to the coastal areas sharing boundaries to the forest, more and

more people started going to the forest in order to collect shrimp seeds. People who lost home and cultivable lands due to shrimp farming also started to go to the forest in order to earn a livelihood.

All of these activities resulted in ruining beehives with queen bees which affected severely the ecology of the forests. Because there were less bees, the flowers were not pollinated properly and because the flowers were not pollinated, there were not enough fruits for the deer or other herbivorous wildlife species, which eventually affected the tiger's food supply. Besides, the tigers are also being continuously irritated by the people trespassing through their territory. So, the tigers became more violent and started attacking on the honey gatherers, fishermen, wood collectors and even the villages round the forest area more frequently.



Fig 1.12 Traditional honey collection in Sundarbans (source: Muhammad Mostafigur Rahman)



1.5 The Tiger



Fig 1.13 The Royal Bengal Tiger is one of the most famous national branding icons of Bangladesh. This image is taken during an international cricket match (source: cricviz.com).

'The conflict between humans and tigers in the Sundarbans is rooted in the socio-economic condition of the local people and the tigers' man-eating habits. The per capita income in the Sundarbans is estimated at less than half the state average. In their struggle for survival thousands of people enter the forest braving the crocodiles, sharks and tigers in order to gather honey, cut wood and catch fish. This brings them face to face with the tigers. Sometimes the tigers enter villages near the buffer zones and carry off men, women or cattle. This is an area where tigers kill hundreds of people a year, but since they are a protected species, killing a tiger that has been preying on a village will bring in the government authorities to mete out punishment; a terrifying prospect for the deceased's near and dear. Thus, the new widow and the victim's children are forbidden to cry and taught to say their father has died of diarrhoea, because if the actual cause of death is found out the family members will be forced to pay for the dead trespasser and will be treated like criminals.'

Prioritizing the Tiger: A History of Human-Tiger Conflict in the Sundarbans
Chakrabarti R. 2019

The Sundarbans is the only mangrove forest of the world that is home to tigers. After the last cyclone attack named 'Aila', the number of the tigers in the forest reduced rapidly. Besides, there are stories of tigers being killed by people in the surrounding shrimp farming area. The tigers also kill human. According to unofficial records, there are about 100 people killed every year in the human tiger conflict zones of the Sundarbans. But due to poaching and illegal human access to the forest, the numbers of the tigers are reducing at an alarming rate.

The tigers usually have their own territory of hunting and roaming. Because of their need for large quantity of foods, they need a big territory to hunt. That is why the number of the deers and other preys' matter so much in the behavior of the tigers of the Sundarbans. Besides, the increasing salinity is another reason that the tigers of the Sundarbans are becoming more violent day by day.

The tiger is not only an exotic creature of the forest, but also it is a great indicator of the lost forest human balance in the interface regions. Being the top consumer after human in the forest ecology, it clearly shows every changes and actions that affects the forest ecological balance.



Fig 1.14 A tiger being released after caught while attempting an attack (source: W)



1.6 The Mythical Forest

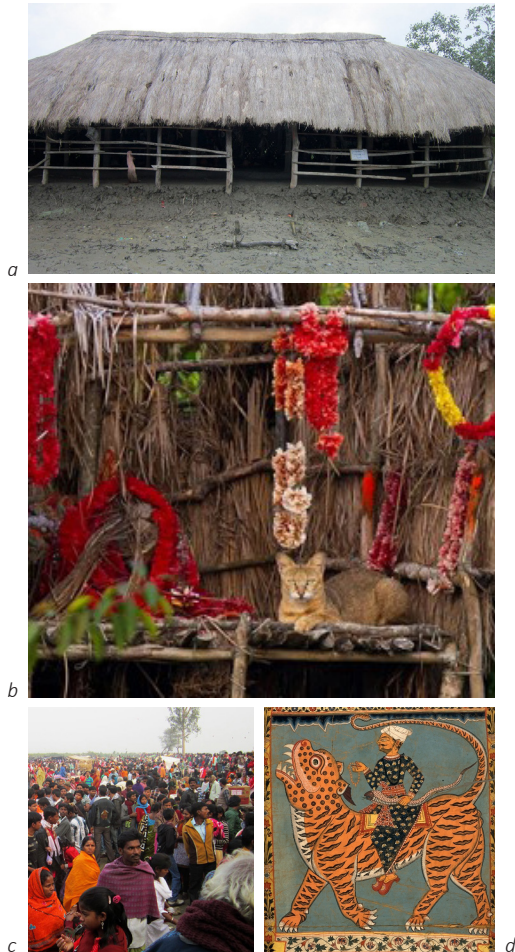


Fig 1.15

a. A shrine of Bonbibi (source: Shatarupa Bhattacharyya, ruralindiaonline.org)

b. A wild cat in the shrine (source: ruralindiaonline.org)

c. Annual festival deidacted to forest spirits (source: ruralindiaonline.org)

d. Part of a tiger scroll (source: British Museum)

e. Sketch of Bonbibi



*"I am the mother of all in these 18 Bhatias,
Everyone who calls me mother will be rid of
troubles, Whosoever calls me Mother when in
trouble, Will never come to harm from others"*

-the Punthi of "Bonbibi Johurnama"

In the 12th century, with the arrival of the new muslim 'imams – religious leaders in islam religion', parts of the forest needed to be cleared to grow new settlements. Back then the forest was full of biodiversity, loaded with tigers and crocodiles. When the clearing of the forest took place, the tigers started attacking the new people who took away parts of their territory. With the rising fear of the tigers and the thrive to make new settlements, people created myths (that are known today) about tigers, gods and goddesses. Since the essence of the myths lie in a hostile forest context occupied by the native 'hindu' people and the new 'muslims', the stories remained very political. They were non secular stories connecting some of the features of both of these religions.

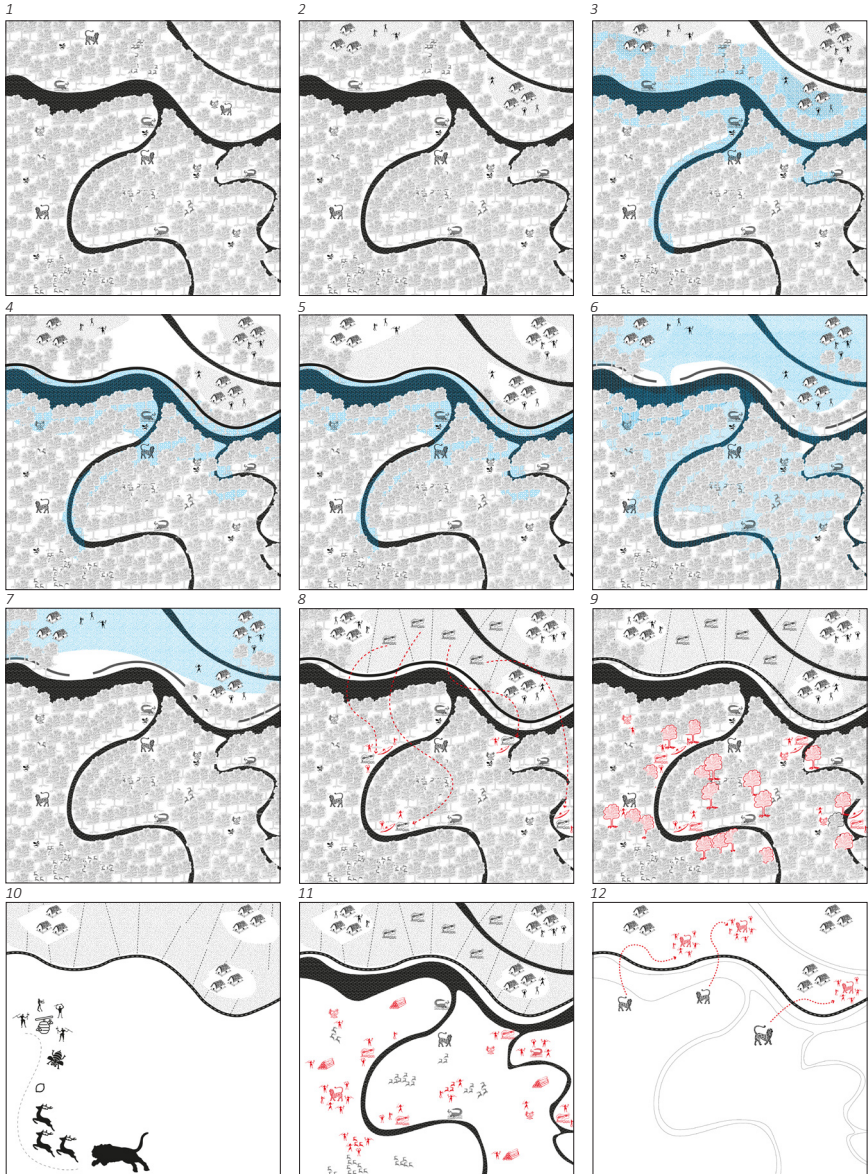
Till today, the sundarbans remain a place where people regardless of any religion worships the same goddesses and gods. Historical proofs of this mythical stories are found in the british museum archive in large scrolls, which exhibits the tendencies of the

then people to translate and connect to the natural patterns found in the forest. Even today, there are shrines in the forest and the interface where locals would go and worship before entering the forest. There are annual festivals where lot of people gathers to share their gratitude to 'bonbibi', the goddess of the forest. They also wear a mask depicting the face of another tiger lord 'dakhin ray' to cover their back of the head to keep the tiger away. Though it is not sure if the tiger understands it or not, but it gets confused if it cannot determine which is the frontal part of the body of its prey.

The shrines of the 'bonbibi' can be considered as treasures in the forest matrix where rituals take place to maintain the balance between the forest and the humans.

1.7 The Storyboard

Fig 1.16 The Storyboard



Narration of the storyboard

1, 2

The story started when People started creating small villages in the forest.

3, 4

The river would flood annually both of the banks and deposit sediments. then the govt built the polders to stop flooding in order to create a more productive landscape. cultivable lands were inside, but since the land was not having flood, it was not rising with the surrounding landscape.

5

And when there were bigger floods,
The water came in but it could not go out.

6

The land became salty and people shifted to shrimp farming from rice.

7, 8

The farms needed shrimp seeds which could be collected from the forest
Once people started going to forest they found there were more things to collect such as wood and honey. People also did that in past, but they were few and had their traditional ways of doing that.

9, 10

But now, there were lot of people without any respect for the ecology
The destruction of the beehives affected the whole food chain.

11

Besides they also involved themselves in poaching of deers, tigers, crocodiles and birds.

12

With no food and lost territory, tigers started attacking surrounding neighborhood and got killed.

1.8 The Web of Interdependencies at the Human- Forest Interface



Fig 1.17 Diagram sketch showing the complex web at the interface



'As the centuries passed, our appetite for their assets became unsustainable. Since the start of civilisation, intensified logging, the advance of agricultural fields, and urban sprawl have seen 46% of the world's forests cleared (Crowther Et al, 2015). Forest goods now support a multibillion-dollar industry, upon which millions of people depend. However, despite the commendable efforts of international agencies and national governments, the sustainable management of these valuable resources remains a challenge, with 7.6 million hectares of forest still lost annually, primarily from the tropics (FAO, 2015).'

At the human-forest interface, Nature Communications

Fig 1.18 A tiger at the village forest interface of the Sundarbans, an indicator of the lost balance between the men and mangrove. (source:www.wildlifeconservationtrust.org)

There is no legally defined area as an interface for the sundarbans at present. But whether defined or undefined, the interface exists. It is an area where stories are born and incidents take place. A forest carries such a great significance in its own existence that people who lives in the surrounding areas cannot ignore it. They become involved actively or passively in an interaction that has been happening since the early ages of human history. The forest provides them with resources as food, wood, medicine, honey and a lifestyle.

There are traditional timber product collectors of the forest who know which part of the forest is ready to harvest at what time of the year. They go there and collect wood and leaves and because the leaves are trimmed, they can grow again in the next season. When the forest department apply their prohibition for entering the forest, they do not take into account these considerations. As a result, if a part of the blooming of the trees is delayed because of a change in the annual weather or something similar happens, the authorities still do not adjust their prohibition period. Eventually next year, there will be less fruits, and then the other dependents on those fruit supplies will also be affected. Problems like deforestation and over exploitation of the resources take place gradually. They also create a market that becomes dependent on that exploitation system. Therefore, a sudden change can cause serious

imbalance in the interface web, even if done with a good intention.

The shrimp farms are another example. People also did it in the past, but they had their own system of dikes to hold and release brackish water. But with large scale polders, larger business opportunities were created, eventually it started generating an economy which is doubtlessly better than previous times. They cannot be removed just because they are polluting the forest. Neither the tiger nor the people will follow any overnight instructions that might bring a sudden change.

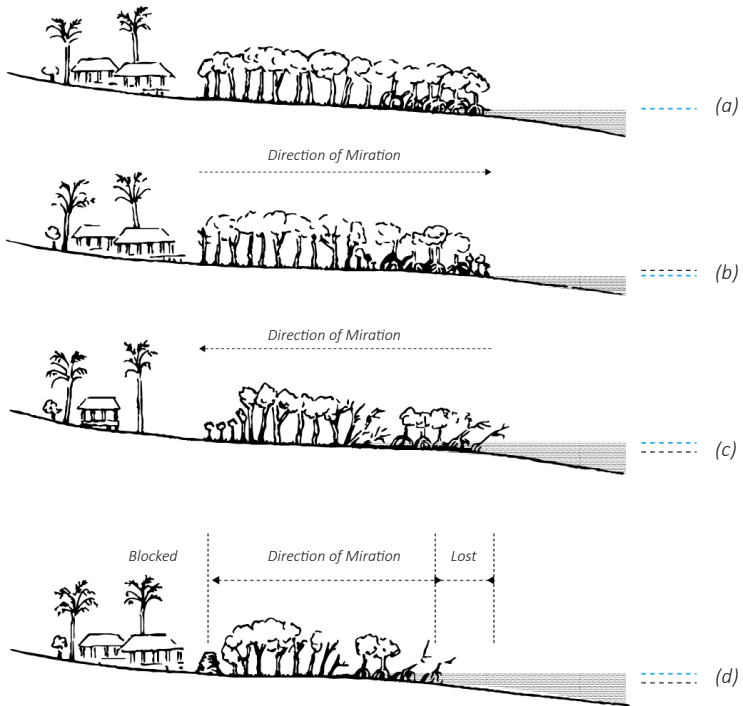


Fig 1.19 At a mangrove interface, the forest should always be allowed to move back and forth. With the change in water level due to erosion and sedimentation, the forest always migrates from or to the land.

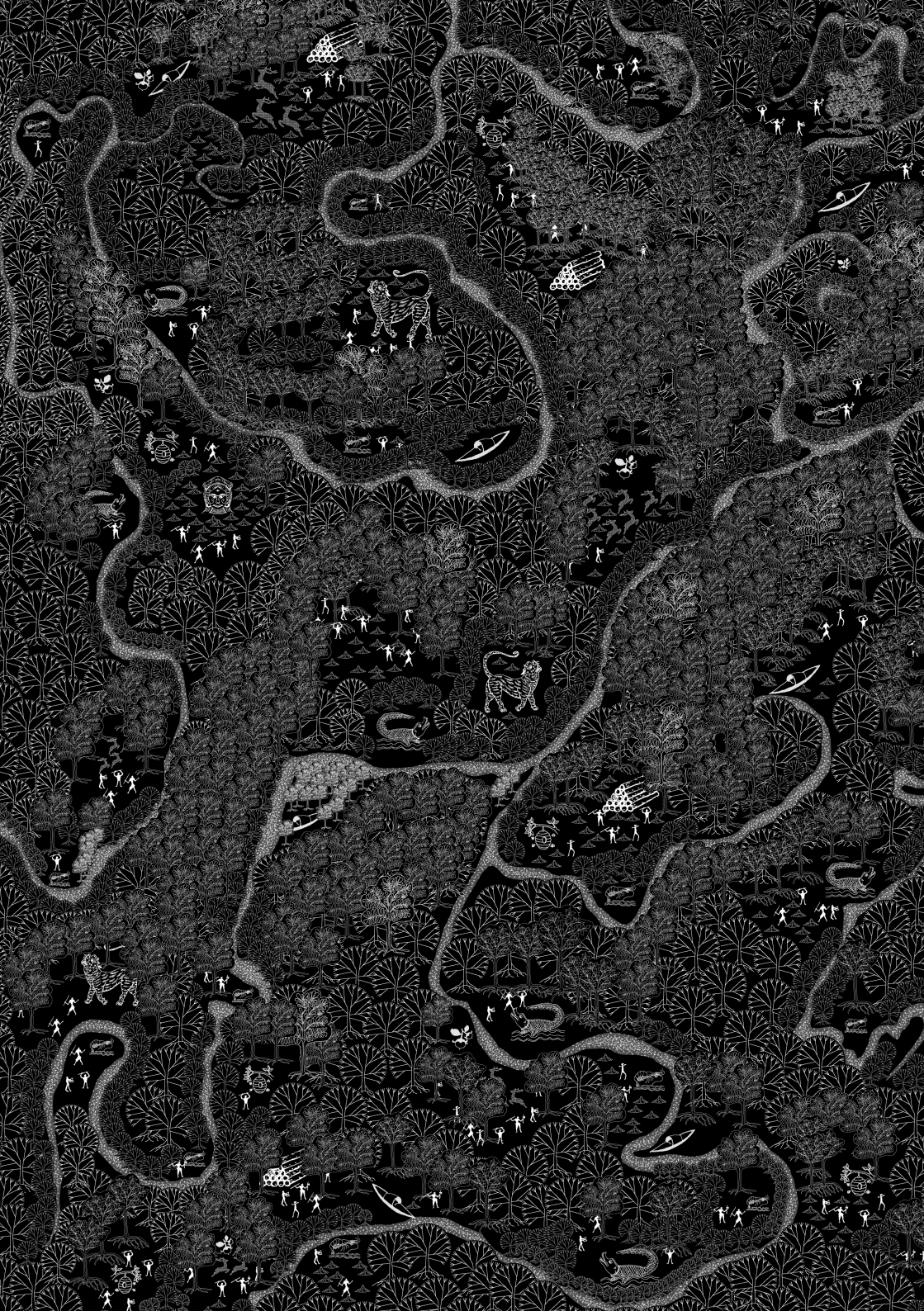
(a) Stable water level

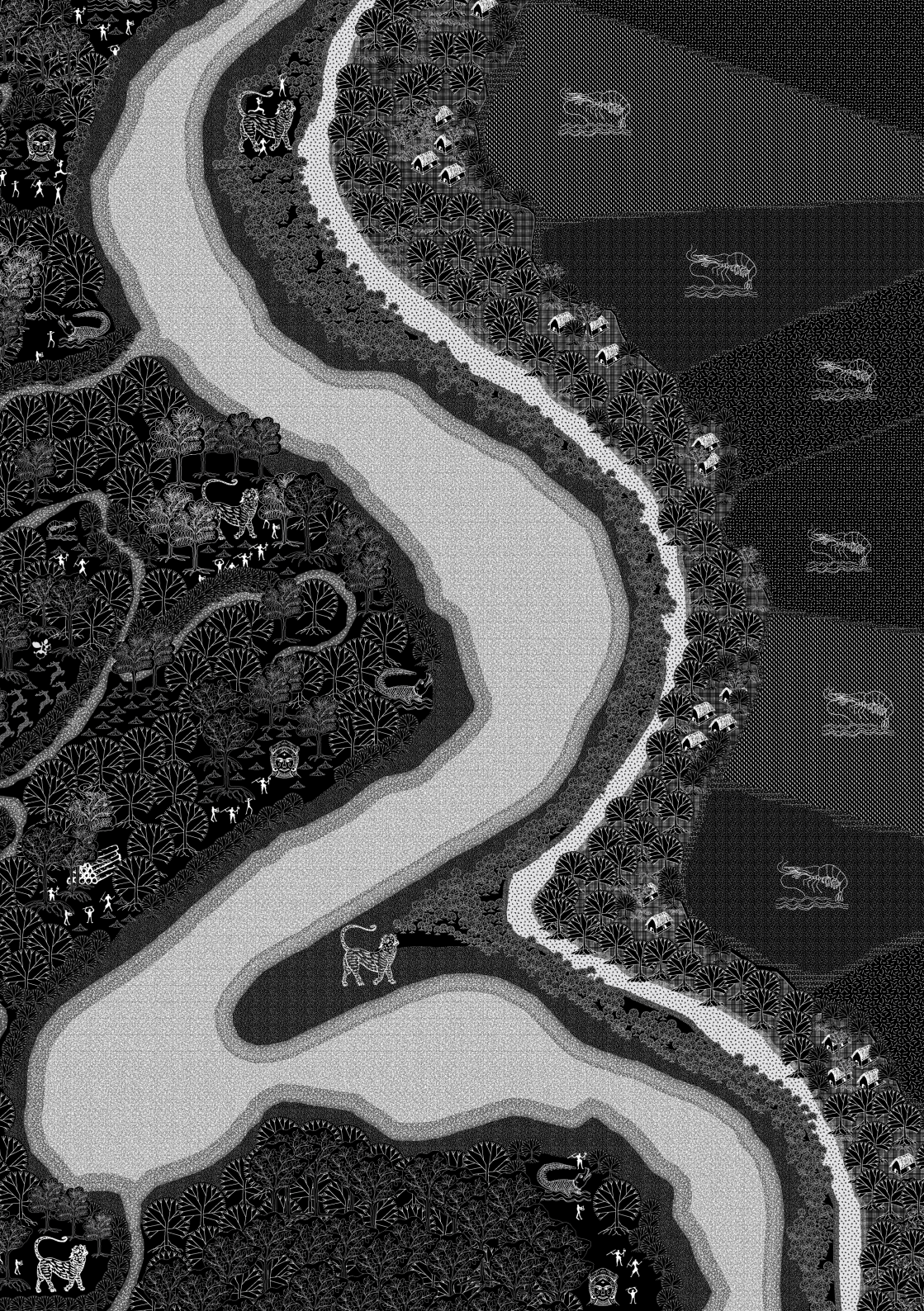
(b) Water level is decreasing, mangrove starts reclaiming more land

(c) Sea level rise, mangrove starts moving landward direction

(d) Parts of the mangrove is lost because of the blocked inland

Figure modified from: Gilman Et al (2007)





1.9 The Economy and Politics of Frozen Food Exports of Bangladesh: We must accept the Shrimp Farms



Fig 1.20 Destinations of the shrimp products from Bangladesh



Fig 1.21 Photo of Late Karunamayi Sarkar, a martyr of the land acquisition protest at polder 22

(source: Successful protests to remain a shrimp-free zone in Polder 22, Khulna, Bangladesh, www.dhakatribune.com)

‘Structural adjustment programmes imposed on Bangladesh by the World Bank and the International Monetary Fund since the 1980s provided ample opportunities to earn high foreign exchange by venturing into export oriented activities. During the second half of the 1980s, major international banks and development agencies began financing projects for promoting commercial shrimp production in Bangladesh; the World Bank and the UNDP funded the Shrimp Culture Project in 1986 and the Third Fisheries Project in 1991, while the Asian Development Bank supported another shrimp project in Chittagong in south-eastern Bangladesh (Adnan, 2013). These projects allowed for large scale land grabbing, by any means necessary, in the coastal districts for commercial aquaculture. This transition from agriculture to aquaculture was facilitated by armed representatives and strong political leaders who used sluice gates in the polders designed to flood the islands. Once the land is waterlogged, there wasn’t much the local communities could do, unless the local anti-shrimp community groups or village committees could regain control of the sluice gates to let the water out.’

Name of conflict: Successful protests to remain a shrimp-free zone in Polder 22, Khulna, Bangladesh Environmental Justice Atlas, <https://ejatlas.org/conflict>

Though shrimp farming is considered responsible for a number of conflict and environmental pollutions which are affecting the mangrove very badly, it can be seen as an opposite situation of ‘Plant blindness’, a term which is used to explain the situation where people do not recognize some of the plant species that are most common and grow in abundance. Just as opposite, here, the shrimp farming or the tiger is only seen as problems, when, they are just the symptoms. For example, when a tiger attacks, it does not attack just because it wants to change

its menu. It comes out from the forest only when there are reasons for it to come out and these days, most of those reasons are created by active or passive human activity.

Considering the contribution of the shrimp export to the economy, it is needless to say that it is not possible to stop such a huge economic sector. Rather, if understood and analysed the problem thoroughly, it can be modified, redeveloped and redesigned by gaining knowledge from other similar cases as a holistic cultural landscape.

1.10 Men Mimicking Mangroves!



Fig 1.22 Acting as a nursery, mangroves play an important role in supporting fisheries (Photo by Octavio Aburto, National Geographic)

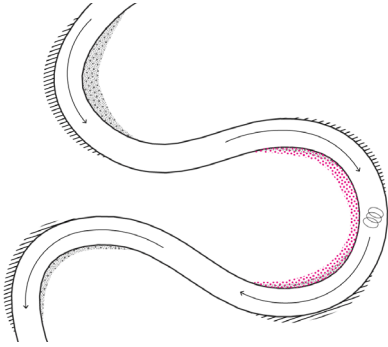


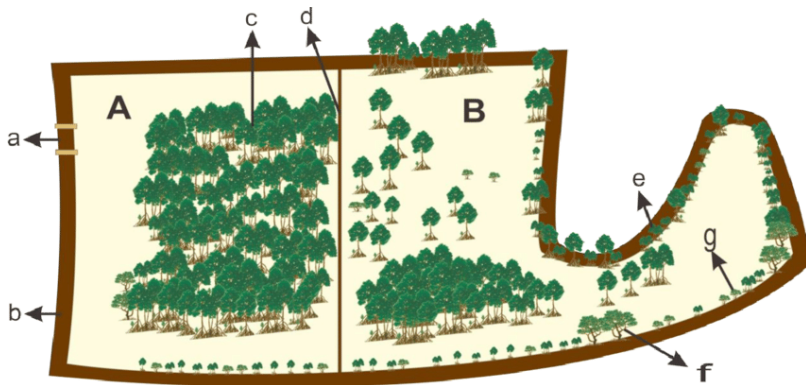
Fig 1.23 Condesation of shrimp seeds (in red)



Fig 1.24 Edge dynamics of a typical mangrove meandering river bank

At the Sundarban rivers, the continuous process of erosion and sedimentation makes meander happen through helical current. The current not only accumulates and densifies the sediments, but also it carries every other object that floats or lives in the water with it. The mangrove roots, submerged by water, acts like a shelter for all the living organisms against tidal currents. The meeting of fresh and salt water

in shallow depth fed by a plenty of sunlight is the feeding and breeding place for fishes, shrimps, crabs, crocodiles and all other living things. The shrimp seeds, carried by tidal and helical current accumulates in places where the new sediments also accumulate. Because it is usually a new land along the banks, not covered by roots and top covers, it becomes easy for the seed collectors to go there and collect seeds.



Silvofishery model in Lubuk Kertang village.
 A. *Silvofishery with the dominance of saplings,*
 B. *Silvofishery with the dominance of seedlings.*
 a. *Pond sluice (silvofishery gate for brackish water),*
 b. *Beds,*
 c. *Rhizophora saplings,*
 d. *Limiting net,*
 e. *Rhizophora seedlings,*
 f. *Avicennia saplings,*
 g. *Avicennia seedlings*

Fig 1.25 Introducing of a silvofishery pond on sapling and seedling density based in Lubuk Kertang Village, North Sumatera.
 (Figure by Mohammad Basyuni
<https://www.researchgate.net/publication/333659778>)

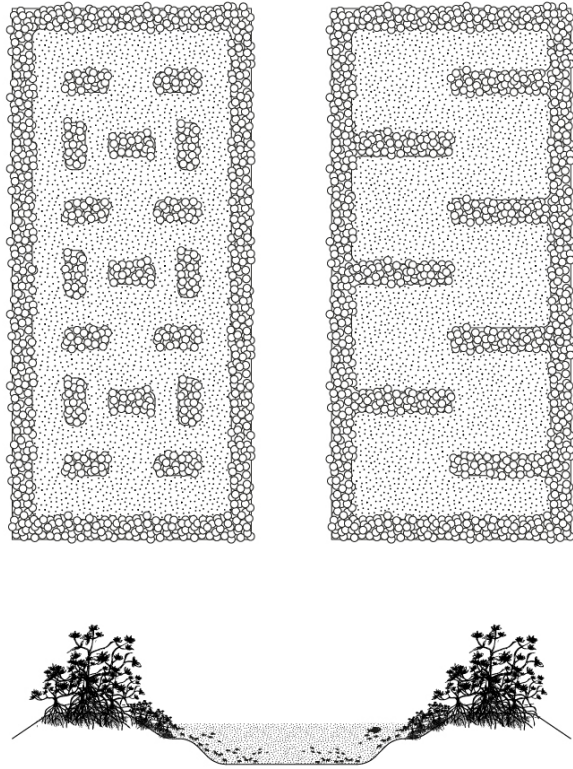


Fig 1.26 typical plan and section of mangrove based shrimp farming techniques

In Vietnam, Indonesia and Philippines people are mimicking the mangrove edge conditions to farm shrimp. This mangrove-based aquaculture is called the silvofishery, where the brackish water from the tidal flows is controlled by gates while entering inland farms. The farms have rows of mangroves and sometimes the farms re built on parts of mangrove forest itself. But the technique they use is very ecological because the mangrove can produce

food and shelter for the shrimps which is more similar to their natural habitats.

Besides, the mangrove roots also help to filter the water that is polluted by the shrimps and the food wastes. The mangrove grown shrimps have good international market demands because of their ecological value.

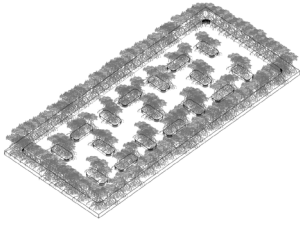
1.11 The Maze of Brackish Water



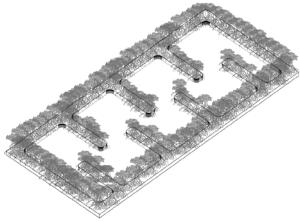
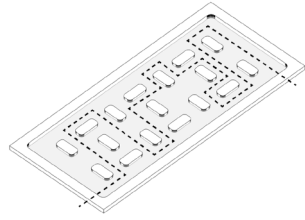
While doing silvofishery, the framers need to make sure that the brackish water comes into contact with maximum length of mangrove root edges. It is because the roots interchange nutrients and creates shelter for the shrimps. In order to do so, the rows of the mangroves are often adjusted in a way that it almost creates a maze. Though unintentional, the patterns created by the rows are often amazing and have a great quality to be translated into mazes, labyrinths and even meanders!

Fig 1.27 Mangrove based silvo fishery Program: Sustainable Coastal Livelihood: Integrated Mangrove Fishery Farming System www.iucn.org

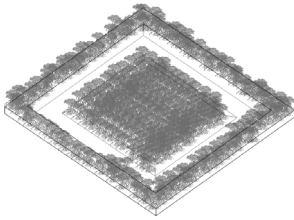
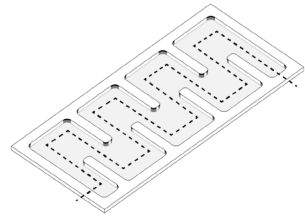
*Fig 1.28 (next page)
Different models of silvofishery used in different conditions. The water flow is shown with the black dotted line on the second column figures.
Type a and b tries to create meandering mazes while type c, d and e are more regular rectangular paths.
The later creates chunks of forest patches which has the potential to be seen as gardens!*



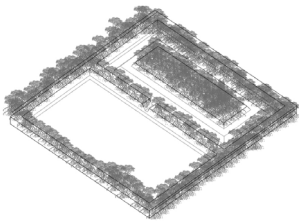
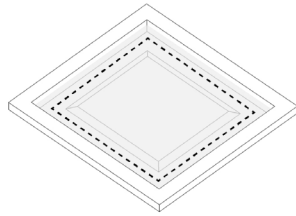
(a)



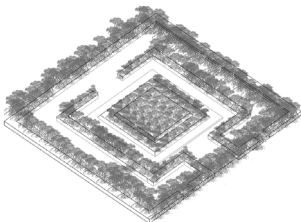
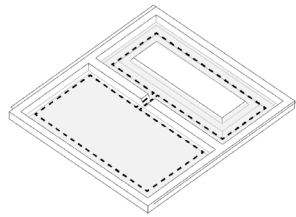
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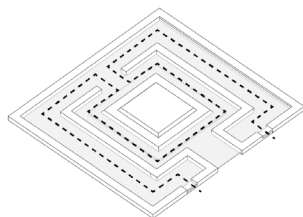
(c)



(d)

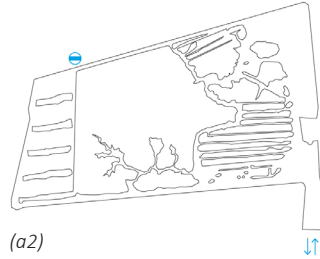


(e)





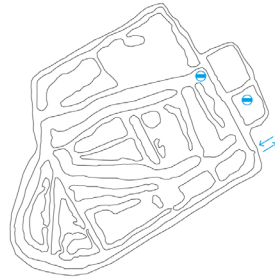
(a1)



(a2)



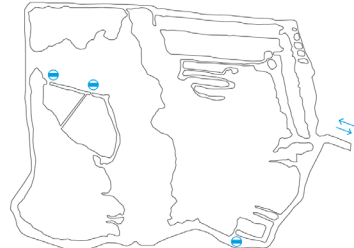
(b1)



(b2)



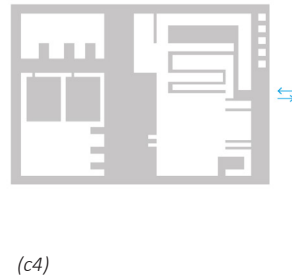
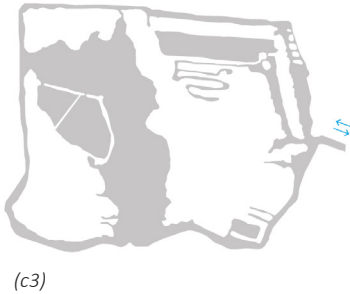
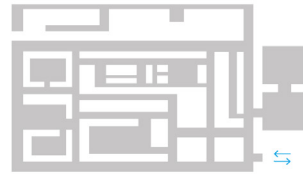
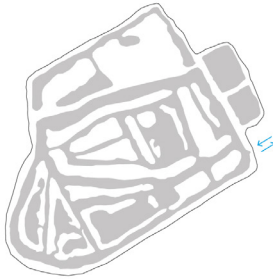
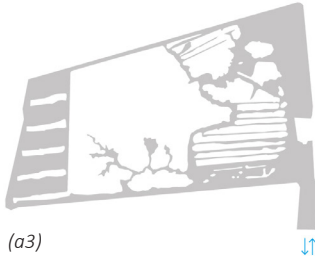
(c1)



(c2)

In order to explore more, Google images have been used to trace three random silvofishery based shrimp farms from Vietnam that lies in the Mekong delta, sharing edges with mangrove forests. These farms were selected because of their clear exhibition of maze and meander like patterns.

*Fig 1.29 Tracing shrimp farms from Vietnam
a2, b2 and c2 shows water direction by
blue arrows and water control by using blue
circles.*



The brackish water area has been coloured in grey in figure a3, b3 and c3. The next column tries to illustrate the simplified version of the patterns that are created in these farms. Converting the random lines into straight lines, we can draw simple geometries of rectangular shapes to represent them. The idea of maze becomes clearer.

Fig 1.30
a3, b3, c3 shows water in grey
a4, b4, c4 simplifies the shapes into rectangular patterns

CHAPTER 2:
THE PATTERNS OF
MEN AND
MANGROVE

'Patterns are everywhere,
and it is by recognizing them
that we can orientate our-
selves, try to make sense of
the world and predict the
way that certain actions
might occur.'

Landscape Pattern, Perception And Process
Simon Bell



Fig 2.1 Is the pattern of the tiger skin very different from the other meandering patterns of its habitat? (source: Joydip Suchandra Kundu, AP)



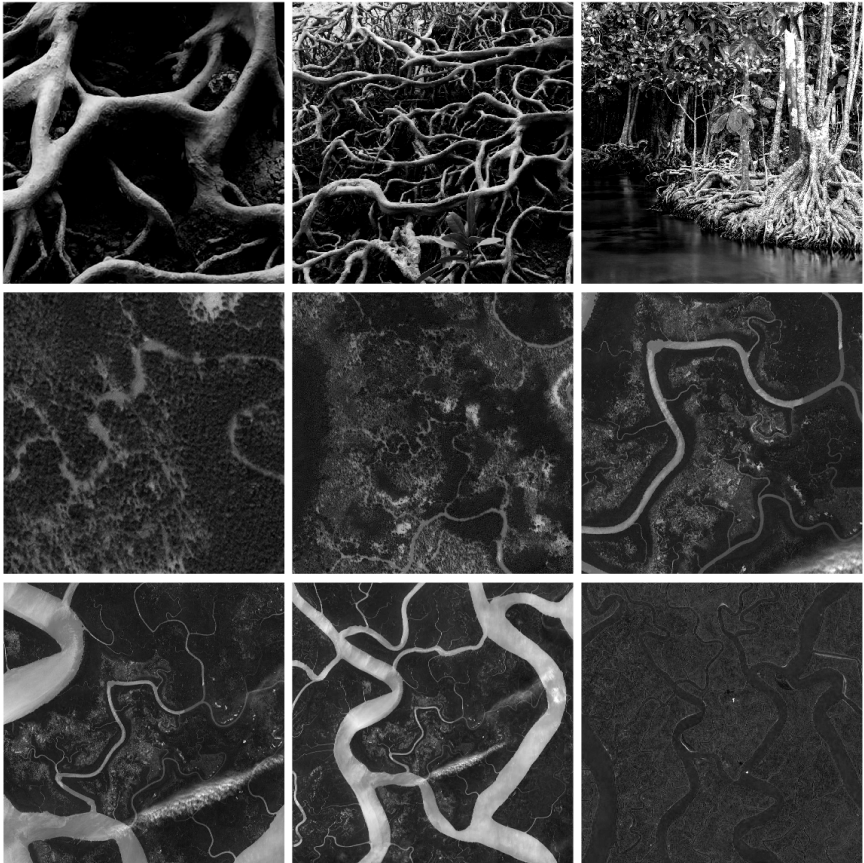
feb2 2017



feb1 2017

Fig 2.2 Cloud formation at the Sundarbans (source: www.zoom.earth.com)

2.1 The Fractal of Branching Meanders



*Fig 2.3 Meandering pattern found at the Sundarbans in different scale
(source:Google Earth)*

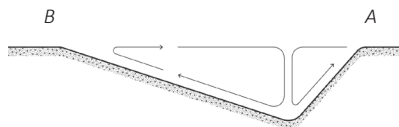
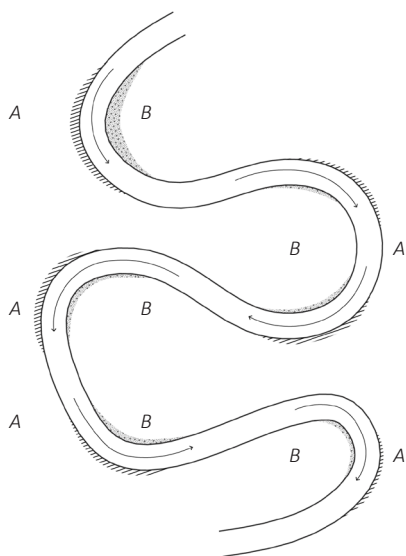


Fig 2.4 A visual explanation of the meandering rivers. The helical current is the main responsible factor for the sedimentation and erosion of the rivers

A= Erosion, B= Sedimentation

The Sundarbans exhibits an exclusive display of meanders, ranging in a variety of scales, from the halophytic roots to the aerial view level. The complex fractal of branching patterns made by meandering lines can also be seen even on the patterns of the tiger skin and even in the cloud formation over the forest atmosphere.

The meandering rivers are always under an ongoing process of erosion and sedimentation. The large quantity of sediment flow with the water against a very low elevation change in its path is one of the major reasons for this phenomenon. The water is always creating a helical current,

which basically takes away sediments from one bank and settles it down to another bank of the river.

In geometry, meanders are very close to spiral shapes. Both are driven by growth impulses of a point. If the growth impulse goes in a same direction, it creates spiral shape, and if the growth impulse alternates itself it creates a meander. So, technically the meanders can be created by joining points. In nature, usually the fluid flow against a almost flat background helps creating meanders. It can be the fluid itself or it can be the background against the fluid flow that reflects meandering qualities.

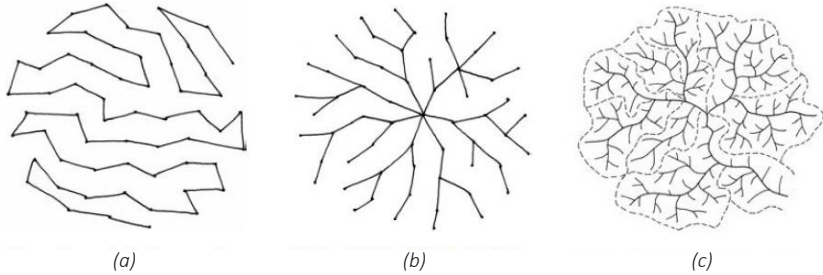


Fig 2.5 Analysis of Patterns Shown by Simon Bell in His Book 'Landscape Pattern, Perception And Process'

- (a) Creation of Meandering Pattern by Adding Points*
- (b) Branching Pattern*
- (c) Fractal of Branching Meanders*

While meandering is about going single path in alternating directions, branching is about going different directions from one common origin point. The direction paths can be many, but they must have a common origin. In rivers, the branching pattern becomes more vibrant, because it always uses the 'less work' principle. The controlling factor usually is the landform, against which the branching occurs.

The branching and the meandering can happen at the same time, resulting in complex fractal geometries. In fractal, repetition of same branching can be seen in different scales. They become very special when this repetition of branching follows the mean-

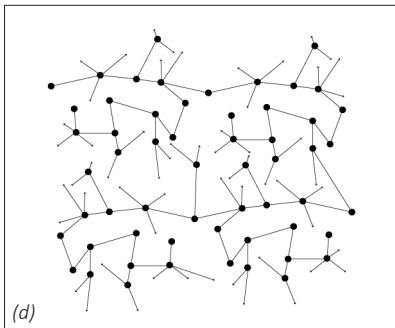
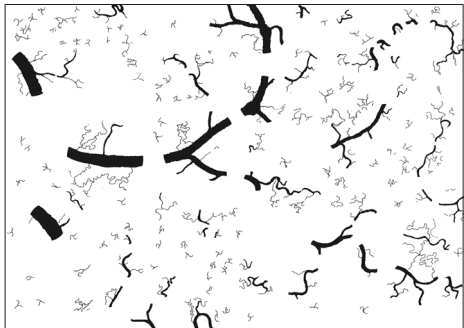
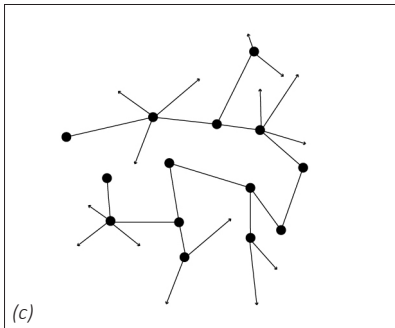
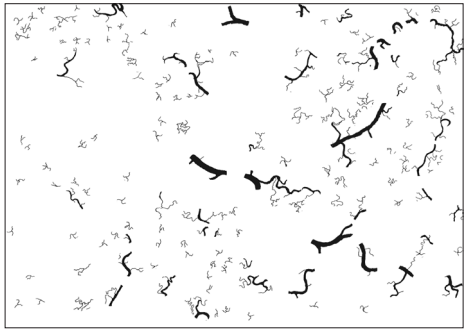
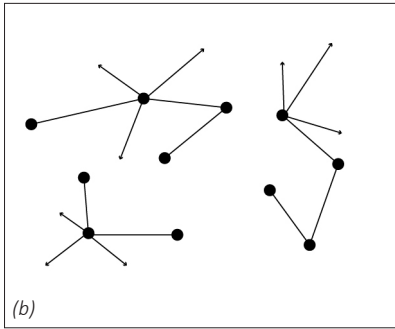
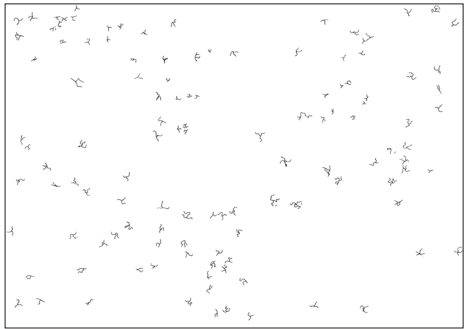
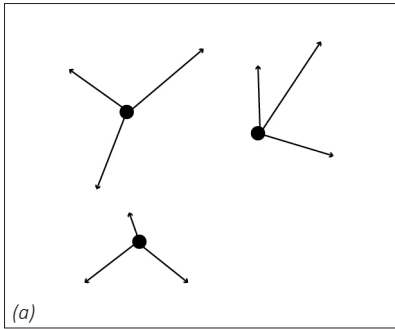
Fig 2.6 (next page)

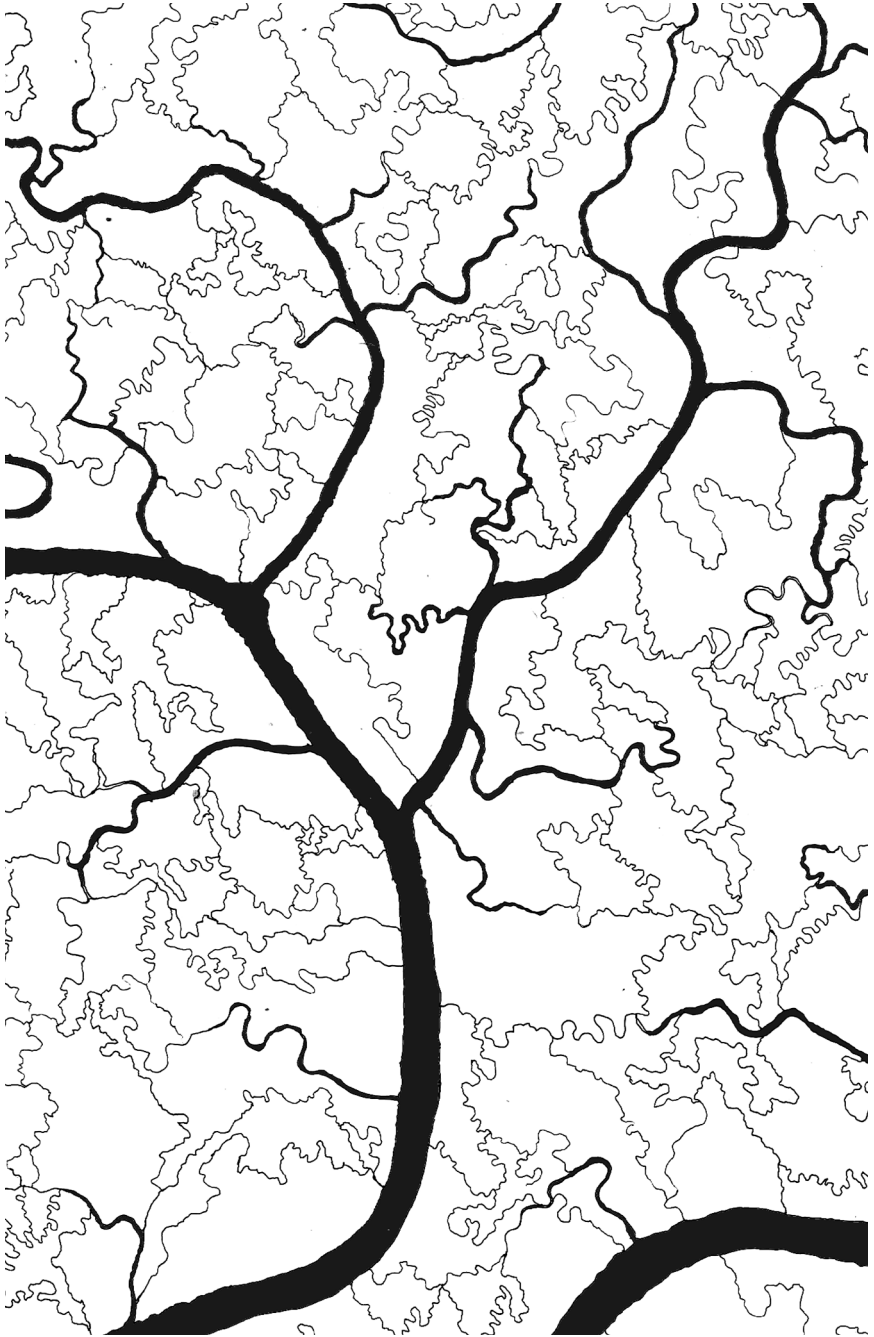
Analysis of the Sunderban river patterns

- (a) Smallest branches*
- (b) Small branches creating bigger branches*
- (c) Bigger branches creating meander*
- (d) Meandering branches creating fractal*

dering pattern, which happened in the rivers of the Ganges delta, specially at the Sunderbans part.

The analysis done on the next page tries to figure out these patterns by tracing a part of the Sunderbans from an aerial photograph. First, the photo was traced where smallest part of the meander is visible. Then the smallest parts have been separated where the first phase of the branching takes place. Then the geometry was converted into lines and dots. By repeating the same technique in larger scales, we finally find a scenario where we see the branches creating fractal of meanders.







2.3 The Ancient 'Meanderers'



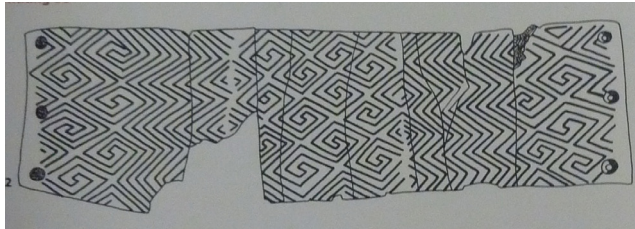
Fig 2.7 The 'Gazi Scroll' from ca 1800
(source: <https://www.britishmuseum.org/>)



Fig 2.8 Use of a simple version of the meandering patterns in different parts of The 'Gazi Scroll' (source: <https://www.britishmuseum.org/>)

One amazing example of people's attraction of Sundarban patterns can be found in the paper painted scroll named 'The Gazi Scroll' from ca 1800 century, which is presently archived at the British Museum Archive. The scroll illustrates a story about famous Muslim saints 'Gazi Peer' and 'Manik Peer'. The context of the stories lies in the 12th and 13th century Sundarbans

surrounding settlements of Bengal. While telling about the mythical powers of these saints, the scroll uses a range of motifs which seems very much inspired from the local context. The water, clouds, tiger skin and trees are painted in a way that clearly expresses the effort to interpret those natural patterns into art.



'From the beginning the meander was not only an ornament; it was a symbol, a metaphor for water.'

-Lithuanian-American archeologist Marija Gimbutas (1921-1994)

Fig 2.9 Upper Paleolithic armlet of ivory with rafters and meanders, Mezin (18,000 – 15,000 BC), Source: Marija Gimbutas, Die Sprache der Göttin (German edition), 1995, pict. 38



Meandering lines inscribed in a triangle in Val di Susa (Western Alps). Source: Arcà et al. 1995



Pattern from South India (source: Santarcangeli, P., (1997) El libro de los laberintos. Ed. Siruela, Madrid)



Labyrinth of the Tohono O'otam Indians (Arizona). Source: Phillips (2001)

Fig 2.10 Different meanders and labyrinth created by different cultures

The history of people using meanders is very old. Apparently, greeks were the first ones to convert meanders to labyrinths, which have been used at different scales ranging from coins to huge land marks throughout the pre-historic and medieval periods all over the world. They have been used for astronomy, contemplation and telling stories. While the primary and only objective of the labyrinth is achieving as much as complexity of a single path inside a frame, different cultures still produced astonishingly different patterns of labyrinths. The labyrinth from the western alps tries to achieve meanders within a triangular frame, while the indian one shows the

complexity of avoiding meanders yet trying to reach a concentric division. The special qualities of the labyrinths also vary from culture to culture.

The patterns that are discussed here were amongst the most common patterns used by people for creating landforms in the past that can be considered as designed landscapes. These strong, bold and easy shapes are myserious, handy and easy to construct even without seeing from sky.

2.4 How the Patterns of Men and Mangrove Meets Today: A Simplified Diagram

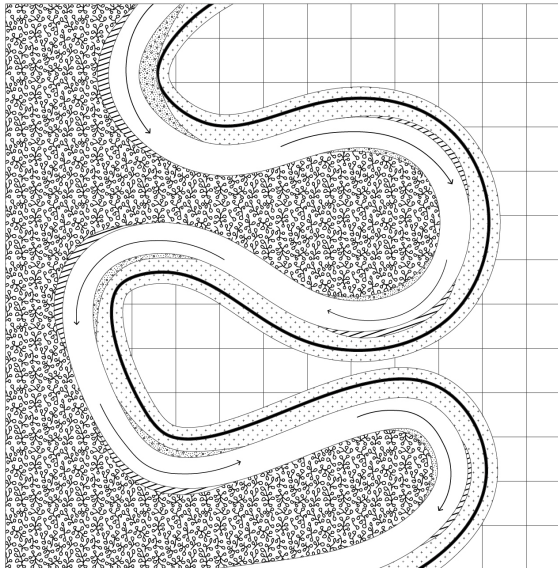


Fig 2.11 Is the river the only separator between men and mangrove?

*Fig 2.12 Layers of the interface (next page)
(a) Google image (b) the forest top cover (c) the river
(d) the polder (e) water system occupied by settlements (f) the farm tiles
(g) buildings (h) freshwater ponds (i) all layers juxtaposed*

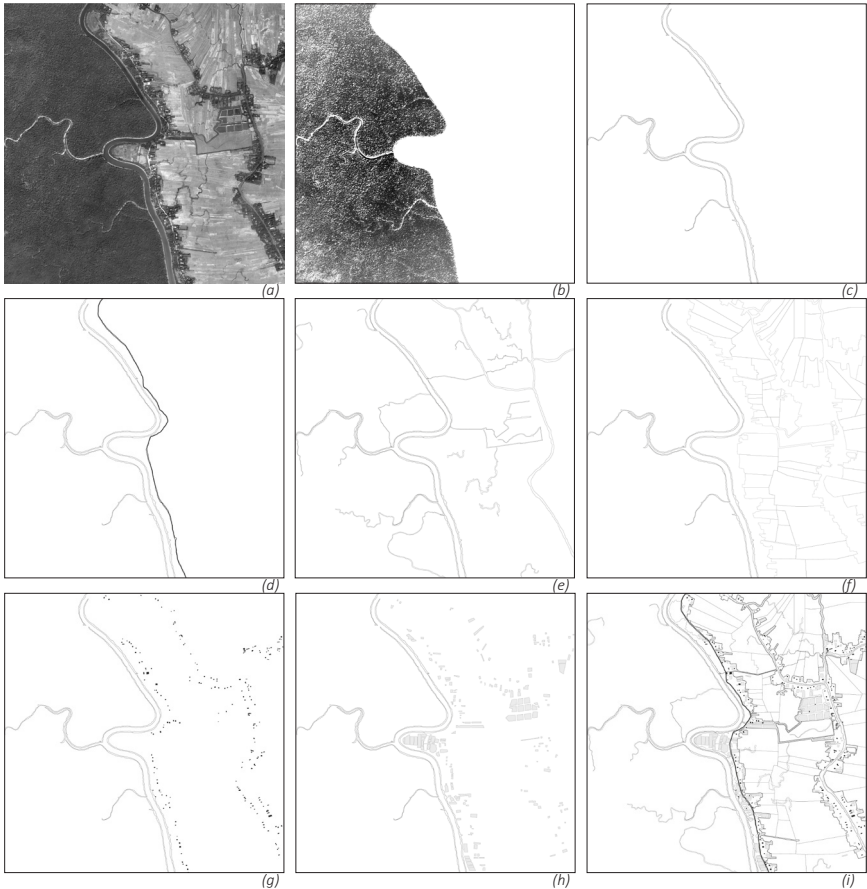


Fig 2.12

In the previous paragraphs the complexity of the mangrove patterns has been discussed. Now if we want to see what is the line between the men and mangrove, we will find that it is only the river that separates them. A satellite image of a small part has been used to analyse and describe this situation but the scenario is same for all the edges of the forest that share border with human settlements.

The importance of the polders cannot be ignored. The lack of inland sediment deposition can be seen as a management issue, and there are projects going on named TRM (tidal river management) to solve this. But the question that arises here is ‘Should it be only the river that divides the men and mangrove?’ the polder simply follows the river and therefore there is no flexible transition space neither for people nor for the forest.



Fig 2.13 Google images showing edges of the Sundarbans shared with settlements; row 1 shows the wet edge, row 2 the north and row 3 is showing the eastern edge of the forest

Should river be the only
threshold between men and
mangrove?

CONCLUSION

SEED OF A
NEW CULTURAL
LANDSCAPE



Fig.3 Iranian Bāgh (garden). The burial place of Omar Khayyam at Nishapur. Source: Mousavi, A; Stronach, D. 2012. Ancient Iran from the Air. Mainz: Verlag Philipp von Zabern.

Now that the problem scenario is drawn and some aspects of this scenario has been discussed; based on the questions that arose in the previous chapters, what assumptions can be made that will guide the web of interdependency at the interface toward a new cultural landscape? Can it be the 'Fingers of the Ganges delta'? or the 'Polder Gardens' of Bengal Delta?

Considering the complexities of the context it would be rational to think about a pilot project, a unit that can be seen as a seed for the new cultural landscape. There are examples of projects from the past which were designed as initiators of something bigger. The geopolitical importance of the design of ancient Persian gardens with an idea of a new city or the use of the 'Limans' in the Israeli deserts to initiate an ecology that is a primary step to create settlements in the desert can be seen as planting 'designed seeds' in a problem matrix to achieve certain conditions with a strategy for different time frames.

Problems such as unsustainable shrimp farming, imbalance in forest ecology, blocked migration of the mangroves are not new. People in different countries with similar conditions have already tried to solve some of those and already have been successful. Though those solutions always came from an ecological perspective, some of the projects actually involved community

contribution into their program which included active participation of local inhabitants. But then question arises like what happens when the program ends? What will be people's participation if there is no one to supervise or guide? These questions would be clearer if we ask, would it not be easier or nicer if people were given something that is more of a culture than a project? May be for longer term benefits, the interface needs something more than an ecological, agricultural, environmental, hydrological or a forestry-based solution, maybe they need a new cultural landscape.

Study of silvofishery shows us that it has strong geometrical potentials along with its positive ecological impacts. Our site also shows a very rich display of patterns. Some of those patterns are common and have great historical background of being used by humans. It would be interesting to see if these ecological, mythical, historical and cultural patterns can be combined to design a seed of a new cultural landscape at the human forest interface of the Ganges delta.

LIST OF FIGURES

Part	Serial	Title	Source
1	1	Fishermen wearing masks with a reverse face to confuse the tiger as a safety measure while going to the forest	Ashok Jain; WWF, https://www.naturepl.com/stock-photo-fishermen-wearing-masks-to-protect-from-tiger-attack-sunderband-w-image01032757.html
	2	Location of the Sundarbans mangrove forest	author
	3	A typical forest village interface at the Sundarbans	https://www.google.com/maps
	4	A Hindu village in the Sundarbans	F. P. Layard. Ferozepore 1843, https://en.wikipedia.org/wiki/Momin_Mosque#/media/File:Village_in_Pirojpur.jpg
5	a	Location of the Sundarbans mangrove forest in Bangladesh map	author
	b	Tiger in Sundarbans-Nationalpark	Dibyendu Ash, wikimedia commons, https://www.newindianexpress.com/nation/2019/apr/10/tigers-decomposed-body-found-in-bengals-sundarbans-1962342.html
	c	Mangrove Arial Roots	M is for mangrove, https://www.aqua.org
	d	Brown Winged Kingfisher	https://commons.wikimedia.org/wiki/File:Brown-winged_Kingfisher_in_golden_light_in_Sundarban.jpg
	e	Salt Water Crocodile	https://commons.wikimedia.org/wiki/File:Big_croc.jpg
6		Satelite view of the Sundarbans mangrove forest in Bangladesh	NASA
	7	visual description of the polders at work in Bangladesh	author
	8	Villagers taking part at a polder reconstruction in Bangladesh	Perera D. (2016). Uncertain Waters: Deltaic Interventions in Bangladesh amid Precarious Conditions. Michigan Joournal of Sustainability, 29)
	9	Shrimp for sale	Allison Joyce, Rampal Power Plant and Shrimp Farming in the Sundarbans , 2014, http://thephotobrigade.com/2014/05/rampal-power-plant-and-shrimp-farming-in-the-sundarbans-by-allison-joyce/
10		Shrimp farms inside the polders	Photo: STIP, Deltaic plain country learns what further industry actions could help its shrimp achieve higher market access, 2019, https://www.aquaculturealliance.org/advocate/bangladesh-seeks-more-buck-for-its-bagda/
	11	Honey produced in Sundarban	dhakadough.com
	12	Traditional honey collection in Sundarbans	Muhammad Mostafiqur Rahman, Honey collection declines in the Sundarbans, 2018, https://www.dhakatribune.com/climate-change/2018/07/13/honey-collection-declines-in-the-sundarbans
	13	an international cricket match	http://cricviz.com/2017/03/tigers-find-bite-colombo
	14	A tiger being released after caught while attempting an attack	Joydip Suchandra Kundu, AP, https://eu.usatoday.com/story/news/world/2017/10/04/tiger-widows-india-sundarbans/689101001/
15	a	A shrine of Bonbibi	Shatarupa Bhattacharyya, https://ruralindiaonline.org/articles/mabonbibi-mother-to-humans-and-tigers/
	b	A wild cat in the shrine	Shatarupa Bhattacharyya, https://ruralindiaonline.org/articles/mabonbibi-mother-to-humans-and-tigers/
	c	Annual festival deidacted to forest spirits	Shatarupa Bhattacharyya, https://ruralindiaonline.org/articles/mabonbibi-mother-to-humans-and-tigers/
	d	Part of a tiger scroll	https://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=233075&partId=1
	e	Sketch of Bonbibi	author
	16	The Storyboard	author
	17	Diagram sketch showing the complex web at the interface	author
	18	A tiger at the village forest interface of the Sundarbans, an indicator of the lost balance between the men and mangrove.	Human Wildlife Interface Management, https://www.wildlifeconservationtrust.org/our-work/forests-and-wildlife/human-wildlife-interface-management/

19	At a mangrove interface, the forest should always be allowed to move back and forth.	figure modified from: Gilman E. L., Ellison J., Coleman R., 2007, Assessment of Mangrove Response to Projected Relative Sea-Level Rise And Recent Historical Reconstruction of Shoreline Position, Environmental Monitoring and Assessment 124(1-3):105-30 DOI: 10.1007/s10661-006-9212-y, Fig 1 - Four scenarios for generalized mangrove response to relative sea-level rise
20	Destinations of the shrimp products from Bangladesh	author
21	Photo of Late Karunamayi Sarkar, a martyr of the land acquisition protest at polder 22	Successful protests to remain a shrimp-free zone in Polder 22, Khulna, Bangladesh, https://ejatlas.org/conflict/successful-protests-to-remain-a-shrimp-free-zone-in-polder-22-bangladesh
22	Acting as a nursery, mangroves play an important role in supporting fisheries	Octavio Aiburto, National Geographic, https://blog.nationalgeographic.org/2017/06/06/1frame4nature-under-the-mangrove-sea/
23	Condensation of shrimp seeds	author
24	Edge dynamics of a typical mangrove meandering river bank	author
25	Introducing a silvofishery pond on sapling and seedling density based in Lubuk Kertang Village, North Sumatera.	Figure by Mohammad Basuyuni https://www.researchgate.net/publication/333659778
26	typical plan and section of mangrove based shrimp farming techniques	author
27	Mangrove based silvo fishery	Sustainable Coastal Livelihood: Integrated Mangrove Fishery Farming System (IMFFS), https://www.iucn.org/sites/dev/files/content/documents/2016/imffs_sgf_project_report.pdf
28	Different models of silvofishery used in different conditions.	author
29	Tracing shrimp farms from Vietnam	image: https://www.google.com/maps , drawing by author
30	Tracing shrimp farms from Vietnam	author
2	1 Is the pattern of the tiger skin very different from the other meandering patterns of its habitat?	Joydip Suchandra Kundu, AP, https://www.theguardian.com/commentisfree/2015/jan/21/india-tiger-revival-conservation-hope-europe-carnivores
	2 Cloud formation at the Sundarbans	www.zoom.earth.com
	3 Meandering pattern found at the Sundarbans in different scale	modified from: https://www.google.com/maps
	4 A visual explanation of the meandering rivers. The helical current is the main responsible factor for the sedimentation and erosion of the rivers	drawing by author following a figure from Simon Bell's book LANDSCAPE PATTERN, PERCEPTION AND PROCESS, p 152 fig 6.14
	5 Analysis of Patterns Shown	Simon Bell, Landscape Pattern, Perception And Process, p 24, fig 1.11; p25, fig 1.13,1.14
	6 Analysis of the Sunderban river patterns	author
	7 part of the 'Gazi Scroll' from ca 1800	https://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=233075&partid=1
	8 Use of a simple version of the meandering patterns in different parts of The 'Gazi Scroll'	https://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=233075&partid=2
	9 Upper Paleolithic armet of ivory with rafters and meanders, Mezin (18,000 – 15,000 BC)	Marija Gimbutas, Die Sprache der Göttin (German edition), 1995, pict. 38
	10 Different meanders and labyrinth created by different cultures	Meandering lines inscribed in a triangle in Val di Susa , Arcá, A., Fossati, A., Gambari, F.M., Mano, L., Mercado, L., Rostagno, E. and Santacroce, A., (1995). Immagini dalla Preistoria. Incisioni e pitture rupestri: nuovi messaggi dalle rocce delle Alpi occidentali. Corall Edizioni, Cuneo ; Pattern from South India, Santarcangelo, P., (1997) El libro de los laberintos. Ed. Siruela, Madrid, Labyrinth of the Tohono O'otam Indians (Arizona), Phillips T., (2001) Through mazes to mathematics (consulted February 2006). http://www.math.sunysb.edu/~tony/mazes/index.html
	11 Is the river the only separator between men and mangrove?	author
	12 Layers of the interface	author
	13 Google images showing edges of the Sundarbans shared with settlements	image: https://www.google.com/maps
3	Iranian Bāgh (garden). The burial place of Omar Khayyam at Nishapur.	Mousavi, A; Stronach, D. 2012. Ancient Iran from the Air. Mainz: Verlag Philipp von Zabern; http://thecityasaproject.org/2015/07/geopolitics-of-tabula-rasa-persian-garden-and-the-idea-of-city/

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